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ORIGINAL ARTICLE

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Objective: To estimate the incidence and direct medical costs for fatal and non-fatal fall injuries among US adults aged ⩾65 years in 2000, for three treatment settings stratified by age, sex, body region, and type of injury.

Methods: Incidence data came from the 2000 National Vital Statistics System, 2001 National Electronic Injury Surveillance System-All Injury Program, 2000 Health Care Utilization Program National Inpatient Sample, and 1999 Medical Expenditure Panel Survey. Costs for fatal falls came from *Incidence and economic burden of injuries in the United States*; costs for non-fatal falls were based on claims from the 1998 and 1999 Medicare fee-for-service 5% Standard Analytical Files. A case crossover approach was used to compare the monthly costs before and after the fall.

Results: In 2000, there were almost 10 300 fatal and 2.6 million medically treated non-fatal fall related injuries. Direct medical costs totaled $0.2 billion dollars for fatal and $19 billion dollars for non-fatal injuries. Of the non-fatal injury costs, 63% ($12 billion) were for hospitalizations, 21% ($4 billion) were for emergency department visits, and 16% ($3 billion) were for treatment in outpatient settings. Medical expenditures for women, who comprised 58% of the older adult population, were 2–3 times higher than for men for all medical treatment settings. Fractures accounted for just 35% of non-fatal injuries but 61% of costs.

Conclusions: Fall related injuries among older adults, especially among older women, are associated with substantial economic costs. Implementing effective intervention strategies could appreciably decrease the incidence and healthcare costs of these injuries.

Fall related injuries are a serious public health issue among people aged ⩾65 years in developed countries.[1–3] More than a third of older adults fall each year[4 5] and 10% to 20% of falls cause serious injuries such as fractures or head traumas.[6] Non-fatal fall injuries are associated with considerable morbidity including decreased functioning and loss of independence[7] as well as significant use of healthcare services.[3 8 9] In 2002, over 12 900 older adults in the United States died as a result of falls,[10] 1.67 million older adults were treated in emergency departments (EDs) for fall related injuries and 388 000 were subsequently hospitalized.[10] The vast majority of these falls (>99.9%) were unintentional.[10] In a study comparing medical expenditures for 18 leading medical diagnoses for older adults, "injuries and poisoning" ranked seventh (after circulatory diseases, nervous system disorders, mental disorders, respiratory diseases, digestive diseases, and neoplasms.)[11]

A number of previous studies in the US have estimated the medical costs associated with older adult falls. Two studies calculated only the costs for hospitalized fall injuries,[6 8] one included costs for combined treatment settings within a limited geographic area,[12] and others examined the costs for two types of fall injuries—osteoporotic fractures[13] and hip fractures.[14] One study assessed national costs of fatal and non-fatal falls for people aged ⩾65 years in 1994 and reported that direct medical costs and productivity losses totaled $20.2 billion ($31 billion in year 2000 dollars).[15]

In addition to being dated, these studies were limited by the populations they included, the modeling techniques used to estimate unit medical costs, and the degree to which they were able to stratify costs by key injury characteristics. This study provides estimates of the costs of fatal and non-fatal falls in persons aged ⩾65 years using recent data to assess the incidence and medical costs of falls stratified by age, sex, body region, type of injury, and treatment setting.

METHODS

Incidence and cost estimates were derived from a number of different data sources because no single nationally representative data set would allow us to estimate fatal and non-fatal fall incidence and direct medical costs. A complete description of the methodology to assess incidence and costs of fatal falls is provided by Finkelstein *et al*.[16] A short summary of this methodology follows.

Fatal falls

Incidence data for fatal fall injuries in 2000 were obtained from the National Center for Health Statistics' National Vital Statistics System (NVSS). We computed unit medical costs separately for five places of death identified in the NVSS data: death-on-scene/at home, death-on-arrival to the hospital, death at the ED, death at the hospital after inpatient admission, and death at a nursing home. Depending on the place of death, the medical costs incurred could include coroner/medical (C/ME), medical transport, ED, inpatient hospital, and nursing home charges.

