Incidence and costs of injuries to children and adults in the United States

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Abstract

Background: Injuries are a leading cause of death and acquired disability, and result in significant medical spending. Prior estimates of injury-related cost have been limited by older data, for certain population, or specific mechanisms.

Findings: This study estimated the incidence of hospital-treated nonfatal injuries in the United States (US) in 2013 and the related comprehensive costs. Injury-related emergency department (ED) visits and hospitalizations were identified using 2013 Healthcare Cost and Utilization Project (HCUP) data. Models estimated the costs of medical spending and lost future work due to injuries in 2013 U.S. dollars. A total of 31,038,072 nonfatal injury-related hospitalizations and ED visits were identified, representing 9.8 per 100 people. Hospital-treated nonfatal injuries cost an estimated $1.853 trillion, including $168 billion in medical spending, $223 billion in work losses, and $1.461 trillion in quality of life losses.

Conclusions: Approximately one in 10 individuals in the US is treated in the hospital for injury each year, with high corresponding costs. These data support priority-setting to reduce the injury burden in the US.

Background

Injuries are a leading cause of death and acquired disability in children and adults, and result in significant medical spending nationwide. Prior estimates of injury-related cost have been from much older data (Danseco et al. 2000; Miller et al. 2000; Corso et al. 2006), for certain populations (e.g., children (Miller et al. 2000; Zaloshnja et al. 2012; Roy et al. 2008), Medicaid recipients (Roy et al. 2008)), for certain mechanisms (e.g., consumer products (Lawrence and Miller, 2014), agricultural (Zaloshnja et al. 2012)), or for cost totals that only include medical care (Dieleman et al. 2016). This study provides contemporary national estimates of the incidence of hospital-treated nonfatal injuries for children and adults in the United States in 2013 and the related comprehensive costs by age, household income, payer, metropolitan residence, disposition, injury severity score, injury mechanism and injury intent. While incidence describes the magnitude of the problem, costs provide a better measure of burden by accounting for multiple injury consequences – e.g., severity, disability – in a single unit of measurement.

Methods

Injury-related emergency department (ED) visits and hospitalizations were identified using 2013 Healthcare Cost and Utilization Project (HCUP) sample-based ED (Agency for Healthcare Research and Quality (AHRQ), n.d.) and inpatient (Agency for Healthcare Research and Quality (AHRQ), n.d.) datasets. This study used deidentified administrative data and was exempt from review by our institution. Injuries were defined as diagnoses 800–995 in the International Classification of Diseases, Ninth Revision, excluding late effects, 905–909. We used the standard external-cause matrix from the Centers for Disease Control and Prevention. (Centers for Disease Control and Prevention (CDC), n.d.-a; Centers for Disease Control and Prevention (CDC), n.d.-b).

We applied an established US injury cost model to the HCUP datasets to estimate the costs of injuries in 2013 U.S. dollars (Lawrence et al. 2015; Spicer et al. 2011). The Agency for Healthcare Research and Quality (AHRQ) weights HCUP Nationwide Emergency Department Sample (NEDS) and Nationwide Inpatient Sample (NIS) data to provide national estimates. 2014 NEDS
estimates are based on sampling non-admitted cases from all EDs in 34 states. 2014 NIS estimates are based on a one-in-five random sample of inpatient discharges from every hospital in 44 states and the District of Columbia. (Agency for Healthcare Research and Quality, n.d. Agency for Healthcare Research and Quality (AHRQ), n.d.). Costs include medical spending and lost future work. In addition, we take a societal perspective by including the estimated value of lost quality of life. Medical spending

Table 1 Cost of Hospital-Treated Nonfatal Injuries in the United States, 2013 (2013 United States $)

