Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.JournalofSurgicalResearch.com

An epidemiologic overview of 13 years of firearm hospitalizations in Pennsylvania

Brian W. Gross, BS,[a] *Alan D. Cook, MD,*[b] *Cole D. Rinehart, BS,*[a] *Caitlin A. Lynch, BS,*[a] *Eric H. Bradburn, DO, MS, FACS,*[a] *Katherine A. Bupp, BS,*[a] *Chet A. Morrison, MD, FACS, FCCM,*[a] *and Frederick B. Rogers, MD, MS, FACS*[a,*]

[a] *Trauma Services, Trauma and Acute Care Surgery, Penn Medicine Lancaster General Health, Lancaster, Pennsylvania*

[b] *Trauma Research Program, Department of Surgery, University of Arizona College of Medicine, Trauma and Critical Care, Chandler Regional Medical Center, Chandler, Arizona*

ARTICLE INFO

Article history:
Received 12 August 2016
Received in revised form
21 October 2016
Accepted 10 November 2016
Available online 17 November 2016

Keywords:
Firearm violence
Gun violence
Gunshot wound
Firearm hospitalization
Functional status at discharge
Mortality

ABSTRACT

Background: Gun violence is a controversial public health issue plagued by a lack of recent research. We sought to provide a 13-y overview of firearm hospitalizations in Pennsylvania, analyzing trends in mode, intent, and outcome. We hypothesized that no adjusted change in mortality or functional status at discharge (FSD) would be observed for gunshot wound (GSW) victims over the study period.

Methods: All admissions to the Pennsylvania Trauma Outcome Study database from 2003 to 2015 were queried. GSWs were identified by external cause-of-injury codes. Collected variables included patient demographics, firearm type, intent (assault and attempted suicide), FSD, and mortality. Multilevel mixed-effects logistic regression models and ordinal regression analyses using generalized linear mixed models assessed the impact of admission year (continuous) on adjusted mortality and FSD score, respectively. Significance was set at $P < 0.05$.

Results: Of the 462,081 patients presenting to Pennsylvania trauma centers from 2003 to 2015, 19,342 were GSWs (4.2%). Handguns were the most common weapon of injury ($n = 7007$; 86.7%) among cases with specified firearm type. Most GSWs were coded as assaults ($n = 15{,}415$; 79.7%), with suicide attempts accounting 1866 hospitalizations (9.2%). Suicide attempts were most prevalent among young and middle-aged white males, whereas assaults were more common in young black males. Rates of firearm hospitalizations decreased over time (test of trend $P = 0.001$); however, admission year was not associated with improved adjusted survival (adjusted odds ratio: 0.99, 95% confidence interval: 0.97-1.01; $P = 0.353$) or FSD (adjusted odds ratio: 0.99, 95% confidence interval: 0.98-1.00; $P = 0.089$) while controlling for demographic and injury severity covariates.

Conclusions: Temporal trends in outcomes suggest rates of firearm hospitalizations are declining in Pennsylvania; however, outcomes remain unchanged. To combat this epidemic, a multidisciplinary, demographic-specific approach to prevention should be the focus of future scientific pursuits.

* *Corresponding author*. Department of Trauma, Penn Medicine Lancaster General Health, 555 N. Duke St., Lancaster, PA 17604. Tel.: +1 717 544 5945; fax: +1 717 544 5944.
E-mail address: frogers2@lghealth.org (F.B. Rogers).

0022-4804/$ – see front matter © 2016 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jss.2016.11.021

Introduction

Despite leading all high-income nations in firearm mortality,[1] research detailing firearm-related injuries in the United States remains scarce in the wake of funding restrictions and public policy concerns.[2,3] According to the most recent report from the National Vital Statistics System of the Centers for Disease Control and Prevention, in 2013, firearms accounted for 17.4% of all injury-related fatalities in the United States—closely trailing motor vehicle collisions as the third leading cause of injury-related death.[4] From 2010 to 2012, firearms were the cause of more than 67,000 injuries per year, with the majority of these cases requiring hospitalization.[5] Although several reports detailing trends in firearm injuries and fatalities throughout the country have surfaced in recent years,[5-11] limited research exists providing detailed epidemiologic characterizations of the hospitalized firearm-injured population, making analysis and insight into this subgroup particularly prudent.

Although large, national firearm studies by Fowler *et al.*,[5] Wintemute,[9] and Kalesan *et al.*[10] have provided a much needed foundation for analyzing and combating this major public health problem, insight into patient-specific injury metrics and mechanisms, as well as outcomes besides mortality, are restricted. Although studies analyzing firearm hospitalizations at an institutional/regional level are available to address these deficits, such as that of Livingston *et al.*[6] and Morrison *et al.*,[11] these works likely suffer from a lack of generalizability.

