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Sex Differences in Early Cardiovascular and All-Cause Hospitalization Outcomes After Surviving Firearm Injury

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Abstract

The majority of the burden of firearm injury in the United States is on men as compared to women. There is limited evidence regarding sex differences in short-term hospitalization outcomes after surviving firearm injury. The risk of cardiovascular and all-cause hospital readmission, length of stay (LOS), and costs within 180 days after surviving an index firearm injury was compared between males and females. A claims-based, retrospective, cohort study was performed using Nationwide Readmission Database (2013–2014) to obtain a cohort of patients who survived an index hospitalization of firearm injury. The analysis was performed in August 2017. Cox proportional hazard regression models were used to estimate hazard ratio (HR) and 95% confidence intervals (95% CIs). Among 17,594 males and 2,289 females discharged alive after index firearm injury hospitalization, 14.4% and 13.2% were readmitted within 180 days. Within 180 days, the risk of cardiovascular readmission was 3.3 times greater among males versus females (HR = 3.34, 95% CI [1.18, 9.44]. Risk of all-cause readmission among males was greater at 90 days (HR = 1.40, 95% CI [1.04, 1.87]. Patients surviving a firearm injury have a substantial risk of subsequent hospitalizations. Cardiovascular readmissions are greater among males than females during the first 6 months after injury and may be indicative of a continuing long-term risk of health and patient outcomes that contributes to the overall burden of firearm injury.

Keywords

firearms, injury, readmissions, injury severity, sex differences

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The majority of the burden of firearm injury in the United States is on men as compared to women (Kalesan, French, Fagan, Fowler, & Galea, 2014). In 2015, the rate of firearm-related deaths among males was 19.6 per 100,000 and among females was 3.2 per 100,000 (Kalesan et al., 2014). In the same year, the incidence rates of nonfatal firearm injury were 47.9 per 100,000 among males, an increase of 24% from 38.0 per 100,000 in 2001 (Centers for Disease Control and Prevention, 2017). Comparatively, incidence rates of nonfatal firearm injury in females increased 16% from 4.33 per 100,000 in 2001 to 5.6 per 100,000 in 2015 (Centers for Disease Control and Prevention, 2017). During the last decade, the cost of acute and longer term medical care and recovery for firearm injury patients has increased greatly (Cook, Lawrence, Ludwig, & Miller, 1999; Lee, Quraishi, Bhatnagar, Zafonte, & Masiakos, 2014). Risk of subsequent readmission is a marker of ongoing injury severity for any injury that requires a first hospitalization (Hammond et al., 2015). Although there have been clinical studies that have reported the outcomes during the acute care hospitalization for firearm injuries (Kalesan et al., 2014; Sise, Calvo, Spain, Weiser, & Staudenmayer, 2014), there are no studies that have

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delineated sex differences in subsequent hospitalizations after surviving the index hospitalization, particularly cardiovascular outcomes. While the majority of the burden of American gun deaths occurs among men compared to women, whether men carry the majority of the burden of morbidity as well is unknown. This morbidity can continue throughout the lifetime and has implications for health-care providers in addressing index injuries and continuing comorbidities considering the potential for ongoing sex-specific injury severity and morbidity.

Given this lack of scientific evidence regarding sex differences in readmission outcomes after surviving an acute event of firearm injury, the objective of this investigation was to determine the risk of all-cause and cardiovascular readmission within 30, 60, 90, and 180 days after being discharged alive following an index firearm injury emergency room (ER) visit and hospitalization. This analysis assessed the total readmission visits, total cost of hospitalization, cost per readmission, total length of stay (LOS) in days, and LOS per readmission in days.

Methods

Study Design

A claims-based, retrospective, cohort study of index hospitalizations of firearm injury was conducted comparing males to females.

Data Source

This analysis was conducted using the Nationwide Readmissions Database (NRD) (HCUP, 2013) from 2013 to 2014. The NRD contains nationally representative information on hospital admissions with patient linkage numbers to track readmissions within a state. In the 2013 NRD, there are approximately 14 million discharges from 2,006 hospitals from 21 state inpatient databases; representing 49.3% of the U.S. population and 49.1% of U.S. hospitalizations. In the 2014 NRD, there are approximately 14 million discharges from 2,048 hospitals from 22 state inpatient databases; representing 51.2% of the U.S. population and 49.3% of U.S. hospitalizations. The NRD includes all discharges and those who have died in the hospital. Diagnoses and procedures during each hospitalization are categorized using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. The readmissions within a year could be identified but data are not designed to be linked across years. Therefore, the discharges during the first 6 months of 2013 and 2014 were used to allow a minimum follow-up duration of 6 months after an index firearm-related injury.