| Number Medical | Work Loss | Quality of Life | Total Cost | Total Cost per Injury |
|----------------|-----------|----------------|------------|----------------------|
| 31,038,072 | $167,968,253,878 | $223,116,101,911 | $1,461,482,900,000 | $1,852,567,255,789 |
| Age Group | | | | |
| < 1 | 261,308 | $1,432,470,125 | $1,789,973,631 | $22,287,154,385 | $25,509,598,141 |
| 1–11 | 4,447,463 | $12,032,484,055 | $18,626,763,126 | $181,322,230,105 | $211,981,477,286 |
| 12–17 | 2,823,241 | $8,816,169,603 | $13,443,289,763 | $145,256,948,411 | $167,516,407,777 |
| 18–24 | 3,773,148 | $13,600,427,953 | $23,698,584,864 | $186,399,030,940 | $223,698,043,757 |
| 25–34 | 4,442,848 | $17,457,020,563 | $36,742,723,349 | $205,840,515,715 | $260,040,259,627 |
| 35–44 | 3,711,266 | $15,005,365,402 | $34,704,621,851 | $150,463,641,515 | $200,173,628,768 |
| 45–64 | 6,458,720 | $40,319,428,609 | $65,703,484,864 | $186,399,030,940 | $223,698,043,757 |
| 65+ | 4,800,513 | $59,285,698,881 | $28,387,430,398 | $255,529,916,815 | $343,203,046,094 |
| Household Income Quartile | | | | |
| 0-25th percentile | 9,572,854 | $47,498,738,599 | $67,315,490,069 | $419,419,736,702 | $534,233,965,370 |
| 26th–50th percentile | 8,347,113 | $43,448,674,708 | $57,933,681,503 | $380,949,318,832 | $482,331,675,043 |
| 31st-75th percentile | 6,923,897 | $39,294,070,461 | $50,758,794,647 | $339,582,090,153 | $429,634,955,261 |
| 76th–100th percentile | 5,533,774 | $33,659,639,931 | $40,997,146,789 | $284,762,942,717 | $359,419,729,437 |
| Payer | | | | |
| Medicare | 5,599,892 | $62,116,899,402 | $40,517,276,172 | $297,763,145,616 | $400,397,321,190 |
| Medicaid | 7,429,391 | $29,171,568,219 | $45,103,953,532 | $314,054,136,094 | $388,329,657,845 |
| Other | 15,231,785 | $64,317,973,204 | $113,654,085,383 | $712,228,646,085 | $890,200,704,672 |
| Private/Commercial/PPO/HMO | 2,776,540 | $12,348,412,934 | $23,823,408,746 | $137,372,720,655 | $173,544,542,335 |
| Rural/Urban | | | | |
| Urban | 24,549,308 | $134,880,605,547 | $179,608,748,796 | $1,164,443,500,000 | $1,478,932,854,343 |
| Rural | 6,292,866 | $31,930,197,067 | $41,617,830,131 | $286,073,751,174 | $359,621,782,382 |
| Disposition | | | | |
| Treated and Released | 28,387,504 | $66,949,430,931 | $86,132,322,982 | $788,923,246,256 | $942,005,100,222 |
| Admitted | 2,650,568 | $101,018,722,894 | $136,983,778,903 | $725,559,644,444 | $910,562,146,268 |
| Injury Severity Score (ISS) | | | | |
| 0 | 4,007,518 | $23,294,466,781 | $9,224,703,223 | $78,422,515,363 | $110,941,685,367 |
| < 5 | 23,472,855 | $81,231,568,219 | $125,971,348,386 | $797,810,907,004 | $1,005,014,226,462 |
| 5–14 | 1,533,316 | $30,493,165,675 | $36,049,311,657 | $287,923,572,318 | $355,177,764,843 |
| > 15 | 2,024,383 | $32,237,139,158 | $51,870,738,645 | $297,325,896,016 | $381,433,773,819 |
| Region | | | | |
| Northeast | 486,635 | $18,095,855,894 | $24,900,562,684 | $119,160,902,927 | $161,347,321,505 |
| Midwest | 601,215 | $21,755,142,226 | $29,756,502,527 | $144,786,266,911 | $196,239,911,664 |
| South | 1,027,654 | $36,344,852,910 | $52,530,343,991 | $258,276,688,480 | $347,151,885,381 |
| West | 535,064 | $24,862,871,864 | $30,606,369,728 | $150,353,786,126 | $205,823,027,718 |
| Hospital Type | | | | |
| Nonteaching | 11,451,866 | $26,985,059,893 | $34,347,299,866 | $311,700,719,574 | $373,033,079,333 |
| Teaching | 11,244,316 | $26,914,053,295 | $35,054,247,432 | $316,475,541,375 | $378,443,842,102 |