The purpose of this study was to provide a detailed 13-y statewide epidemiologic overview of the hospitalized firearm population in the Commonwealth of Pennsylvania, analyzing temporal trends in mode of injury, intent, and outcomes. By using one of the largest, most detailed trauma registries in the nation, our objective is to provide needed insight into injury mechanism and functional outcome metrics not available elsewhere in the literature. As investigations by Fowler *et al.*[5] and Kalesan *et al.*[10] reported reductions in national rates firearm hospitalizations over time, we hypothesized that similar decreasing trends would be observed in Pennsylvania. Similarly, as the majority of both recent institutional (Morrison *et al.*[11]) and national works (Fowler *et al.*,[5] Wintemute,[9] and Kalesan *et al.*[10]) have found no temporal change in outcomes (specifically mortality) for those afflicted by firearm injuries, we hypothesized no change in mortality or functional status at discharge (FSD) would be observed in Pennsylvania over the study period.

Methods

After review and approval by the Institutional Review Board of our level II community trauma center, all admissions to the Pennsylvania Trauma Outcome Study (PTOS) database of the Pennsylvania Trauma Systems Foundation were queried. The Pennsylvania Trauma Systems Foundation is a private, nonprofit organization written into the Emergency Medical Services Act to accredit trauma centers within the Commonwealth of Pennsylvania. To remain an accredited institution, trained registrars from the 38 level I-IV trauma centers throughout the state are required to extract and submit deidentified admission/discharge data to PTOS for all patients meeting specified trauma guidelines. Trauma inclusion criteria include all patients with intensive care unit and/or step-down unit admission, hospital stay >48 h/hospital stay 36-48 h with an Injury Severity Score (ISS) ≥9, transfer in and/or transfer out status, or trauma death (including dead on arrival patients).[12] Hospital data from nontrauma centers within the state ($n = 126$) are not included within the PTOS database.

To investigate epidemiologic trends in firearm hospitalizations throughout the state, all admissions to the PTOS database from 2003 to 2015 were queried. Gunshot wounds (GSWs) were coded by the following external cause-of-injury codes (E-codes): (1) accidental firearm-related injury—E922.0, E922.1, E922.2, E922.3, E922.8, E922.9; (2) suicide and/or self-inflicted injury—E955.0, E955.1, E955.2, E955.3, E955.4; (3) assault—E965, E965.0, E965.1, E965.2, E965.3, E965.4; (4) law enforcement—E970; (5) terrorism—E979.4; and (6) undetermined intent—E985.0, E985.1, E985.2, E985.3, E985.4.[13] Injuries resulting from pellet/BB gun projectiles were excluded from analysis. Variables of interest included patient demographics (age, gender, race, ISS, field and admission Glasgow Coma Scale [GCS] score, Abbreviated Injury Scale [AIS] body region scores, and field and admission shock index score), firearm type (handgun, shotgun, hunting rifle, military firearm, and unspecified), intent (suicide attempt, assault, and undetermined), discharge destination, FSD, and in-hospital mortality (including death in the Emergency Department). FSD is a functional status measure comprised of five parts (feeding, locomotion, expression, transfer mobility, and social interaction) scored on a scale from 1 to 4 (1 = complete dependence and 4 = complete independence). Each item is required to be assessed by a member of the patient care team as close to discharge as possible, but not earlier than 48 h before discharge. Patients who die in-hospital are not given an FSD score, and as a result, were excluded from FSD analysis.

Trends in total and yearly incidence of firearm hospitalizations were characterized across the study period with consideration for age, race, firearm type, intent, and injured body region. Outcome measures of interest included trends in FSD and in-hospital mortality across the 13-y timeframe. Unadjusted temporal trends were assessed using Cruzick's nonparametric test for trend across ordered groups (year).[14] Multilevel mixed-effects logistic regression models and ordinal regression analyses using generalized linear mixed models assessed the adjusted impact of admission year (as a continuous variable) on in-hospital mortality and FSD score, respectively. The purpose of implementing these modeling approaches was to gain an adjusted view of trends pertaining to these firearm injury–related outcomes while accounting for clustering of case volume within state trauma centers. Model performance for the multilevel regression was assessed through the area under the receiver operating characteristic curve (AUROC) and by the R-squared value for the generalized linear mixed models.[15,16] All data manipulation and statistical

analyses were performed using Stata/MP, version 14.1 (Stata Corp, College Station, TX). Statistical significance was defined as $P < 0.05$.