Inclusion and Exclusion Criteria

All firearm hospitalizations were identified using ICD-9-CM injury codes by intent of injury. The ICD-9 codes for unintentional or accident were E9220, E9221, E9222, E9223, E9224, E9228, E9229; assault were E9650, E9651, E9652, E9653, E9654, suicide was E9550, E9551, E9552, E9553, E9554, E9556, E9559, undetermined were E9850, E9851, E9852, E9853, E9854, E9856, legal was E970 and war was E991.

First, from 70,886,775 weighted hospitalizations, firearm hospitalization visits were identified using ICD-9 codes. Second, those hospitalizations that were not index firearm hospitalizations, those that were not explicitly admitted from the ER or were transferred from another hospital, and those where the primary diagnosis was injury but were dislocations and sprains, indicative of an error, were excluded. Then the dataset was restricted to those firearm hospitalizations that were discharged between January and the end of June in the respective years. There were a total of 21,693 index firearm hospitalizations (19,166 males and 2,527 females). During the index firearm hospitalizations, there were a total of 1,809 (8.4%) in-hospital deaths (1,572 [8.2%] males; 237 [9.2%] females). The remaining 17,594 males and 2,289 females, a total of 19,883, were included in the current study. Boston University School of Medicine institutional review board approved this study (H-35309).

Study Variables

Outcomes. The primary outcomes were the time-to-first cardiovascular and all-cause readmission to hospital within the first 180 days after being discharged alive following an index hospitalization due to firearm injury. The cardiovascular readmission is a composite outcome of heart failure, myocardial infarction, atrial fibrillation and aortic dissection. These outcomes included both fatal and nonfatal readmissions after index hospitalization discharge. The secondary outcomes were readmission due to heart failure (ICD-9: 40201, 40211, 40291, 40401, 40403, 40411, 40413, 40491, 40493, 428, 4280, 4281, 4282, 42820, 42821, 42822, 42823, 4283, 42830, 42831, 42832, 42833, 4284, 42840, 42841, 42842, 42843, 4289), ST-elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction (NSTEMI) (ICD-9: 41000, 41001, 41010, 41011, 41020, 41021, 41030, 41031, 41040, 41041, 41050, 41051, 41060, 41061, 41080, 41081, 41070, 41071, 41090, 41091), atrial fibrillation (ICD-9: 42731), aortic dissection (ICD-9: 44101, 44103, 4411, 4412, 4419), ischemic stroke (ICD-9: 43491), transient ischemic attack (TIA) (ICD-9: 4359), pulmonary embolism (PE) (ICD-9: 41591), deep vein thrombosis (DVT) (ICD-9: 45340), anemia (ICD-9: 2859), gastrointestinal bleed (ICD-9: 5789), acute renal failure (ICD-9: 584, 5845, 5846, 5847, 5848, 5849, 5939), septicemia (ICD-9: 0380, 0382, 0383, 0388, 0389, 0381, 03810, 03811, 03812, 03819, 0384, 03840, 03841, 03842, 03843, 03844, 03849), and complications (ICD-9: 995–999) within 180 days. Additional secondary outcomes were length of stay in days and hospitalization costs in U.S. dollars ($). NRD provides total charges per hospitalization and the cost-to-charge conversion ratio, which were used to calculate costs.

Covariates. The patient-level covariates used were age (categories of 0–15, 16–24, 25–34, 35–44, 45–54, and 55–90), sex (men and women), location (central metro with > 1 million population, fringe metro with > 1 million population, metro with population 250,000 to < 1 million and micropolitan areas), insurance provider (private/ Medicare and Medicaid/self-pay/no charge/other forms), median household national income quartiles ($1–$37,999, $38,000–$47,999, $48,000–$63,999, and ≥$64,000), and whether the patient resided in the same state as the hospital. Clinical comorbidities at the index hospitalization were derived in the dataset from ICD-9 diagnosis codes, and cumulative comorbidity was assessed using the Elixhauser comorbidity score (Elixhause, Steiner, Harris, & Coffey, 1998). Cardiovascular comorbidity score was calculated using Elixhauser definitions for congestive hearts failure, valvular disease, pulmonary circulation disorders, and peripheral vascular disease.

