

A decade of hospital costs for firearm injuries in the United States by region, 2005–2015: government healthcare costs and firearm policies

Sarabeth A Spitzer,^{1,2} Joseph D Forrester,³ Lakshika Tennakoon,³ David A Spain,³ Thomas G Weiser³

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¹Department of Surgery, Brigham and Women's Hospital, Boston, Massachusetts, USA

²Center for Surgery and Public Health, Boston, MA, USA

³Department of Surgery, Stanford University, Stanford, California, USA

Correspondence to

Dr Sarabeth A Spitzer; sspitzer@bwh.harvard.edu

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ABSTRACT

Background Firearm injuries are a costly, national public health emergency, and government-sponsored programs frequently pay these hospital costs.

Understanding regional differences in firearm injury burden may be useful for crafting appropriate policies, especially with widely varying state gun laws.

Objective To estimate the volume of, and hospital costs for, fatal and non-fatal firearm injuries from 2005 to 2015 for each region of the United States and analyze the proportionate cost by payer status.

Methods We used the Healthcare Cost and Utilization Project Nationwide Inpatient Sample to identify patients admitted for firearm-related injuries from 2005 to 2015. We converted hospitalization charges to costs, which were inflation-adjusted to 2015 dollars. We used survey weights to create regional estimates. We used the Brady Gun Law to determine significance between firearm restrictiveness and firearm hospitalizations by region.

Results There were a total of 317 479 firearm related admissions over the study period: 52 829 (16.66%), 66 671 (21.0%), 134 008 (42.2%), and 63 972 (20.2%) for the Northeast, Midwest, South, and West respectively, demonstrating high regional variability. In the Northeast, hospital costs were \$1.98 billion (13.9% of total), of which 56.0% was covered by government payers; for the Midwest, costs were \$1.53 billion (19.7% of total), 40.4% of which was covered by government payers; in the South costs were highest at \$3.2 billion (41.4% of total), but government payers only covered 34.3%; and costs for the West were \$1.94 billion (25.0% of total), with government programs covering 41.6% of the cost burden.

Conclusions Hospital admissions and costs for firearm injuries demonstrated wide variation by region, suggesting opportunities for financial savings. As government insurance programs cover 41.5% of costs, tax dollars heavily subsidize the financial burden of firearm injuries and cost recovery options for treating residents injured by firearms should be considered. Injury control strategies have not been well applied to this national public health crisis.

Level of evidence Level II, Economic and Value Based Evaluation

BACKGROUND

Firearm-related injuries are an important and preventable public health problem in the United States. The US has the highest rate of firearm homicides among developed countries, 25 times higher

than that of comparable countries. Over the last decade, 82% of all individuals killed by firearms in high-income countries were in the United States.¹ Currently, age-adjusted rates of firearm fatalities exceed rates of motor vehicle-related fatalities.²

Direct and indirect costs of firearm violence have been estimated at \$229 billion annually; lifetime medical costs of firearm injuries were estimated at \$3.3 billion in 2000.^{3,4} Hospitalization costs alone for treating firearm-related injuries within the first 6 months have been calculated at a billion dollars a year, with per-patient average cost of \$32 700.^{5–7}

Costs are affected by specific policies related to firearm access and availability. Policies vary by state although effects can often be seen in neighboring states.⁸ As a result, these policies probably result in different regional medical costs and financial responsibility within the USA. We aimed to assess regional costs of hospitalizations for firearm injuries over the past decade and determine the proportion of medical coverage afforded by government (both state and federal payers) through Medicare and Medicaid schemes. Costs borne by state and federal insurance coverage can inform gun policy on both a regional and national level.

METHODS

Data sources

We used the Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample (NIS) from the Agency for Healthcare Research and Quality for 2005 to 2015.⁹ We chose these years as NIS coding practices were different prior to 2005, and in 2016 NIS moved to the International Classification of Diseases, 10th revision coding system. With 8 million discharges a year, NIS is the largest inpatient care database in the USA and contains a stratified sample of non-federal, short-term, and general specialty hospitals; it also provides sample weights that allow national estimates to be derived. However, while NIS provides geographic region, it does not provide state-level details, thus all results could be reported only at the regional level—Northeast, South, Midwest, West.