Results

A total of 462,081 patients were hospitalized at Pennsylvania-accredited trauma centers from 2003 to 2015, of which 19,342 (4.2%) presented with firearm-related injuries. Annual GSW hospitalizations ranged from 1278 in 2003 to 1672 in 2006 and averaged 1488 admissions per year. Rates of firearm hospitalizations (GSWs per total trauma volume by year) ranged from 3.4% in 2014 to 5.3% in 2006 and showed a significant decrease across the study period (test of trend, $P < 0.001$). The GSW patient population was predominantly comprised of severely injured (mean ISS: 16.7 ± 15.9), young (median age: 27 y), black (65.0%), and males (91.2%). A complete breakdown of study population demographics, including Abbreviated Injury Scale body region of maximal injury and yearly firearm-related hospitalizations, is presented in Tables 1 and 2. Overall mortality rate ranged from 24.8% in 2003 to 20.3% in 2013 (Fig. 1) and was significantly higher in white patients compared with black counterparts (26.2%

Table 1 – Firearm-injured study population demographics and injury severity metrics by injury.

Variables	All (n = 19,342)	Assault (n = 15,415)	Suicide attempt (n = 1866)	Law enforcement (n = 261)	Unintentional/undetermined (n = 1800)
Age (y), n (%)					
0-9	162 (0.84)	79 (0.51)	2 (0.11)	0 (0.00)	81 (4.50)
10-19	3758 (19.5)	3228 (21.0)	139 (7.45)	31 (11.9)	360 (20.0)
20-29	8194 (42.5)	7145 (46.5)	389 (20.9)	114 (43.9)	546 (30.3)
30-39	3450 (17.9)	2850 (18.5)	286 (15.3)	58 (22.3)	256 (14.2)
40-49	1906 (9.88)	1275 (8.29)	357 (19.1)	36 (13.9)	238 (13.2)
50-59	951 (4.93)	493 (3.21)	282 (15.1)	14 (5.38)	162 (9.00)
60-69	396 (2.05)	131 (0.85)	169 (9.06)	3 (1.15)	93 (5.17)
70-79	224 (1.16)	31 (0.20)	145 (7.77)	3 (1.15)	45 (2.50)
80-89	111 (0.58)	16 (0.10)	81 (4.34)	1 (0.38)	13 (0.72)
90-99	17 (0.09)	2 (0.01)	12 (0.64)	0 (0.00)	3 (0.17)
100+	129 (0.67)	122 (0.79)	4 (0.21)	0 (0.00)	3 (0.17)
Unknown	44 (0.23)	43 (0.28)	0 (0.00)	1 (0.38)	0 (0.00)
Sex, male, n (%)	17,633 (91.2)	14,201 (92.1)	1621 (86.9)	256 (98.1)	1555 (86.4)
Race/ethnicity, n (%)					
White	4708 (24.3)	1966 (12.8)	1542 (82.6)	88 (33.7)	1112 (61.8)
Black	12,565 (65.0)	11,686 (75.8)	199 (10.7)	156 (59.8)	524 (29.1)
Asian/Pacific Islander	121 (0.63)	103 (0.67)	12 (0.64)	2 (0.77)	4 (0.22)
Other	568 (2.93)	449 (3.16)	36 (2.01)	5 (1.99)	78 (4.54)
Unknown	1380 (7.14)	1211 (7.86)	77 (4.13)	10 (3.83)	82 (4.56)
Region of maximal injury, n (%)					
Head	3151 (16.3)	1800 (11.7)	1101 (59.0)	20 (7.66)	230 (12.8)
Face	717 (3.71)	500 (3.25)	126 (6.76)	12 (4.60)	79 (4.39)
Neck	383 (1.98)	324 (2.10)	22 (1.18)	5 (1.92)	32 (1.78)
Thorax	4403 (22.8)	3847 (25.0)	230 (12.3)	96 (36.8)	230 (12.8)
Abdomen	3836 (19.8)	3363 (21.8)	158 (8.48)	48 (18.4)	267 (14.9)
Spine	681 (3.52)	611 (3.97)	14 (0.75)	21 (8.05)	35 (1.95)
Upper extremity	4555 (23.6)	3797 (24.6)	115 (6.17)	29 (11.1)	614 (34.2)
Lower extremity	1616 (8.36	1173 (7.61)	100 (5.36)	30 (11.5)	313 (17.4)
GCS, mean ± SD					
Field	11.9 ± 4.97	12.3 ± 4.71	8.06 ± 5.40	11.6 ± 4.89	13.2 ± 4.05
Admission	11.7 ± 5.16	12.1 ± 4.95	7.52 ± 5.56	10.5 ± 5.33	13.1 ± 4.25
Shock index, mean ± SD					
Field	0.85 ± 0.40	0.86 ± 0.41	0.84 ± 0.38	0.88 ± 0.42	0.79 ± 0.32
Admission	0.80 ± 0.39	0.80 ± 0.39	0.86 ± 0.46	0.87 ± 0.34	0.74 ± 0.30
ISS, mean ± SD	16.7 ± 15.9	16.9 ± 16.2	19.9 ± 14.6	18.7 ± 16.5	11.3 ± 12.3

SD = standard deviation.