Hospital-level covariates were bed size of the hospital (small, medium, and large), teaching status of the hospital (metro nonteaching, metro teaching, and non-metro) and whether the hospital was an urban hospital. Severity of injury was considered primarily using the New Injury Severity Score (NISS), measured using ICD-9 diagnostic codes, using the ICD Programs for Injury Characteristic (ICDPIC), a Stata module that translates diagnosis codes into standard injury categories and scores (Clark, Osler, & Hahn, 2009). The NISS was categorized as quartiles (Osler, Baker, & Long, 1997; Osler, Rutledge, Deis, & Bedrick, 1996). The other measure used for injury severity based on location was Injury Severity Score (ISS) (Baker, O'Neill, Haddon, & Long, 1974; Copes, Sacco, Champion, & Bain, 2005; Lavoie, Moore, LeSage, Liberman, & Sampalis, 2004). Only the primary NISS and ISS variables in the present analysis were used.

Statistical Analysis

The two cohorts of male versus female firearm injury patients were compared. All analyses were performed using survey-weighted analysis using weights provided in the NRD. First, the baseline patient, hospital, and injury characteristics were compared; categorical variables were compared using χ^2 tests and continuous variables were compared using the Student's *t*-test. The severity of injury was calculated and compared using ICDPIC v. 3.0 in STATA 14.2 (Clark et al., 2009; StataCorp, 2015). Second, Kaplan–Meier curves using weighted survey estimates were constructed after truncating at 180 days of follow-up. Those patients who did not have a readmission until the end of each year were assumed to be alive until the end of that year. Third, survey-weighted Cox proportional hazard regression models were used, stratified by NISS to allow the baseline risk to vary by NISS, to determine the HRs, 95% CIs and the corresponding *p* values. The multivariable model was additionally adjusted for age, sex, median household income national quartile, hospital teaching status, and Elixhauser comorbidity score. Fifth, survey-weighted Poisson regression and linear regression of log transformed number of readmissions, LOS, and cost of hospitalization were performed at 30, 90, and 180 days. The mean and standard error (*SE*) were predicted from the adjusted model in the two groups and compared. The analysis was performed in August 2017. All analyses were performed using STATA 14.2 MP (StataCorp, 2015).

Results

Participants and Follow-Up

Patient and hospital characteristics are described in Table 1. Firearm hospitalizations were mainly men compared to women (88.5% vs. 11.5%). Males were younger, more likely to be of assaultive intent, less likely to be suicidal, live in central and fringe metropolitan areas, have Medicaid (or self-pay/no charge), live in low-income neighborhoods and more likely to have fewer comorbidities than women. Male patients were also more likely to be treated in urban hospitals. There was no difference in injury severity, cardiovascular comorbidity, or location by sex.

Risk of Cardiovascular Readmissions

A total of 108 (0.6%) cardiovascular patients that were readmitted to the hospital were males and very few were women (0.3%) (Table 2) within the first 180 days after discharge from index hospitalization. At 30 and 90 days, the cardiovascular readmission rate was 0.1% and 0.4% among males with no events among females. Among males, half of these events were diagnosed as atrial fibrillation (54, 0.3%). Kaplan–Meier curves comparing the survival incidence of males versus females are presented in Figure 1. Males had a greater risk of cardiovascular readmission within 180 days (HR = 3.34, 95% CI [1.18, 9.44], $p = .023$) than females. There were a total of 48 events of cerebrovascular readmissions; all events were among men and were mostly PE ($n = 47$). The mean age

Table 1. Baseline Patient, Hospital, and Injury Characteristics.