All fatalities were assigned C/ME costs of $530.[17] Deaths on arrival to the hospital, in the ED, or after admission also were assigned the cost of one-way transport ($212) which was based on average ambulance transport costs for injury victims found in the 1999 Medicare 5% sample. For deaths on arrival or in the ED, we also added average costs for injury fatalities in the ED computed from 363 injury deaths in 1997 Nebraska, New Hampshire, and South Carolina ED discharge data. (These were the only states for which data with charges and discharge destinations were readily available.)

Abbreviations: HCUP-NIS, Healthcare Cost and Utilization Project–Nationwide Inpatient Sample; MEPS, Medical Expenditure Panel Survey; NEISS-AIP, National Electronic Injury Surveillance System–All Injury Program; NVSS, National Vital Statistics System; TBI, traumatic brain injury.

Table 1 Incidence and costs of fatal fall injuries by sex, age, body region, and type of injury, US, 2000*

	Incidence, n = 10 300	Incidence (%)	Cost (millions), n = $179	Cost (%)
Age (years)				
65–74	1700	17	30	17
75–84	3800	37	64	36
85+	4800	47	85	47
Sex				
Men	4700	46	81	45
65–74	1000	21	18	40
75–84	1900	40	32	40
85+	1800	38	31	38
Women	5600	54	97	55
65–74	700	13	12	12
75–84	1900	34	32	33
85+	3000	54	53	55
Body region				
Traumatic brain injury	4700	46	82	46
Lower extremity	3300	32	60	34
Torso	800	8	13	7
Other head/neck	300	3	5	3
Other region†	600	6	9	5
Unspecified	600	6	10	6
Type of injury				
Fracture	4300	42	78	44
Internal organs	2900	28	52	29
Systemic/late effects	200	2	2	1
Superficial/contusions	100	1	1	0
Other type‡	100	1	1	1
Unspecified	2800	28	44	25

*Column totals may differ slightly due to rounding.
†Other region includes injuries of the upper extremity, vertebral column, spinal cord, and systemic/late effects.
‡Other type includes dislocation, strain/sprain, amputation, blood vessel, crushing, burns, and nerves.

For deaths that occurred in the hospital, we included the transport and C/ME costs plus the cost for an inpatient admission that resulted in a fatality, using the 2000 Healthcare Cost and Utilization Project–Nationwide Inpatient Sample (HCUP-NIS) file for those who died in the hospital. HCUP-NIS includes discharge abstracts for 7.45 million inpatient stays from approximately 1000 hospitals. For all inpatient facility estimates from HCUP-NIS, we first multiplied the estimates by cost-to-charge ratios provided by the Agency for Healthcare Research and Quality, and then adjusted for non-facility services—such as professional services used while in the hospital but not included in the admissions billing (for example, surgeon, anesthesia, physical therapy). (See Finkelstein *et al*[17] for a complete description of all adjustments.) For deaths that occurred in nursing homes, we included the transport and C/ME costs plus the adjusted HCUP-NIS cost for an acute care hospitalization with live discharge for those with the same injury diagnosis, plus the average cost of nursing home care computed from the 1999 National Nursing Home Survey.

Non-fatal falls

Non-fatal fall injury incidence included injuries that resulted in hospitalization with survival to discharge and injuries that received medical attention without hospitalization. The latter category included injuries that resulted in an ED visit, an office based visit, or a hospital outpatient visit. Fall injuries that did not receive medical attention were excluded from this analysis.

We estimated the incidence of non-fatal injuries that resulted in medical treatment using the 1999 Medical Expenditure Panel Survey (MEPS) for office based and outpatient visits. This is a nationally representative survey of the US civilian, non-institutionalized population that quantifies the use of health services for approximately 25 000 individuals. We used the 2000 HCUP-NIS for hospitalizations and included records that indicated a live discharge and an injury diagnosis in any of the first three diagnosis fields, and used the 2001 National Electronic Injury Surveillance System–All Injury Program (NEISS-AIP) for ED visits. NEISS-AIP collects detailed ED injury data from a nationally representative sample of 66 hospitals. MEPS, HCUP-NIS, and NEISS-AIP include weights that were applied to generate nationally representative estimates. We limited our sample to those aged ⩾65 years.