We identified admissions caused by firearm-related injuries using the International Classification of Diseases, ninth Revision, Clinical Modification (ICD-9-CM) codes.¹⁰ We included patients if they had an ICD-9-CM diagnosis code of E922.0–0.3, 0.8, 0.9, E955.0–0.4, E965.0–4,

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Table 1 Demographics by hospital region

Demographics	Northeast	Midwest	South	West	Total
Total Firearm Injury	52 829 (16.6)	66 671 (21.0)	134 008 (42.2)	63 972 (20.2)	317 479
Sex					
Male	48 546 (91.9)	59 364 (89)	117 517 (87.8)	55 756 (89.7)	281 183 (89.1)
Female	4264 (8.1)	7313 (11)	16 359 (12.2)	6422 (10.3)	34 358 (10.9)
Total	52 810 (100)	66 677 (100)	133 876 (100)	62 178 (100)	315 539 (100)
PAYCLUMP					
Medicare	2215 (4.2)	3967 (5.9)	9649 (7.2)	2835 (4.4)	18 666 (5.9)
Medicaid	25 070 (47.5)	19 096 (28.6)	28 602 (21.3)	21 917 (34.3)	94 685 (29.8)
Private insurance	9501 (18)	16 659 (25)	29 392 (21.9)	12 786 (20)	68 338 (21.5)
Self-pay	12 212 (23.1)	19 735 (29.6)	45 394 (33.9)	15 022 (23.5)	92 362 (29.1)
Other pay	3827 (7.2)	7225 (10.8)	20 957 (15.6)	11 420 (17.8)	43 429 (13.7)
Total	52 825 (100)	66 682 (100)	133 994 (100)	63 978(100)	317 480 (100)
Race (uniform)					
White	8287 (16.2)	12 332 (27.8)	40 522 (33.5)	14 964 (26.6)	76 105 (27.9)
Black	33 067 (64.6)	27 184 (61.4)	61 451 (50.8)	13 452 (23.9)	135 154 (49.5)
Hispanic	6661 (13)	2998 (6.8)	13 744 (11.4)	23 775 (42.2)	47 178 (17.3)
Asian Pacific	318 (0.6)	211 (0.5)	794 (0.7)	1571 (2.8)	2894 (1.1)
Native American	73 (0.1)	174 (0.4)	898 (0.7)	819 (1.5)	1964 (0.7)
Other	2794 (5.5)	1387 (3.1)	3527 (2.9)	1770 (3.1)	9478 (3.5)
Total	51 200 (100)	44 286 (100)	120 936 (100)	56 351 (100)	272 773 (100)
Median household income national quartile for patient ZIP code					
0 to 25th percentile	25 045 (47.4)	33 542 (50.3)	64 935 (48.5)	19 548 (30.6)	143 070 (45.1)
26th to 50th percentile	8898 (16.8)	13 736 (20.6)	29 408 (21.9)	15 270 (23.9)	67 312 (21.2)
51st to 75th percentile	6977 (13.2)	7451 (11.2)	17 192 (12.8)	13 220 (20.7)	44 840 (14.1)
76th to 100th percentile	4424 (8.4)	3045 (4.6)	7010 (5.2)	7079 (11.1)	21 558 (6.8)
Missing	7480 (14.2)	8909 (13.4)	15 449 (11.5)	8862 (13.9)	40 700 (12.8)
Total	52 824 (100)	66 683 (100)	133 994 (100)	63 979 (100)	317 480 (100)
Injury severity score assigned by ICDPIC Stata program clumped					
0–9 ISS	29 807 (60.8)	33 776 (57.7)	71 313 (58.3)	32 475 (56.3)	167 371 (58.2)
10–15 ISS	8516 (17.4)	11 236 (19.2)	23 110 (18.9)	10 983 (19)	53 845 (18.7)
16–25 ISS	8109 (16.6)	10 457 (17.9)	21 736 (17.8)	10 704 (18.6)	51 006 (17.7)
26 or greater ISS	2563 (5.2)	3021 (5.2)	6240 (5.1)	3534 (6.1)	15 358 (5.3)
Total	48 995 (100)	58 490 (100)	122 399 (100)	57 696 (100)	287 578 (100)
Intent of GSW					
No E-code	1217 (2.3)	3434 (5.1)	5716 (4.3)	11 708 (18.3)	22 075 (7)
Unintentional	9556 (18.1)	14 032 (21)	36 322 (27.1)	10 397 (16.3)	70 307 (22.1)
Self-inflicted	2731 (5.2)	5162 (7.7)	13 555 (10.1)	4625 (7.2)	26 073 (8.2)
Assault	35 673 (67.5)	40 393 (60.6)	68 846 (51.4)	35 342 (55.2)	180 254 (56.8)
Undetermined	3482 (6.6)	3466 (5.2)	9104 (6.8)	1633 (2.6)	17 685 (5.6)
Legal intervention	167 (0.3)	196 (0.3)	450 (0.3)	274 (0.4)	1087 (0.3)
Total	52 826 (100)	66 683 (100)	133 993 (100)	63 979 (100)	317 479 (100)
Disposition of patient (uniform)					
Home	35 991 (68.1)	47 678 (71.5)	96 252 (71.8)	47 082 (73.6)	227 003 (71.5)
Transfer to other hospital	1187 (2.2)	1344 (2)	2530 (1.9)	2721 (4.3)	7782 (2.5)
Transfer to rehabilitation	5216 (9.9)	6084 (9.1)	11 926 (8.9)	5413 (8.5)	28 639 (9)
Home health	5366 (10.2)	5342 (8)	10 363 (7.7)	2381 (3.7)	23 452 (7.4)
Against Medical Advice (AMA)	1159 (2.2)	1112 (1.7)	1769 (1.3)	943 (1.5)	4983 (1.6)
Died	3906 (7.4)	5071 (7.6)	11 102 (8.3)	5259 (8.2)	25 338 (8)
Unknown/other	0 (0)	51 (0.1)	51 (0)	180 (0.3)	282 (0.1)
Total	52 825 (100)	66 682 (100)	133 993 (100)	63 979 (100)	317 479 (100)
Length of stay (Days)	7.4	6.0	7.7	7.2	7.2
Average Age	28.6	29.8	32.3	29.9	30.7
Injury severity score	10.2	10.6	10.6	10.9	10.6