Table 2 – Firearm injury characteristics and study population outcomes by injury intent.

Variables	All (n = 19,342)	Assault (n = 15,415)	Suicide attempt (n = 1866)	Law enforcement (n = 261)	Unintentional/ undetermined (n = 1800)
Year, n (%)					
2003	1278 (6.61)	1027 (6.66)	137 (7.34)	14 (5.36)	100 (5.56)
2004	1337 (6.91)	1041 (6.75)	142 (7.61)	28 (10.73)	126 (7.00)
2005	1532 (7.92)	1235 (8.01)	146 (7.82)	14 (5.36)	137 (7.61)
2006	1672 (8.65)	1406 (9.12)	119 (6.38)	22 (8.43)	125 (6.94)
2007	1546 (8.00)	1278 (8.29)	112 (6.00)	20 (7.66)	136 (7.56)
2008	1461 (7.56)	1169 (7.58)	131 (7.02)	16 (6.13)	145 (8.06)
2009	1434 (7.42)	1147 (7.44)	128 (6.86)	23 (8.81)	136 (7.56)
2010	1512 (7.82)	1221 (7.92)	150 (8.04)	19 (7.28)	122 (6.78)
2011	1542 (7.97)	1214 (7.88)	148 (7.93)	23 (8.81)	157 (8.72)
2012	1542 (7.97)	1215 (7.88)	165 (8.84)	24 (9.20)	138 (7.67)
2013	1515 (7.83)	1164 (7.55)	186 (9.97)	21 (8.05)	144 (8.00)
2014	1404 (7.26)	1077 (6.99)	153 (8.20)	15 (5.75)	159 (8.83)
2015	1567 (8.10)	1221 (7.92)	149 (7.98)	22 (8.43)	175 (9.72)
Firearm type, n (%)					
Handgun	7007 (36.2)	5062 (32.8)	1125 (60.3)	0 (0.00)	820 (45.6)
Shotgun	608 (3.14)	288 (1.87)	168 (9.00)	0 (0.00)	152 (8.44)
Hunting rifle	435 (2.25)	35 (0.23)	162 (8.68)	0 (0.00)	238 (13.2)
Military	35 (0.18)	25 (0.16)	4 (0.21)	0 (0.00)	6 (0.33)
Other/unknown	11,257 (58.2)	10,005 (64.9)	407 (21.8)	261 (100.0)*	584 (32.4)
Discharge destination, n (%)					
Home/residential facility	10,934 (56.5)	9385 (60.9)	255 (13.7)	27 (10.3)	1267 (70.4)
Rehabilitation center	1989 (10.3)	1321 (8.57)	496 (26.6)	29 (11.1)	143 (7.94)
Skilled nursing facility	254 (1.31)	189 (1.23)	29 (1.55)	3 (1.15)	33 (1.83)
Other hospital/trauma center	431 (2.23)	250 (1.62)	82 (4.39)	6 (2.30)	93 (5.17)
Long-term care center	56 (0.29)	25 (0.16)	21 (1.13)	1 (0.38)	9 (0.50)
Hospice	18 (0.09)	4 (0.03)	12 (0.64)	0 (0.00)	2 (0.11)
AMA	180 (0.93)	167 (1.08)	5 (0.27)	0 (0.00)	8 (0.44)
Other/unknown	5480 (28.3)	4074 (26.4)	966 (51.8)	195 (74.7)	245 (13.6)
ICU LOS, d, mean ± SD	2.55 ± 7.39	2.55 ± 7.58	3.24 ± 6.59	3.45 ± 9.09	1.94 ± 6.17
Mortality, n (%)	4446 (23.0)	3292 (21.4)	913 (48.9)	61 (23.4)	180 (10.0)
	Non-fatal (n = 14,896)	Assault (n = 12,123)	Suicide attempt (n = 953)	Law enforcement (n = 200)	Unintentional/ undetermined (n = 1620)
FSD scores, mean ± SD	18.5 ± 2.57	18.6 ± 2.33	17.3 ± 4.26	18.3 ± 2.58	18.5 ± 2.87
Feeding	3.82 ± 0.61	3.86 ± 0.54	3.41 ± 1.11	3.82 ± 0.60	3.80 ± 0.66
Locomotion	3.41 ± 0.85	3.42 ± 0.83	3.30 ± 1.04	3.32 ± 0.97	3.41 ± 0.87
Expression	3.90 ± 0.46	3.93 ± 0.40	3.62 ± 0.88	3.89 ± 0.49	3.89 ± 0.53
Transfer mobility	3.49 ± 0.81	3.50 ± 0.78	3.37 ± 1.00	3.37 ± 0.95	3.49 ± 0.83
Social interaction	3.90 ± 0.47	3.92 ± 0.40	3.59 ± 0.90	3.92 ± 0.40	3.88 ± 0.54