	Total	Male	Female	*p*
N	19,883	17,594 (88.5)	2,289 (11.5)	
Year, *n* (%)				.85
2013	9,966 (50.1)	8,811 (50.1)	1,155 (50.5)	
2014	9,917 (49.9)	8,783 (49.9)	1,134 (49.5)	
Age, mean (*SE*)	30.4 (0.2)	30.2 (0.2)	31.8 (0.6)	.003
Age, *n* (%)				<.0001
0–15	855 (4.3)	685 (3.9)	170 (7.4)	
16–24	7,521 (37.8)	6,817 (38.7)	704 (30.8)	
25–34	5,749 (28.9)	5,162 (29.3)	587 (25.6)	
35–44	2,727 (13.7)	2,373 (13.5)	354 (15.5)	
45–54	1,749 (8.8)	1,423 (8.1)	326 (14.2)	
55–90	1,282 (6.4)	1,134 (6.4)	149 (6.5)	
Intent of injury, *n* (%)				<.0001
Assault/legal intervention	12,266 (61.7)	10,994 (62.5)	1,272 (55.6)	
Unintentional	5,577 (28.0)	4,906 (27.9)	671 (29.3)	
Suicide	1,064 (5.3)	830 (4.7)	234 (10.2)	
Undetermined	977 (4.9)	864 (4.9)	113 (4.9)	
Location, *n* (%)				.002
Central Metro (>1 million)	8,005 (40.5)	7,187 (41.1)	818 (35.9)	
Fringe Metro (>1 million)	3,895 (19.7)	3,498 (20.0)	397 (17.4)	
Metro (250,000–1 million)	4,082 (20.7)	3,525 (20.1)	557 (24.4)	
Micropolitan	3,782 (19.1)	3,272 (18.7)	509 (22.3)	
Insurance, *n* (%)				<.0001
Private/Medicare	5,179 (26.1)	4,431 (25.2)	748 (32.7)	
Medicaid/self/no charge/other	14,659 (73.9)	13,120 (74.8)	1,539 (67.3)	
Median household income national quartile, *n* (%)				.048
$1–$37,999	10,457 (53.4)	9,306 (53.7)	1,151 (50.6)	
$38,000–$47,999	4,745 (24.2)	4,118 (23.8)	627 (27.6)	
$48,000–$63,999	3,036 (15.5)	2,720 (15.7)	316 (13.9)	
≥$64,000	1,353 (6.9)	1,174 (6.8)	179 (7.9)	
Patient resident same as hospital state, *n* (%)	18,459 (92.8)	16,358 (93.0)	2,101 (91.8)	.38
Hospital				
Bed size, *n* (%)				.66
Small	988 (5.0)	861 (4.9)	127 (5.6)	
Medium	4,328 (21.8)	3,857 (21.9)	472 (20.6)	
Large	14,567 (73.3)	12,877 (73.2)	1,690 (73.8)	
Teaching status, *n* (%)				.63
Metro, nonteaching	2,610 (13.1)	2,292 (13.0)	318 (13.9)	
Metro, teaching	16,714 (84.1)	14,799 (84.1)	1,916 (83.7)	
Non-metro	559 (2.8)	504 (2.9)	56 (2.4)	
Urban hospital, *n* (%)	12,723 (64.0)	11,369 (64.6)	1,354 (59.1)	.007
Injury severity				
Computed NISS, mean (*SE*)	13.8 (0.2)	13.8 (0.2)	14.1 (0.4)	.39
Computed NISS, *n* (%)				.42
0–5 (1st quartile)	5,204 (26.2)	4,589 (26.1)	615 (26.9)	
6–10 (2nd quartile)	4,748 (23.9)	4,251 (24.2)	497 (21.7)	
11–22 (3rd quartile)	6,203 (31.2)	5,491 (31.2)	712 (31.1)	
23–75 (4th quartile)	3,726 (18.7)	3,260 (18.5)	466 (20.4)	
ISS body region, *n* (%)				.0001
Head or neck	1,291 (6.5)	1,065 (6.1)	225 (9.8)	
Face	889 (4.5)	748 (4.3)	141 (6.1)	
Chest	2,520 (12.7)	2,194 (12.5)	326 (14.2)	
Abdominal or pelvic contents	5,109 (25.7)	4,561 (25.9)	548 (23.9)	
Extremities or pelvic girdle	7,392 (37.2)	6,631 (37.7)	761 (33.2)	
External	2,538 (12.8)	2,258 (12.8)	280 (12.2)	

(continued)

Table 1. (continued)

	Total	Male	Female	*p*
Computed NISS, mean (*SE*) in each ISS category				
Head or neck	20.8 (0.6)	20.7 (0.7)	21.1 (1.7)	.82
Face	12.5 (0.5)	12.3 (0.5)	13.6 (1.1)	.30
Chest	21.3 (0.4)	21.2 (0.4)	22.5 (1.03)	.23
Abdominal or pelvic contents	18.6 (0.3)	18.8 (0.4)	17.3 (0.8)	.070
Extremities or pelvic girdle	10.0 (0.1)	10.0 (0.1)	9.9 (0.3)	.77
External	5.0 (0.2)	5.1 (0.3)	4.3 (0.5)	.14
Elixhauser comorbidity score				
Mean (*SE*)	0.94 (0.02)	0.92 (0.02)	1.07 (0.04)	<.0001
Categories, *n* (%)				.010
0	9,520 (47.9)	8,506 (48.3)	1,014 (44.3)	
1	5,376 (27.0)	4,776 (27.1)	600 (26.2)	
2	2,910 (14.6)	2,535 (14.4)	376 (16.4)	
≥3	2,078 (10.5)	1,778 (10.1)	300 (13.1)	
Cardiovascular comorbidity score				
Mean (*SE*)	0.03 (0.00)	0.02 (0.00)	0.03 (0.01)	.21
Categories, *n* (%)				.20
0	19,401 (97.6)	17,188 (97.7)	2,213 (96.6)	
1	464 (2.3)	390 (2.2)	75 (3.3)	
2	− (0.1)	16 (0.1)	<10 (0.1)	

Note. All values are weighted frequency and percentages except first line of age, which is weighted mean and *SE*. *p*-value is derived from χ^2 test for all comparisons except comparisons of mean and *SE* which were tested using survey-weighted linear regression. Per NRD data use agreement, reporting of any given cell of tabulated data less than or equal to 10 must be avoided for reasons of confidentiality. ISS = Injury Severity Score; NISS = New Injury Severity Score; NRD = Nationwide Readmissions Database; *SE* = standard error.

of those readmitted due to cardiovascular causes was 56.9 years compared to 30.2 years for those without a cardiovascular readmission ($p < .0001$) (Table 3). The majority of those with a cardiovascular readmission also had three or more comorbidities (54%) as compared to those without a cardiovascular readmission (10.2%, $p < .0001$).