Non-fatal medical costs were based on claims data from 1998 and 1999 Medicare fee-for-service 5% Standard Analytical Files that covered services for about four million Medicare enrollees. The claims contained detailed payment information for all covered services for hospital inpatient, outpatient, skilled nursing, home health, hospice, physicians/supplier services, and durable medical equipment. Our sample was restricted to beneficiaries aged ⩾65 years. We excluded about 356 000 people (17%) who were enrolled in a Medicare HMO because Medicare does not collect information on the number, nature, or costs of their medical visits, as well as people who did not have complete coverage for both physician and hospital services for the full period of analysis. These exclusions assured that we had complete claims for the remaining sample. We further excluded anyone who had any injury related visit during the first three months of 1998 as these may have been for follow up treatment of injuries that occurred in 1997. Finally, we selected the fall related E-codes E880-E886, E888, E957, E968.1, and identified 22 514 beneficiaries in 1998 and 29 347 in 1999 who had sustained fall related injuries.

We used a case crossover approach (previously described elsewhere)[18] and compared the monthly costs in the 12 months before and in the 12 months after the fall. This approach is a modification of the matched case control design in which each case acts as his or her own control. Because the fallers comprised their own comparison group, it was not necessary to control for demographic characteristics or for the costs associated with treating coexisting health conditions.

Table 2 Incidence and costs of non-fatal fall injuries by sex, age, body region, and type of injury, US, 2000*

	Incidence (millions)†, n = 2.6	Incidence (%)	Cost (billions)†, n = $19	Cost (%)
Age (years)				
65–74	0.8	31	4	20
75–84	1.0	39	8	40
85+	0.8	31	8	40
Sex				
Men	0.8	31	5	26
65–74	0.3	38	1	27
75–84	0.3	38	2	45
85+	0.2	25	1	27
Women	1.8	69	14	74
65–74	0.5	28	3	17
75–84	0.7	39	6	39
85+	0.6	33	6	44
Body region				
Lower extremity	0.7	27	9	48
Upper extremity	0.7	27	3	13
Torso	0.4	15	3	13
Other head/neck	0.5	19	2	8
TBI	0.1	4	1	5
Other region‡	0.1	4	2	8
Unspecified	0.1	4	1	4
Type of injury				
Fracture	0.9	35	12	61
Superficial/contusion	0.8	31	3	17
Sprain/strain	0.4	15	1	6
Open wound	0.3	12	1	5
Internal organs	0.1	4	1	4
Dislocation	0.1	4	0	1
Other type§	0.0	0	1	6
Unspecified	0.0	0	0	1

*Column totals may differ slightly due to rounding.
†Incidence and cost totals may differ because some categorical estimates were based on small numbers.
‡Other region includes injuries of the upper extremity, vertebral column, spinal cord, and systemic/late effects.
§Other type includes amputation, blood vessel, crushing, burns, nerves, and systemic/late effects.

Each person had 24 observations, one for each month of the two-year period. We used a generalized linear regression model to estimate the monthly fall injury cost and summed the resulting estimates to compute costs for 12 months for those injured in the analysis year. We included a variance correction to account for clustering within individuals across months. Estimates were computed for total costs and costs stratified by age, sex, body region, and type of injury.

RESULTS

Fatal falls

There were nearly 10 300 fatal fall injuries in 2000 that incurred an estimated cost of $179 million. Both the incidence and medical costs increased with age and were nearly 20% higher for women than for men (table 1). The age specific costs differed for men and women. For people aged 65–74, men's costs were 44% higher than women's ($18 million *v* $12 million); for ages 75–84, costs for men and women were similar ($32 million *v* $32 million). For people aged 85 and older, men's costs remained essentially unchanged ($31 million) while women's costs increased 67% (to $53 million).