ICU LOS = intensive care unit length of stay; SD = standard deviation; AMA = against medical advice.
* All firearm interventions by law enforcement have unspecified firearm type.

versus 21.9%, $P < 0.001$). Mean FSD scores ranged from 18.8 ± 2.19 in 2006 to 18.4 ± 2.85 in 2013 (Fig. 2). Unadjusted trends in mortality (odds ratio: 0.98, 95% confidence interval [CI]: 0.97-0.99; $P = 0.001$) and FSD (odds ratio: 0.99, 95% CI: 0.98-0.99; $P = 0.045$) showed significant decreases across the 13-y study period.

An analysis of injury intent revealed the majority of hospitalized GSW patients were coded as assaults (n = 15,415; 79.7%), with suicide attempts comprising the second largest subcategorization (n = 1866; 9.7%). Law enforcement–inflicted GSWs accounted for 1.4% of admissions (n = 261). Handguns were the most common weapon of injury (n = 7007; 86.7%)

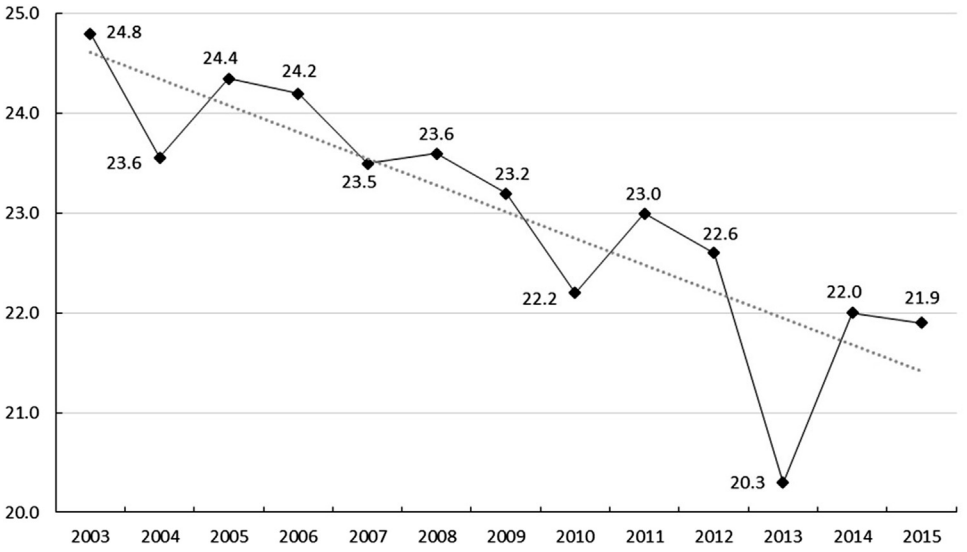

Fig. 1 – Unadjusted mortality rates, 2003-2015.

among cases with specified firearm type ($n = 8085$) and accounted for 60.3% of suicide-related firearm hospitalizations ($n = 1125$). Compared with cases of assault, patients hospitalized for attempted suicide were significantly more likely to die from their injuries (mortality rate: 48.9% *versus* 21.4%; $P < 0.001$). Suicide attempts were most prevalent among young and middle-aged white males, whereas assaults were most common in young black males. Assaults eclipsed suicide attempts as the predominant intent of injury for black patients across every age group and white patients below the age of 46 y. Suicide attempts surpassed assaults as the leading cause of firearm hospitalization in white patients above this age point (Fig. 3). Overall, white patients were significantly more likely than black counterparts to be hospitalized for attempted suicide (32.8% *versus* 1.6% of total GSW hospitalizations by race; $P < 0.001$).

Although unadjusted trends in outcome measures showed significant decreases over the study period, when controlling for age, shock index, GCS motor score, ISS, suicide intent, and clustering within trauma centers, no significant changes in mortality (adjusted odds ratio [AOR]: 0.99, 95% CI: 0.97-1.01; $P = 0.353$; AUROC: 0.95) or FSD (AOR: 0.99, 95% CI: 0.98-1.00; $P = 0.089$; R-squared: 0.82) were observed over time. As expected, age, shock, ISS, GCS motor, and suicide intent were significant predictors of firearm injury mortality (Table 3).