Risk of All-Cause Readmission

A total of 2,531 (14.4%) male and 303 (13.2%) female patients (a total of 14.3%) had their first readmission within 180 days after discharge following the initial index event (Table 2). Kaplan–Meier curves comparing the survival incidence of males versus females of all-cause readmission are presented in Figure 2. During the first 30 days males had a 45% greater risk (HR = 1.45, 95% CI [1.03, 2.03], $p = .029$) than female patients while the risk was 40% greater within 90 days (HR = 1.40, 95% CI [1.04, 1.87], $p = .024$). The risk of all-cause readmission at 180 days among males was not significantly different than among females.

Risk of Other Cause Readmission Within 180 Days

There was no significant difference by sex in the risk of readmission related to anemia, septicemia, and complications. Risk of renal failure was greater among males than females (HR = 3.14, 95% CI [1.23, 8.03], $p = .017$) (Table 2).

Length of Stay and Cost of Hospitalization

Means and standard deviations (*SD*s) predicted from multivariable analysis to assess mean gender differences in total LOS, total costs, and costs per readmission are presented in Table 4. Among those who survived the index hospitalization, after 30, 90, and 180 days, there were no significant difference between male and female patients in the mean of total LOS, LOS per readmission, total costs, and costs per readmission.

Discussion

In this analysis using a nationally representative readmission data in 2013 and 2014, among patients who were discharged alive after an index firearm injury hospitalization, 6 out of every 1,000 and 14 out of every 100 were found to be readmitted to the hospital during the first 180 days for cardiovascular causes and for any cause, respectively. The main observation in this study was that the male patients had a greater risk of cardiovascular readmissions than female patients by a factor of 3.3. Additionally, these events occurred only among males

Table 2. Clinical Outcomes During Readmission.

	Male, *n* (%)	Female, *n* (%)	HR (95% CI)	*p*
All-cause readmissions				
At 30 days	1,103 (6.3)	103 (4.5)	1.45 [1.03, 2.03]	.029
At 90 days	1,885 (10.7)	191 (8.3)	1.40 [1.04, 1.87]	.024
At 180 days	2,531 (14.4)	303 (13.2)	1.19 [0.91, 1.57]	.20
Cardiovascular readmissions				
At 30 days	14 (0.1)	0 (0)	–	
At 90 days	69 (0.4)	0 (0)	–	
At 180 days	108 (0.6)	<10 (0.3)	3.34 [1.18, 9.44]	.023
Heart failure	32 (0.2)	<10 ()	1.04 [0.37, 2.95]	.94
STEMI	30 (0.2)	0 (0)	–	
NSTEMI	26 (0.1)	0 (0)	–	
Atrial fibrillation	54 (0.3)	0 (0)	–	
Aortic dissection	0 (0)	0 (0)	–	
Stroke or TIA or PE	48 (0.3)	0 (0)	–	
Ischemic stroke	0 (0)	0 (0)	–	
TIA	<10 ()	0 (0)	–	
PE	47 (0.3)	0 (0)	–	
DVT	19 (0.1)	0 (0)	–	
Other-cause readmissions				
At 180 days				
Anemia	244 (1.4)	27 (1.2)	1.33 [0.73, 2.44]	.35
Gastrointestinal bleed	24 (0.1)	0 (0)	–	
Acute renal failure	159 (0.9)	10 (0.4)	3.14 [1.23, 8.03]	.017
Septicemia	138 (0.8)	11 (0.5)	2.42 [0.95, 6.16]	.063
Complications	712 (4.0)	68 (3.0)	1.44 [0.96, 2.16]	.078

Note. All values are weighted. Clinical outcomes are derived from ICD-9 CM code indicating primary diagnosis from hospitalization after the index injury hospitalization. HR is adjusted for age, household income, Elixhauser comorbidity score category, treatment at teaching hospital during index injury, and stratified by new injury severity score. Survey-weighted cox proportional hazard regression was used to estimate HRs, 95% CI, and *p* values. Per NRD data use agreement, reporting of any given cell of tabulated data less than or equal to 10 must be avoided for reasons of confidentiality. CI = confidence interval; DVT = deep vein thrombosis; HR = hazard ratio; NSTEMI = non-ST elevation myocardial infarction; PE = pulmonary embolism; STEMI = ST-elevation myocardial infarction; TIA = transient ischemic attack.

during the first 90 days. There were two additional findings. First, the 30-day and 90-day follow-up risks of all-cause readmissions among males were 45% and 40% greater than females at the same follow-up points. At 180 days, there was no difference by sex. Second, there were no sex differences in number of readmissions and cost of readmissions during the first 30, 60, or 180 days.