When analyzed by body region, traumatic brain injuries (TBI) and injuries of the lower extremities were the most frequent and costly injuries; these accounted for 78% of fatalities and 79% of costs. Two types of injuries, fractures and internal injuries, were responsible for 70% of fatal injuries and almost three quarters (73%) of injury costs. However, 25% of fatal injury costs were attributed to unspecified types of injuries.

The pattern for fatality *rates* differed from that seen for incidence and costs. For all three age groups, the rates for men exceeded those for women. Although rates for both men and women increased with age, the relative rate (RR = rate for men/rate for women) was highest for those aged 65–74 (RR = 1.8), somewhat lower for those aged 74–84 (RR = 1.5) and lowest for those aged ⩾85 (RR = 1.1).

Non-fatal falls

Non-fatal injury rates, like fatality rates, increased with age for both men and women. However, women's rates exceeded men's in each age group. The RR (rate for women/rate for men) was lowest for people aged 65–74 (RR = 1.3), somewhat higher for those aged 74–84 (RR = 1.5), and highest for people aged ⩾85 (RR = 1.9).

There were an estimated 2.6 million non-fatal fall injuries with a total annual cost of $19 billion (table 2). Although the incidence of non-fatal falls varied little by age, the costs doubled between ages 65–74 and 75–84 and then remained the same. Women made up 58% of older adults[19] while the incidence of fall injuries among women was 2.3 times higher and the cost was 2.8 times higher than for men. Among women, the incidence of injuries increased 40% from ages 65–74 to 75–84 (0.5 million to 0.7 million) while costs doubled ($3 billion to $6 billion.) However, from ages 75–84 to ages ⩾85, the incidence of fall injuries *decreased* 14% (from 0.7 million to 0.6 million) while costs did not change. In contrast, men had no increase in incidence from ages 65–74 to 75–84 (0.3 million for both age groups) although costs doubled (from $1 billion to $2 billion.) From ages 75–84 to ages ⩾85, both the incidence and costs decreased.

The most frequent non-fatal injuries were those to the lower and upper extremities. Although the number of injuries was similar, lower extremity injuries accounted for almost half (48%) of direct medical costs while injuries of the upper extremities were responsible for 13%. Fractures were both the most frequent and expensive type of injury—accounting for

Table 3 Costs (in billions) of nonfatal fall injuries by sex, body region, and type of injury, by treatment setting, US, 2000*

	Hospital ($12†)	Cost (%)	Emergency department ($4†)	Cost (%)	Outpatient & MD's office ($3†)	Cost (%)
Age (years)						
65–74	2	19	0.9	21	1	25
75–84	5	42	1.5	36	1	38
85+	5	39	1.8	43	1	38
Sex						
Men	3	25	1	25	1	32
Women	9	75	3	76	2	67
Body region						
Lower extremity	8	62	1	20	1	28
Upper extremity	1	8	1	24	1	25
Torso	1	9	1	27	0	9
Other head/neck	1	7	0	10	0	9
TBI	1	5	0	7	0	0
Vertebral column	1	4	0	0	0	9
Other region‡	1	4	0	10	0	3
Unspecified	1	1	0	2	1	16
Type of injury						
Fracture	10	80	1	27	1	32
Superficial/contusion	1	7	1	34	1	29
Sprain/strain	0	2	0	10	1	19
Open wound	0	3	1	12	0	3
Internal organs	1	5	0	7	0	0
Dislocation	0	1	0	2	0	3
Other type§	0	1	0	0	0	13
Unspecified	0	2	0	7	0	0

*Column totals may differ slightly due to rounding.
†Cost totals may differ because some categorical estimates were based on small numbers.
‡Other region includes injuries of the upper extremity, vertebral column, spinal cord, and systemic/late effects.
§Other type includes amputation, blood vessel, crushing, burns, nerves, and systemic/late effects.

just over a third of all non-fatal injuries and 61% of costs. The second most frequent type was superficial injuries/contusions. Fractures and superficial injuries combined were responsible for three quarters of non-fatal fall injury costs.