Discussion

The results of this investigation suggest that firearm injuries were a continual source of trauma within the Commonwealth of Pennsylvania—contributing to, on average,

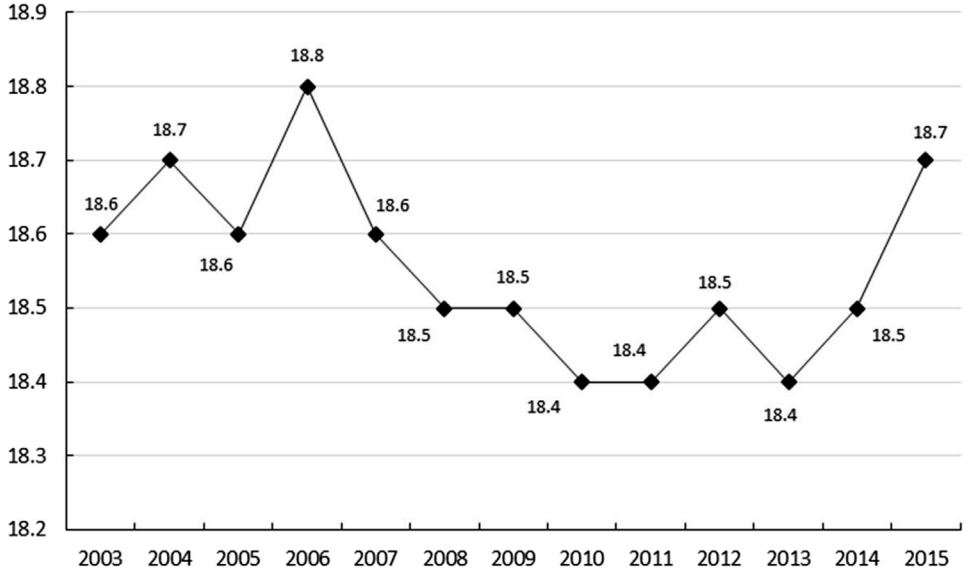

Fig. 2 – Mean FSD scores, 2003-2015.

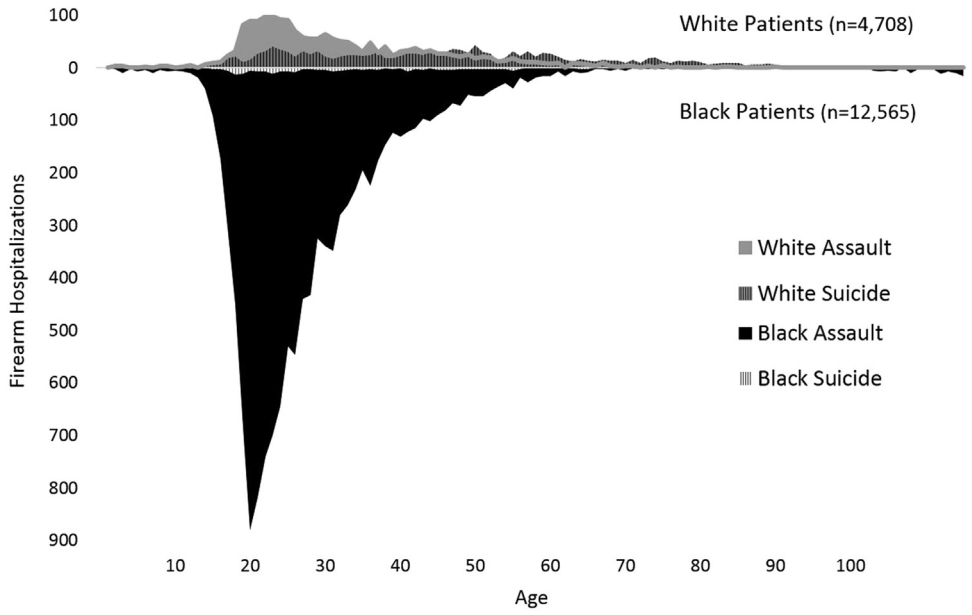

Fig. 3 – Assault *versus* attempted suicide hospitalizations by age and race, 2003-2015.

1400 hospitalizations per year over the study period. As a state with combined urban and rural sectors and relatively few restrictions on gun ownership following the "Stand your ground legislation" in 2011,[17] this finding, although alarming, is not at all surprising. Despite 13,781 people dying from GSWs in Pennsylvania from 2005 to 2014,[18] research detailing the epidemiology of firearm violence in the state remains scarce[19]—further impeding our understanding of this major public health issue. Absent such knowledge, identification of beneficial, targeted preventive measures, and subsequently, improvements in outcomes for those afflicted by GSWs will likely not occur—as the results of our study suggest. Supporting our hypothesis, rates of firearm hospitalizations were found to be on the decline throughout the state, whereas mortality and functional outcome measures for those afflicted by GSWs remained unchanged over the past 13 y. Considering the diverse rural and urban/suburban distribution within the Commonwealth of Pennsylvania, it is plausible to suggest the epidemiologic characteristics detailed within this analysis hold generalizable value to the nation at large.