Nonfatal firearm injuries have been on the rise nationally since 2001, while fatal injuries have remained constant (Kalesan et al., 2017; Vandewalle, Peceny, Dolejs, Raymond, & Rouse, 2017). The Hospital Readmission Reduction Program was created in 2008 in an effort to reduce expensive readmissions within 30 days. Since the implementation of this program, Medicare has reported a decline in readmissions within 30 days after discharge of patients undergoing certain targeted surgical procedures (colectomy, lung resection, abdominal aortic aneurysm repair, coronary artery bypass graft, aortic valve replacement, mitral valve repair) from 6.8% in 2010 to 4.8% in 2012 (Ibrahim, Nathan, Thumma, & Dimick, 2017). Another study that assessed the effect of the Affordable Care Act reported a slower rate in reduction of the 30-day readmission rate among targeted surgical patients (4.7% in 2015) (Zuckerman, Sheingold, Orav, Ruhter, & Epstein, 2016). In this study, the rates of all-cause readmission within 30 days among firearm injury hospitalizations was 6.3% during 2013 and 2014, with a continuing increase reaching 14.3% by 180 days, indicating not only a higher rate of 30-day readmission as compared to after targeted surgical procedures but also an increasing risk of readmission with time. Interestingly, in one single center study, readmissions after orthopedic surgery reported a 5% readmission rate at 30 days and a 6% rate at 90 days (Weinberg, Kraay, Fitzgerald, Sidagam, & Wera, 2017), indicating the comparatively high burden of morbidity among firearm injury patients as observed in this study.

To date, this study provides the first evidence of sex-specific differences in readmission rates after discharge

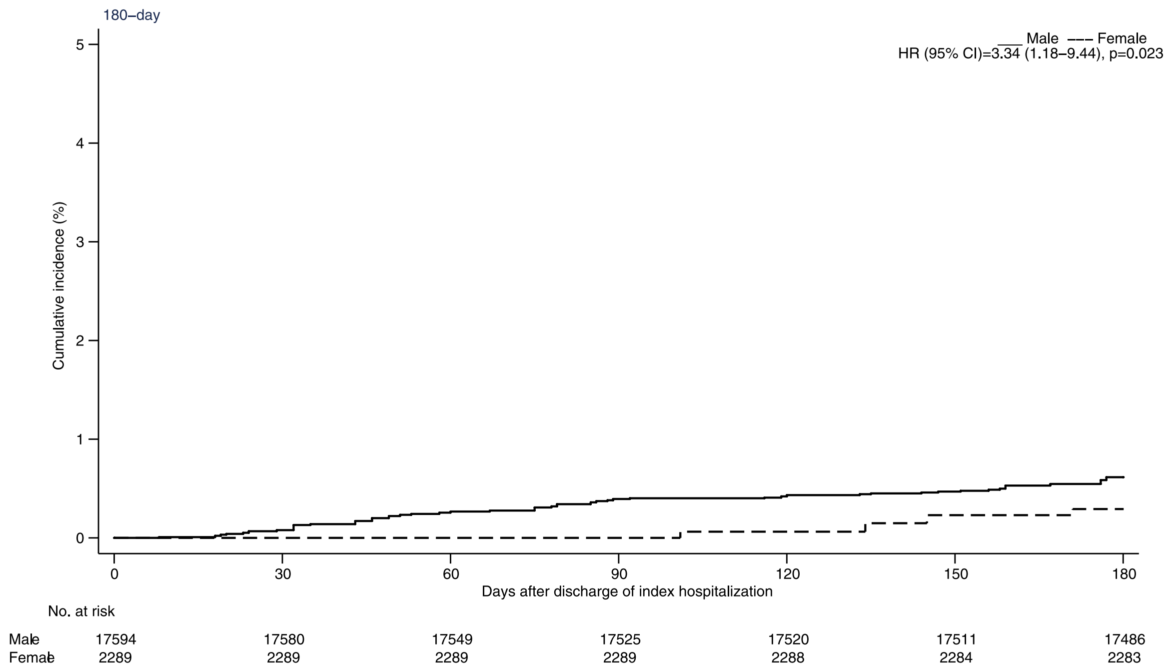

Figure 1. Kaplan–Meier curve for 180-day risk of cardiovascular readmission.
Survival incidence curves compare cardiovascular readmission among males and females. The solid line denotes males and broken line denotes females.