Medical costs varied by treatment setting (table 3). Hospitalized injuries were the most costly, followed by injuries treated in EDs and in outpatient settings (outpatient clinics and doctors' offices). The highest percentage of hospitalization costs was for people aged 75–84; the highest percentage of ED treatment costs was for people aged ⩾85. Direct medical expenditures for women, who made up 58% of the older population, were 2–3 times higher than for men for all treatment settings. Women aged ⩾85 accounted for 6% of the older population and incurred 33% of the total fall injury costs.

When examined by body region, lower extremity injuries were responsible for the majority (62%) of hospitalization costs and the largest proportion (28%) of outpatient costs. In contrast, injuries to the torso and upper extremities were the most costly injuries treated in EDs. Among the different types of injuries, fractures accounted for 80% of hospitalization costs and almost a third of outpatient costs while superficial injuries/contusions were responsible for about a third of ED costs.

DISCUSSION

This study provides national estimates of the incidence and direct medical costs associated with fall related injuries among adults aged ⩾65 in the United States. In 2000, there were 10 300 fatal and 2.6 million non-fatal fall related injuries. Estimated direct medical costs for these injuries totaled $0.2 billion dollars for fatal and $19 billion dollars for non-fatal falls. By comparison, largely omitting nursing home costs and looking just at the medical costs traceable directly to falls without fully capturing the costs of complications using the case crossover method, Finkelstein *et al*[16] estimated medical costs at $12.8 billion for the same cases analyzed here. One study found that 12% of older adults who fell subsequently required long term nursing home care.[20] Hip fractures are especially traumatic. Older adults who survive hip fracture often experience significant disability and loss of independence.[21 22] After hospitalization, many hip fracture patients are discharged to nursing homes where up to 25% of these formerly independent older adults remain for at least a year.[23]

Our findings are more similar to those reported by Englander and colleagues[15] who estimated the direct costs of falls in the US in 1994 was $21 billion (in year 2000 dollars). A recent study using 1997 MEPS data estimated the cost of fall related injuries among non-institutionalized older adults was $6.9 billion (in year 2000 dollars).[24] This analysis, based on a sample of 4000 seniors, used self-reported falls data which often are underestimated.[25] In addition, this study excluded hospital patients and nursing home residents who are at much higher risk of sustaining fall related injuries than are community dwelling seniors.[26]

International studies underscore the substantial economic burden caused by fall related injuries, regardless of the medical care system. A recent study reported that, in 1999, ED and hospital care for fall related injuries among people aged ⩾60 cost the United Kingdom almost £1 billion (US$1.9 billion)[3] A Western Australia study estimated ED treated and hospitalized fall injuries among people aged ⩾65 cost the Australian healthcare system $86.4 million (US$66.1 million)[9]

Cost estimates differed by treatment settings. Of the direct medical costs for non-fatal injuries, almost two thirds were for injuries that required hospitalization, one fifth for injuries treated in EDs, and one eighth for injuries treated in outpatient settings. Twelve billion dollars, or 61%, was for treatment of fractures. This is similar to a study that used 1999 Medicare claims data and found that 67% of injury

claims were for fractures.[27] These injuries accounted for 80% of hospitalization costs, 27% of ED costs, and 32% of outpatient costs.