AMA, Against Medical Advice; GSW, gun shot wound; ISS, injury severity score.

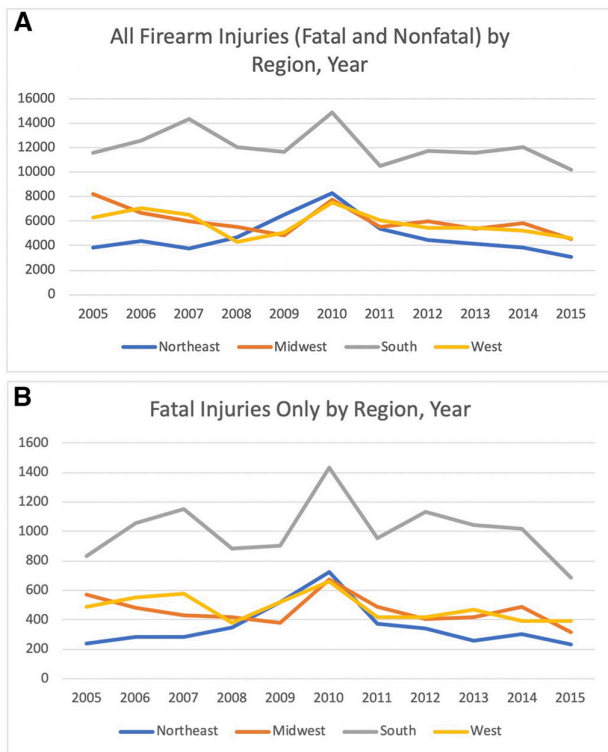


Figure 1 (A) All firearm injuries (fatal and non-fatal) by Region, Year. All firearm injuries by United States geographical region. (B) Fatal injuries only by region, year. Fatal injuries by United States geographical region.

E979.4, E985.0–0.4, or E970. Because E-codes distinguish emergency conditions, we were able to identify injured patients.

We did not include patients treated and released from an emergency department (ie, not admitted) or subsequent inpatient experiences not associated with an E-code (ie, readmission). We derived injury severity score using ICD Programs for Injury Characteristic, a Stata module that translates diagnosis codes into standard injury categories and scores.¹¹ We reported race/ethnicity according to NIS classification: White, Black, Hispanic, Asian/Pacific Islander, Native American, and other. Asian/Pacific Islanders, Native Americans, and other comprised small numbers in our sample and were combined as ‘other’.

Primary outcome of interest was cost associated with hospitalizations for firearm-related injuries and payer of record. NIS contains information regarding the total charges billed for services and cost to charge ratios, allowing us to estimate costs. We inflation-adjusted costs to 2015 dollars using Consumer Price Index rates.