Table 3. Patient Characteristics by Readmission Status at 180 Days Following Index Hospitalization.

	Total	Yes	No	*p*
All-cause readmission, *n* (%)	19,883	2,834 (14.3)	17,050 (85.7)	
Age, mean (*SE*)	30.4 (0.2)	32.9 (0.6)	30.0 (0.2)	<.0001
Elixhauser comorbidity categories, *n* (%)				<.0001
0	9,520 (47.9)	959 (33.8)	8,561 (50.2)	
1	5,376 (27.0)	790 (27.9)	4,586 (26.9)	
2	2,910 (14.6)	577 (20.3)	2,334 (13.7)	
≥3	2,078 (10.5)	509 (17.9)	1,569 (9.2)	
Cardiovascular readmission, *n* (%)	19,883	115 (0.6)	19,769 (99.4)	
Age, mean (*SE*)	30.4 (0.2)	56.9 (2.8)	30.2 (0.2)	<.0001
Elixhauser comorbidity categories, *n* (%)				<.0001
0	9,520 (47.9)	15 (13.4)	9,504 (48.1)	
1	5,376 (27.0)	24 (20.9)	5,352 (27.1)	
2	2,910 (14.6)	14 (11.7)	2,897 (14.7)	
≥3	2,078 (10.5)	62 (54.0)	2,016 (10.2)	

Note. All values are weighted. Clinical outcomes are derived from ICD-9 CM code indicating primary diagnosis from hospitalization after the index injury hospitalization. *p*-value is derived from χ^2 test for Elixhauser comorbidity categories. Mean and *SE* of age and NISS were tested using survey-weighted linear regression. NISS = New Injury Severity Score; *SE* = standard error.

from firearm injury hospitalization. In comparable hospitalizations, for example, acute myocardial infarction hospitalizations, where the cohort is predominantly male, women were 54% less likely than men to be readmitted to the hospital throughout the first year (22% men and 13% women) (Lundback et al., 2017). In contrast, in another large-scale study of over 3 million hospitalizations, female sex was associated with the highest risk of hospital readmission following myocardial infarction and women demonstrated a modest but significantly higher risk for overall hospital readmission compared to men (Dreyer et al., 2017). The results of this study identified an increased readmission to the hospital among men during 30 and 90 days and then no risk difference at 180 days. These results