Although the lack of outcome improvements for hospitalized GSW victims found in this study is disheartening, it is congruent with a modest amount of literature on firearm violence. In 2015, Wintemute[9] published the results of an epidemiologic review of firearm violence in the United States, in which he reported no change in mortality rate for firearm-injured patients over the past decade. Similarly, in an analysis of trauma-related mortality using the National Trauma Data Bank, Sise *et al.*[19] found no change in firearm-related deaths for hospitalized trauma patients from 2002 to 2010, despite observing survival improvements in other trauma categories including motor vehicle collisions. Perhaps most alarmingly, in an analysis of 6322 GSW hospitalizations, Livingston *et al.*[6] reported a significant 5% increase in firearm-related mortality at a level I urban trauma center over an 11-y period. Other efforts at the national level by Kalesan *et al.*[10] and Fowler *et al.*[5]

Table 3 – Adjusted trends in mortality and functional status at discharge by admission year.

Variable	Mortality model (n = 19,342)		Functional status at discharge model (n = 14,896: nonfatal patients)	
	AOR (95% CI)	P value	AOR (95% CI)	P value
Admission year	0.99 (0.97-1.01)	0.353	0.99 (0.98-1.00)	0.089
Age	1.02 (1.02-1.03)	<0.001	0.98 (0.98-0.99)	<0.001
Shock index	2.02 (1.74-2.35)	<0.001	0.81 (0.70-0.92)	0.003
GCS motor	0.53 (0.51-0.54)	<0.001	1.41 (1.36-1.46)	<0.001
ISS	1.08 (1.07-1.09)	<0.001	0.94 (0.93-0.94)	<0.001
Intent (suicide)	2.34 (1.92-2.85)	<0.001	0.54 (0.44-0.66)	<0.001
	AUROC: 0.95		R-squared: 0.82	

analyzing the gun violence epidemic in the United States found that despite significant reductions in firearm injury rates over time, mortality for GSW cases is not improving—although it should be noted that these works included both trauma and nontrauma center managed populations, likely comprising a less severely injured cohort of patients presenting with minor injuries.

Despite advances in emergency medicine and trauma care over the past decades, the fact that outcomes for firearm-hospitalized patients managed throughout Pennsylvania's mature trauma system are not improving, suggests that prevention should be the focus of future legislative and scientific pursuits. As shown through this study, and previously published works,[5,19] gun violence is a multifaceted epidemic, plaguing demographic subgroups in drastically different ways. To combat such a complex problem, an understanding of the racial and age-related implications of gun violence is necessary.

Although underemphasized in this study, suicides have been reported to account for more than 60% of all firearm deaths in the United States.[5] Considering the fact that only 9.7% of GSW hospitalizations in Pennsylvania were coded as suicide attempts from 2003 to 2015 suggests the majority of these patients are successful in taking their lives, dying prehospital. As shown in this study, the white population appears to be more prone to hospitalization because of self-inflicted firearm injury than other subgroups—particularly middle-aged and older white males (Table 2, Fig. 3). In addition, hospitalizations because of assaults are substantially overrepresented in the young, black, male population, a finding consistent with that of Fowler *et al.*[5] and Wintemute.[9] The increased mortality observed for hospitalized white patients in this study is therefore likely the result of the increased prevalence of suicide attempts found among this population compared with other racial segments. These findings, in conjunction with previous research detailing the epidemiology of gun violence throughout the nation, exemplify the need for public policy initiatives to combat the specific nature of this diverse epidemic among varying demographic subgroups.

This study is not without its limitations. In addition to the inherent limitations of any retrospective analysis, this piece provides insight into only one specific firearm-injured population—those hospitalized for their wounds at trauma centers. As a result, patients receiving treatment for minor injuries at nontrauma centers, as well as those who die pre-hospital are not included in this analysis. Although the purpose of this study was to detail trends pertaining to the hospitalized GSW population, the authors realize this work falls short in providing a complete epidemiologic understanding of the gun violence epidemic in the Commonwealth of Pennsylvania.