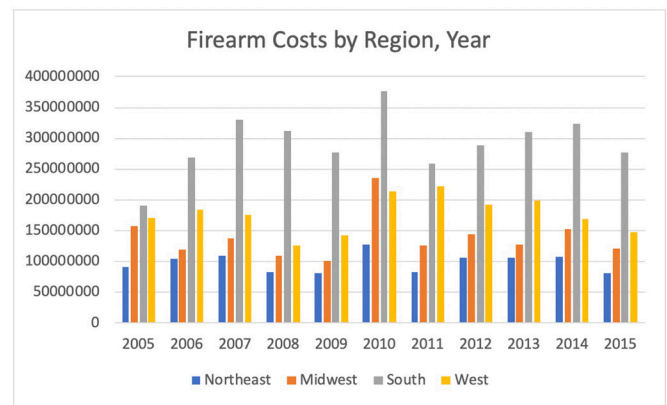


Figure 2 Firearm costs by region, year.

We used the Brady Gun Law Score card as a measure of firearm regulation restrictiveness by state. We converted letter grades for each state into a condensed continuous variable (all A grades given a score of 5, all B grades given a score of 4, down to F given a score of 0) for each region. T-tests and ANOVA tests were used to determine significance between firearm restrictiveness and firearm hospitalizations by region.

We performed unadjusted and adjusted analyses. We used the Student t-test for normally distributed continuous data. We used X2 analysis and analysis of variance to compare categorical variables. We considered $p < 0.05$ to be significant. We used linear regression to determine adjusted costs on the basis of payer status. Regression variables included demographics, length of stay, injury severity scores, and hospital region; we controlled for center.

We used Stata SE version 14.1 (StataCorp LP, College Station, TX) for analyses. NIS contains survey strata using US Census division, location, teaching status, ownership, and bed size. We applied survey weights according to HCUP recommendations to create national estimates for the entire US population.

RESULTS

We identified 317 479 patients admitted for firearm injuries over the 11 years of the study; 89.1% were male, and the average age was 31 (table 1). Firearm related hospital admissions were highest in the South, with 41.4% of all admissions; the Northeast had the lowest number of admissions (16.6%). Length of stay was highest in the South at 7.7 days, and lowest in the Midwest at 6.0 days, while average injury severity score was relatively consistent across regions, ranging from 10.2 in the Northeast to 10.9 in the West. As a function of intent, assaults were the highest proportion in the Northeast (67.5%), while self-inflicted injuries were highest in the South (10.1%). Most patients were

Table 2 Regional and percentage cost by insurance status

	Northeast		Midwest		South		West		Total
Government	\$602.1 M	18.70%	\$619.8 M	19.20%	\$1102.5 M	34.20%	\$899.9 M	27.90%	\$3224.5 M
Medicare	\$54.6 M	12.00%	\$84.3 M	18.50%	\$221.7 M	48.70%	\$94.5 M	10.80%	\$455.1 M
Medicaid	\$547.5 M	19.80%	\$535.5 M	19.30%	\$880.9 M	31.80%	\$805.4 M	29.10%	\$2769.4M
Private	\$198.2 M	12.50%	\$355.4 M	22.40%	\$683.7 M	43.10%	\$349.4 M	22.00%	\$1586.8 M
Self-Pay	\$197.9 M	10.90%	\$390.2 M	21.40%	\$888.8 M	48.80%	\$346.2 M	19.00%	\$1823.2 M
Other	\$77.6 M	6.90%	\$167.2 M	14.80%	\$538.6 M	47.60%	\$349.1 M	30.80%	\$1132.5 M
Total cost	\$1076.0 M	13.90%	\$1532.7 M	19.70%	\$3213.8 M	41.40%	\$1944.7 M	25.00%	\$7767.2 M
Percentage of US Population		17.60%		21.30%		37.60%		23.50%	

discharged home (71.5%); deaths occurred in 8.0% of all hospitalizations. Racial distribution of injuries was notable for a large proportion of Black patients throughout all regions, making up 49.5% of the total patient population, as well as a high proportion of Hispanic patients in the West (42.2%) in comparison with the national average of 17.3% (table 1). Firearm injuries and fatalities remained relatively constant over the 11 years of the assessment with the exception of a notable increase in 2010 (figure 1a and b).