(2013 United States $)}
## Table 2 Cost of Hospital-Treated Nonfatal Injuries in the United States by Mechanism, 2013 (2013 United States $)

| Mechanism               | Number Medical | Medical Work Loss | Quality of Life | Total | Total Cost per Injury |
|------------------------|----------------|-------------------|-----------------|-------|-----------------------|
| **UNINTENTIONAL INJURIES** |                |                   |                 |       |                       |
| Cut/pierce             | 1,912,149      | $3,631,594,141    | $4,922,277,919  | $28,292,232,329 | $36,846,104,389 |
| Drowning/submersion    | 9762           | $167,765,380      | $585,909,962    | $2,699,855,258  | $3,453,521,600  |
| Fall                   | 8,810,752      | $64,201,479,065   | $72,918,304,289 | $505,230,956,245 | $642,350,739,599 |
| Fire/flame             | 80,131         | $754,650,203      | $728,172,630    | $5,538,602,465  | $7,021,425,298  |
| Hot object/substance   | 292,856        | $988,725,136      | $1,708,949,240  | $12,359,395,079 | $15,057,069,455 |
| Firearm                | 35,858         | $358,159,858      | $703,471,847    | $2,983,640,338  | $4,045,272,043  |
| Machinery              | 113,545        | $44,119,276       | $1,864,062,780  | $10,644,611,515 | $13,034,793,571 |
| MVT Occupant           | 2,498,200      | $13,763,057,426   | $22,257,335,570 | $97,781,307,804 | $133,801,600,800|
| MVT Motorcyclist       | 157,995        | $2,736,135,308    | $5,580,436,675  | $21,245,276,186 | $29,561,848,169 |
| MVT Pedestrian         | 137,296        | $2,181,788,505    | $16,715,035,234 | $22,444,966,640 | $66,747,098,169 |
| MVT Unspecified        | 219,970        | $1,053,152,143    | $1,820,906,676  | $9,972,036,013  | $12,846,094,832 |
| Pedal cyclist, other   | 324,071        | $1,476,820,932    | $3,263,738,075  | $20,108,440,875 | $24,848,999,882 |
| Pedestrian, other      | 19,026         | $169,750,289      | $289,186,145    | $1,884,173,134  | $2,343,109,568  |
| Transport, other       | 294,317        | $2,358,186,236    | $5,066,645,020  | $29,023,314,277 | $36,448,145,533 |
| Bites and stings       | 1,234,452      | $2,547,309,358    | $2,869,717,927  | $27,803,209,134 | $33,220,236,419 |
| Other natural/environmental | 178,925    | $1,168,724,588    | $2,035,124,771  | $5,323,753,810  | $7,405,806,472  |
| Overexertion           | 2,335,656      | $6,555,552,120    | $10,283,916,364 | $65,455,667,267 | $82,295,135,751 |
| Poisoning              | 469,441        | $2,957,904,882    | $836,596,717    | $19,797,098,590 | $23,591,600,189 |
| Struck by/against      | 3,724,620      | $8,646,126,741    | $14,196,566,363 | $142,802,749,122 | $165,645,442,226|
| Suffocation            | 37,714         | $2,035,124,771    | $5,323,753,810  | $27,803,209,134 | $33,220,236,419 |
| Other spec & classification | 1,108,881 | $4,457,686,594    | $6,606,013,305  | $34,468,145,533 | $7,405,806,472  |
| Other specified, NEC   | 679,383        | $2,473,750,166    | $3,703,018,649  | $23,320,236,419 | $29,489,752,622 |
| Unspecified            | 2,116,751      | $9,391,792,223    | $12,521,017,713 | $60,497,266,532 | $82,410,076,468 |
| **SELF-HARM INJURIES**  |                |                   |                 |       |                       |
| Cut/pierce             | 104,661        | $555,649,912      | $1,526,402,750  | $5,323,753,810  | $7,405,806,472  |
| Drowning/submersion    | 265            | $3,418,777        | $21,334,930     | $76,901,789    | $101,655,496    |
| Fall                   | 2377           | $1,283,916,364    | $674,562,123    | $1,024,919,875  | $1,413,271,781  |
| Poisoning              | 469,441        | $2,957,904,882    | $836,596,717    | $19,797,098,590 | $23,591,600,189 |
| Struck by/against      | 3,724,620      | $8,646,126,741    | $14,196,566,363 | $142,802,749,122 | $165,645,442,226|
| Suffocation            | 37,714         | $2,035,124,771    | $5,323,753,810  | $27,803,209,134 | $33,220,236,419 |
| Other specified, NEC   | 679,383        | $2,473,750,166    | $3,703,018,649  | $23,320,236,419 | $29,489,752,622 |
| Unspecified            | 2,116,751      | $9,391,792,223    | $12,521,017,713 | $60,497,266,532 | $82,410,076,468 |