Medical expenditures for women, who made up 58% of the older population,[19] were 2–3 times higher than for men for all treatment settings. It is likely that this difference represented treatment costs for osteoporotic fractures, principally hip fractures. Osteoporosis is a metabolic disease that causes bones to become porous and susceptible to fracture and it disproportionably affects older women.[28] Women sustain hip fractures at a significantly higher rate than men[29 30] and treatment typically includes surgery and hospitalization, frequently followed by nursing home admission and extensive rehabilitation.[31] Although we could not identify specific kinds of fractures (the type of fracture is incompletely coded for fatalities and ICD-9 coding is not included in NEISS-AIP), a 1995 study found that 63% of direct medical expenditures for osteoporotic fractures were for hip fractures.[32]

Falls are the most common mechanism of TBI[33] and are the leading cause of hospital admissions for TBI.[34] If a fall related head injury occurs, older adults are particularly susceptible to intracranial hemorrhage, especially if they are taking anticoagulants.[35] TBI accounted for almost half of fatal falls and associated costs. Fatality rates from TBI are highest among the oldest old, those aged ⩾85.[36] To reduce these serious and often fatal injuries, it is essential that we implement fall interventions.

Injuries to internal organs were responsible for 28% of deaths and 29% of medical costs for fatal falls. The high prevalence of this type of fall related injury has not been reported previously. Additional research is needed to clarify why older adults are at risk of dying from these types of injuries and how such fatalities could be prevented.

Although the estimated economic impact is substantial, direct medical costs do not fully portray the financial burden of fall related injuries. Our data did not permit us to estimate the costs associated with lost wages and housework for the injured or their informal caregivers, or for non-medical expenditures (for example, wheelchair ramps), insurance claims processing costs, reduced quality of life, and decreased functional capacity of many older adults who sustained fall related injuries.

This analysis has a number of limitations. We derived the incidence and cost estimates from different data sources which adds uncertainty to the total cost estimates. This was necessary because no single nationally representative data set would allow us to estimate detailed fatal and non-fatal incidence and costs. For example, Medicare data exclude those in Medicare HMOs and therefore could not be used to estimate injury incidence. Our analysis quantified costs for 12 months post injury. However, without additional analyses we could not identify which services were responsible for the increase in costs. Finally, most of the data sources were subject to some reporting and measurement errors which increased the lack of precision around the estimates, may have introduced some additional bias, and precluded computation of standard errors.

The magnitude of this economic burden underscores the need to implement cost effective intervention strategies. A recent meta-analysis of the intervention literature found that fall prevention programs, analyzed as a group, effectively reduced the risk of falling by 11%,[37] and a systematic review reported that multicomponent interventions for community dwelling seniors reduced fall risk 27%.[38] Among people at high risk (for example, those who have fallen at least once before), clinical assessment combined with individualized fall risk reduction and patient follow up was effective, lowering the risk of falling by 18%.[37]

Key points

- Direct medical care costs totaled $0.2 billion for fatal and $19 billion for non-fatal fall related injuries among people aged ⩾65.
- Medical expenditures for women, who made up 58% of the older adult population, were 2–3 times higher than for men for all medical treatment settings.
- Fractures were both the most frequent and most expensive type of non-fatal injury.
- The economic burden of fall related injuries underscores the need for effective interventions.

Among community dwelling older adults, the risk of falling is 3–4 times higher among people with muscle weakness or gait and balance disorders.[39 40] The most effective single intervention was exercise which, overall, lowered the risk of falling between 12%[37] and 20%.[38] Types of effective exercises included Tai Chi,[41 42] balance and gait training, and strength building.[43–45]

Because falls are frequently the result of interactions between individuals and their environments, effective multicomponent interventions generally address multiple risk factors.[46] These might include risk factor screening; exercise or physical therapy to improve gait, balance and strength; medication management (which involves reducing the number of medications, especially psychoactive medications); education about fall risk factors; referrals to healthcare providers for treatment of chronic conditions; vision assessment and correction; and home hazard reduction.[47–51]

Implications for prevention

Our results show that fall related injuries among older adults, especially among older women, are associated with substantial economic costs that are borne by individuals, society, and the medical care system. Although research has identified interventions that can reduce fall related injuries, implementation remains limited. Additional efforts are needed to successfully disseminate cost effective fall prevention programs, and to promote widespread adoption at the local level. By employing effective interventions, we can appreciably decrease the incidence of fall related injuries, improve the health and quality of life of older adults, and significantly reduce healthcare costs.

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