Total costs of hospitalizations and readmissions for firearm injuries from 2005 to 2015 were \$7.77 billion; the Northeast contributed the lowest amount to this total—\$1.08 billion—while the South contributed three times this amount—\$3.21 billion (table 2, figure 2). Government payer plans (Medicare and Medicaid) were responsible for 41.5% of costs of hospitalization for firearm injuries in the Northeast, but only 34.3% of total hospital costs in the South (table 2), while self-pay patients were liable for 28% of the costs in the South, compared with 17.8% of the costs in the West. Proportional costs by region broke down as follows: the Northeast contains 17.6% of the US population and was responsible for 13.9% of the costs of hospitalizations for firearm injuries; the Midwest contains 21.3% of the population and contributed 19.7% of the costs; the South contains 37.6% of the population and contributed 41.4% of the costs; and the West contains 23.5% of the population and contributed 25.0% of the costs.

We found significant differences between regions for strength of firearm regulations, with the Northeast having the strongest regulations (mean of 3.56 out of 5, where 1 is the weakest control laws and 5 is the strongest control), and the South having the weakest firearm regulations (mean of 1.75 out of 5, $p=0.03$ (online supplemental table 1); the Midwest had a mean of 2.3, and the West had a mean of 2.5.

DISCUSSION

Hospital costs of treating patients injured by firearms amounted to \$7.8 billion dollars over the last decade, and taxpayer-funded government insurance programs covered 42% of this expense. Government coverage was highest in the Northeast and lowest in the South; however, the South had the highest overall costs for treating firearm injuries—41.4% of the total costs—even though the South only accounts for 37.6% of the US population. The South also had the highest proportion of self-paying patients. This, combined with overall poverty levels, indicates that states in the Southern region shift financial responsibility for hospital costs following firearm injuries onto the individual. The policy implications of this are readily apparent: regions with the least stringent firearm policies incur greater financial costs related to firearm injury.

Notably, southern states have higher rates of cardiovascular and metabolic disease, and were also less likely to expand Medicaid in the setting of the Affordable Care Act.^{12–14} Therefore, this region may face further risks of overburden due to underfunded healthcare facilities. Similarly, the risk of firearm injury is higher in communities of color which often experience greater financial stress. The financial burden of firearm injuries therefore falls on populations least equipped to handle such costs.

Government insurance programs are fundamental lifelines for seniors and the poor while providing a safety net, although an inadequate one, for health costs. Firearm injuries represent an ongoing, expensive burden to both patients and the US healthcare system. Policies that enable higher levels of gun availability while simultaneously rejecting expansion of healthcare coverage

for poor, uninsured, or underinsured residents represent an anti-poor policy.

This study has many limitations, the most important of which are due to limitation in the NIS and Nationwide Readmissions Database (NRD). Neither database reports state-level data, thus allocating costs to specific states is not possible. The NIS does not include costs of healthcare outside of hospitalizations, and the NRD does not link patients over different calendar years—thus the actual costs are likely to exceed those reported here. In addition, because these data are based on sampling, there is risk of disproportionate representation from trauma centers that could result in inaccurate estimations of firearm injuries nationwide. In addition, sampling may occasionally result in rounding errors on the order of single individuals. Furthermore, our use of E-codes could exclude patients who were classified under different codes; misclassification of codes is always a possibility, thus limiting our ability to fully capture all patients injured by firearms. Finally, patients who were treated and released or who died after arrival but prior to admission are not captured in these costs, but could represent a substantial cost burden on hospitals.

Another limitation is our extrapolation of 2010–2015 NRD readmission costs to the prior years of the study, which assumes the demographics and injuries of the latter years are similar to the former. Neither NIS nor NRD charges include professional fees, which have been shown to average approximately 20% of total acute care payments during an inpatient stay.⁴ Finally, relationships between costs, insurance coverage, and specific gun policies is not straightforward, as the transporting of guns across state borders limits any specific state regulation from impacting overall injury rates at a national level. These relationships are further affected by policy that addresses underlying social determinants of health, such as education and economic opportunity, which are not directly related to firearms.

Regional differences in the costs of hospitalizations for firearm injuries are pronounced, and are probably affected by state gun laws. Taxpayer-funded coverage of hospital treatments for firearm injuries amounted to \$3 billion between 2005 and 2015, with the largest proportional payments for these injuries being incurred by the South. These costs underestimate lifetime medical costs of such injuries as they do not include long-term or home healthcare costs, medications, other non-inpatient medical services, or opportunity costs from disability and lost productivity, which have been shown to be substantial. Relationships between gun policies and costs to taxpayers need to be more fully explored if policy makers are to make informed decisions about the implications of specific laws and statutes, as well as mechanisms to ensure cost recovery options for treating residents injured by firearms.

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