| **ASSAULT**            |                |                   |                 |       |                       |
| Cut/pierce             | 73,932         | $491,701,003      | $1,138,106,551  | $5,476,377,890  | $7,106,185,444  |
| Drowning/submersion    | 69             | $642,802          | $1,964,335      | $7,164,047     | $9,771,184      |
| Fall                   | 1646           | $12,022,160       | $37,569,063     | $169,630,025   | $219,221,249    |
| Number | Medical | Work Loss | Quality of Life | Total | Total Cost per Injury |
|--------|---------|-----------|----------------|-------|----------------------|
| Fire/flame | 595 | $3,858,466 | $9,261,217 | $69,978,211 | $83,097,894 | $139,678 |
| Hot object/substance | 1962 | $15,993,005 | $17,535,750 | $153,556,467 | $187,085,222 | $95,368 |
| Firearm | 30,131 | $927,098,739 | $1,530,254,784 | $6,968,840,319 | $9,426,193,842 | $312,844 |
| MVT Occupant | 1660 | $6,798,022 | $12,494,180 | $130,515,813 | $149,808,015 | $90,225 |
| Poisoning | 176 | $7,901,485 | $2,498,250 | $73,345,138 | $84,265,501 | $141,740 |
| Struck by/against | 611,218 | $2,512,923,350 | $6,795,903,883 | $56,416,139,291 | $65,724,966,524 | $107,531 |
| Suffocation | 3006 | $10,208,810 | $27,416,530 | $127,393,050 | $165,018,390 | $54,888 |
| Other specified & classifiable | 119,372 | $604,801,671 | $1,005,672,954 | $7,496,925,042 | $9,107,399,667 | $76,294 |
| Other specified, NEC | 165,835 | $571,842,316 | $1,014,664,619 | $11,060,805,689 | $12,647,312,624 | $76,265 |
| Unspecified | 169,769 | $879,584,274 | $2,260,749,692 | $17,139,072,436 | $20,279,406,402 | $119,453 |
| **UNDETERMINED INTENT** | | | | | | |
| Cut/pierce | 3731 | $13,136,329 | $31,468,294 | $124,000,521 | $168,605,144 | $45,196 |
| Drowning/submersion | 233 | $912,250 | $8,301,876 | $31,576,211 | $40,790,337 | $175,501 |
| Fall | 3950 | $398,026 | $99,196,652 | $333,040,805 | $472,040,417 | $119,510 |
| Fire/flame | 2913 | $15,518,883 | $31,234,477 | $242,655,585 | $289,408,944 | $99,345 |
| Hot object/substance | 595 | $3,699,041 | $7,221,322 | $73,345,138 | $84,265,501 | $141,740 |
| Firearm | 4014 | $74,095,787 | $129,946,857 | $546,583,710 | $650,526,354 | $186,991 |
| MVT Other | 459 | $3,147,206 | $6,780,905 | $22,866,321 | $32,605,003 | $85,342 |
| Other natural/environmental | 2703 | $58,901,837 | $45,949,242 | $145,873,538 | $250,724,617 | $92,761 |
| Poisoning | 126,707 | $892,799,765 | $326,704,590 | $5,843,044,484 | $7,062,487,393 | $55,379 |
| Suffocation | 267 | $1,684,991 | $9,729,591 | $19,495,093 | $31,019,675 | $117,601 |
| Other specified & classifiable | 463 | $4,000,582 | $8,221,322 | $43,121,482 | $56,939,727 | $122,885 |
| Other specified, NEC | 14,025 | $64,785,622 | $98,439,086 | $539,613,549 | $702,838,257 | $50,114 |
| Unspecified | 76,146 | $313,398,577 | $320,997,827 | $2,566,738,535 | $3,201,134,939 | $42,039 |
| **LEGAL INTERVENTION** | | | | | | |
| Cut/pierce | 1449 | $3,102,948 | $6,635,734 | $22,866,321 | $32,605,003 | $22,502 |
| Firearm | 1383 | $41,617,599 | $57,218,311 | $234,236,902 | $333,072,812 | $240,832 |
| Poisoning | 349 | $645,957 | $336,617 | $13,470,021 | $14,552,045 | $41,469 |
| Struck by/against | 41,824 | $127,374,328 | $266,063,345 | $1,325,708,220 | $1,719,145,893 | $41,104 |
| Other specified & classifiable | 1174 | $9,406,164 | $8,221,940 | $41,502,028 | $59,103,012 | $50,375 |
| Other specified, NEC | 121 | $1,064,568 | $2,915,549 | $9,994,667 | $13,974,784 | $115,142 |
| Unspecified | 6937 | $20,238,437 | $42,810,948 | $214,315,994 | $277,365,380 | $39,984 |
| **UNSPECIFIED INTENT** | | | | | | |
| Drowning/submersion | 443 | $27,326,952 | $54,731,485 | $204,710,316 | $286,768,754 | $646,970 |
| Other natural/environmental | 49,694 | $686,083,672 | $522,349,852 | $2,757,831,073 | $3,966,264,597 | $79,814 |
| Poisoning | 81,013 | $677,091,885 | $163,997,422 | $4,002,093,054 | $4,843,182,361 | $59,783 |
| Suffocation | 28327 | $1,760,326,274 | $379,312,268 | $1,302,485,774 | $3,442,124,316 | $121,514 |
| Other specified & classifiable | 57,020 | $351,856,081 | $246,844,436 | $698,824,829 | $1,297,525,346 | $22,756 |
| Unspecified | 2,499,592 | $18,048,042,991 | $24,246,394,615 | $139,111,309,043 | $181,405,746,649 | $72,574 |