Conclusion

Firearms were a continual source of hospitalization throughout the Commonwealth of Pennsylvania over the past 13 y, showing diverse patterns of injury among demographic subgroups. Unfortunately, despite a reduction in firearm hospitalizations over time, outcomes for those afflicted by firearm injuries are not improving. To combat the gun violence epidemic in Pennsylvania, and the United States at large, further research and demographic-specific public policy prevention initiatives are essential.

Acknowledgment

The authors would like to extend their deepest gratitude and appreciation for the creative insight and guidance of Lori Rineer, the Marketing Coordinator for Penn Medicine Lancaster General Health.

Authors' contributions: B.G., A.C., C.R., C.L., E.B., K.B., C.M., F.R. contributed in study design. B.G., A.C., C.R., C.L., K.B., F.R. collected the data. B.G., A.C., C.R., C.L., K.B., F.R. analyzed the data. B.G., A.C., C.R., E.B., C.M., F.R. interpreted the data. B.G., A.C., C.R., C.L., E.B., K.B., C.M., F.R. involved in preparing the manuscript. E.B. did editorial oversight.

Disclosure

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

REFERENCES

1. Richardson EG, Hemenway D. Homicide, suicide, and unintentional firearm fatality: comparing the United States with other high-income countries, 2003. *J Trauma*. 2011;70:238–243.
2. *Omnibus Consolidated Appropriations Act of 1997. Public law No. 104-108, 110 Stat 3009*. Washington, D.C.: Government Publishing Office; 1996:244.
3. *Consolidated Appropriations Act of 2012*. Washington, D.C.: Government Priting Office; 2011.
4. Xu J, Murphy SL, Kochanek KD, Bastian BA. Deaths: final data for 2013. *Natl Vital Stat Rep*. 2016;64:1–119.
5. Fowler KA, Dahlberg LL, Haileyesus T, Annest JL. Firearm injuries in the United States. *Prev Med*. 2015;79:5–15.
6. Livingston DH, Lavery RF, Lopreiato MC, et al. Unrelenting violence: an analysis of 6322 gunshot wound patients at a Level I trauma center. *J Trauma Acute Care Surg*. 2014;76:2–9. discussion 9-11.
7. Firearm injury in the United States. Firearm and Injury Center at Penn, 2011. Available at: http://www.uphs.upenn.edu/ficap/resourcebook/pdf/monograph.pdf. Accessed June 15, 2016.
8. Fleegler EW, Lee LK, Monuteaux MC, et al. Firearm legislation and firearm-related fatalities in the United States. *JAMA Intern Med*. 2013;173:732–740.
9. Wintemute GJ. The epidemiology of firearm violence in the twenty-first century United States. *Annu Rev Public Health*. 2015;36:5–19.
10. Kalesan B, French C, Fagan JA, et al. Firearm-related hospitalizations and in-hospital mortality in the United States, 2000-2010. *Am J Epidemiol*. 2014;179:303–312.
11. Morrison C, Gross B, Horst M, et al. Under fire: gun violence is not just an urban problem. *J Surg Res*. 2015;199:190–196.

12. *Pennsylvania Trauma Systems Foundation Operational Manual for the Data Base Collection System*. Pennsylvania Trauma Systems Foundation; 2015. Available at: www.ptsf.org/upload/2014_PTOS_Manual_Tab_1_through_4_Final.doc, Accessed September 17, 2016.
13. Injury Prevention & Control. *Data & Statistics (WISQARS™): Matrix of E-code Groupings*. Atlanta, GA: Epidemiology Program Office, Centers for Disease Control and Prevention (CDC), Public Health Service, U.S. Department of Health and Human Services; 2011. Available at: www.cdc.gov/injury/wisqars/ecode_matrix.html. Accessed September 18, 2016.
14. Cuzick J. A wilcoxon-type test for trend. *Stat Med*. 1985;4:543–547.
15. Hanley J, McNeil B. The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology*. 1982;143:29–36.
16. Hosmer DW, Lemeshow S. Goodness of fit tests for the multiple logistic regression model. *Commun Stat-Theroy Methods*. 1980;9:1043–1069.
17. National Conference on State Legislatures. *"Self defense and 'Stand Your ground',"* 2013. Available at: http://www.ncsl.org/issues-research/justice/selfdefense-and-stand-your-ground.aspx. Accessed June 1, 2016.
18. Parsons C, Vargas EW. *Pennsylvania Under the Gun: 5 Measures of Gun Violence in the Keystone State*. Center for American Progress; 2016. Available at: http://cdn.americanprogress.org/wp-content/uploads/2016/05/10070108/PAguns-brief1.pdf. Accessed June 3, 2016.
19. Sise RG, Calvo RY, Spain DA, et al. The epidemiology of trauma-related mortality in the United States from 2002 to 2010. *J Trauma Acute Care Surg*. 2014;76:913–919.