*Deaths due to injuries inflicted by police or other law enforcement agents*
includes hospital and professional services, emergency transport, rehabilitation, prescriptions, home health care, and medical equipment. Lost future work includes future value of work that patients would be unable to do if they were killed or permanently disabled. Future costs were stated in present value using a 3% discount rate. (Lawrence and Miller 2014). We valued quality of life lost with a widely published value of $152,733 per quality-adjusted life year, net of work loss (Miller and Hendrie, 2013). We used the same value per QALY of present-value life expectancy for all people. Because life-expectancy varies by age and sex, the total QALY loss to a death or permanently disabling injury also does.

Results
Incidence
A total of 31,038,072 nonfatal injury-related hospitalizations and ED visits were identified in 2013 (Table 1). This represents 9.8 per 100 people.

Costs
Hospital-treated nonfatal injuries in 2013 cost an estimated $1.853 trillion, including $168 billion in medical spending, $223 billion in work losses, and quality of life losses valued at $1.461 trillion (Table 1). The total estimated cost per injury was approximately $59,700, including approximately $2400 in medical spending, $7200 in lost future work and $47,100 in quality of life losses. The total costs per injury were highest for the oldest and youngest age groups; individuals < 1 year old ($97,623) and 65 years and older ($71,493). Total cost per injury was slightly higher for those with Medicare and Medicaid versus those with commercial insurance or other payer types. While 91.5% of patients with injuries were discharged, this represented only 8.8% of costs. In contrast, the 8.5% of patients admitted represented 91.2% of costs.

Falls and struck by/against injuries contributed to 35% of nonfatal injury costs (Table 2) and were the leading causes in all age groups (results not shown). The most severe and debilitating injuries will result in higher costs. Among hospital-treated nonfatal injuries, near-drownings, self-harm, and firearm-related violence are the most costly. The external cause of injury was not coded for cases accounting for 9% of total injury costs.

Discussion
Approximately one in 10 individuals in the United States is injured each year are treated in a hospital, with high corresponding costs. Our calculated rate of 9.8 injuries per 100 people in 2013 is nearly half that of the 18.135 injuries per 100 population estimate by Corso et al. based on data from 2000. (Corso et al. 2006) While a prior study of US spending on personal health care found that injuries accounted for $168 billion (8%) of the $2.1 trillion in medical spending in 2013, our comprehensive injury medical spending estimate exceeds that, even while excluding the 12 million injuries treated in physician’s offices and clinics. (Dieleman et al. 2016) Limitations of the study include the absence of outpatient and ambulatory data, as well as the possibility of misclassification based on ICD codes.

These cost data from 2013 support priority-setting and selection of interventions to reduce the burden of injury in the United States.

Abbreviations
ED: Emergency department; HCUP: Healthcare Cost and Utilization Project; MVT: Motor vehicle traffic; NEC: Not otherwise classifiable

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Availability of data and materials
Please contact author for data requests.

Authors’ contributions
This study was designed by MRZ, RSS, and TRM. Data analysis and collection was done, or supervised, by MRZ, RSS, BAL, TRM. Data interpretation and manuscript preparation were done by MRZ, RSS, BAL, TRM. All authors made significant contributions to drafting and critical revision of the manuscript and approved the final version.

Ethics approval and consent to participate
The study was not human subjects research and was exempt from review. Consent to participate not applicable.

Competing interests
The authors declare that they have no competing interests.

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