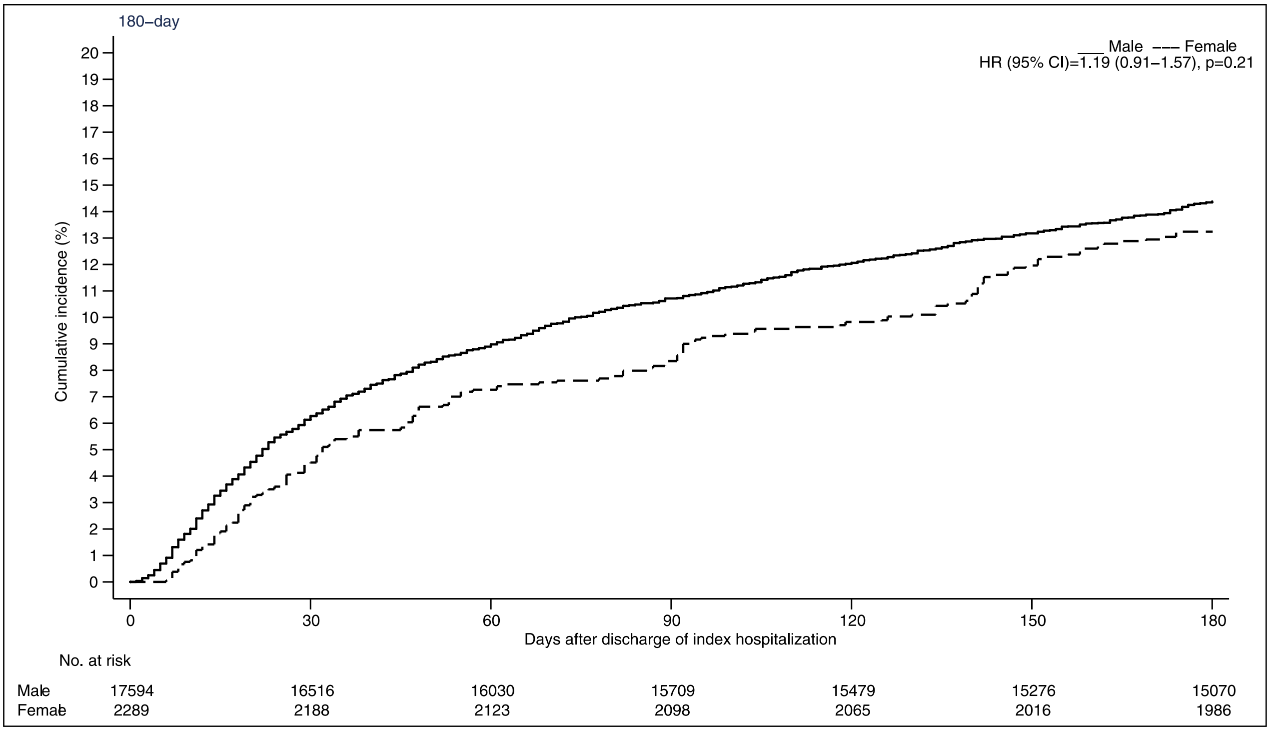

Figure 2. Kaplan–Meier curve for 180-day risk of all-cause readmission.
Survival incidence curves compare all-cause readmission among males and females. The solid line denotes males and broken line denotes females.

indicate an entirely different sex-specific profile among firearm injury patients compared to readmissions after chronic disease treatment. These results may be in concordance with readmission assessment after specific orthopedic surgical procedures where the risk of readmission was greater among male patients (Basques, Webb, Bohl, Golinvaux, & Grauer, 2015).

Interestingly, the present investigation provides preliminary evidence regarding the risk of early cardiovascular and acute renal failure hospital readmission after firearm injury. Although male firearm hospitalizations in this study were younger than female patients, those readmitted for cardiovascular causes were older. The most frequent cause of cardiovascular readmissions in this study, with greater risk among males than females, was due to atrial fibrillation. This increased cardiovascular risk may be explained by the older age of those admitted for cardiovascular diseases, indicative of early aging. There is some evidence linking trauma and heart failure (Alkhawam et al., 2016; Mehrotra, Dalley, & Mahon, 2012; Namai, Sakurai, & Fujiwara, 2007). The results of increased risk of cardiovascular readmission were similarly demonstrated in a study of 30-day readmission after cranial neurosurgery, where there was an increased risk of congestive heart failure hospitalizations (Moghavem, Morrison, Ratliff, & Hernandez-Boussard, 2015). A retrospective evaluation of trauma patients reported that among those trauma patients with prior history of heart failure, 24% were readmitted due to heart failure complications (Alkhawam et al., 2016). However, neither sex differences nor firearm-related cardiovascular risk was reported.

The factors contributing to readmission after nonfatal firearm injury are worthy of future investigation, particularly by designing studies with longer follow-up. Moving forward, an opportunity may present itself to design sex-based interventions to improve care for patients after discharge over the first several months following index firearm injury, including interventions in men that aim to improve health outcomes in an often economically disadvantaged population with limited access to health care.

These results have several limitations. First, data from claims-based hospitalizations were used, where there is no active follow-up to assess mortality or other non-hospitalization morbidity after being discharged alive. Second, the lack of longer follow-up restricts the analysis, preventing longer term follow-up analysis approaches that might be useful to address the questions at hand. Third, although the patient-level data are weighted to allow for national estimates, the sample does not provide race/ethnicity variable that precludes analysis to explore race/ethnicity differences in risk. Fourth, the data collection procedures may have been different in different hospitals and states, which may result in possible misclassification bias. On the other hand, the lack of sufficient follow-up duration after surviving the index hospitalization may have underestimated the counts of readmissions,

Table 4. Multivariable Association Among Females Versus Males With Costs and Duration of Readmissions.

	Male	Female		
	Mean (*SD*)	Mean (*SD*)	IRR (95% CI)	*p*
No. of readmissions				
At 30 days	1.03 (0.55)	1.05 (0.44)	1.19 [0.99, 1.40]	.067
At 90 days	1.17 (0.88)	1.25 (0.85)	1.03 [0.85, 1.25]	.077
At 180 days	1.26 (1.12)	1.27 (0.99)	1.21 [0.98, 1.49]	.077
	Mean (*SD*)	Mean (*SD*)	*b* (95% CI)	*p*
Total cost, $				
At 30 days	7,732 (1156)	8,818 (1220)	−0.13 [−0.45, 0.19]	.43
At 90 days	8,964 (804)	10,984 (1046)	−0.18 [−0.44, 0.09]	.20
At 180 days	12,235 (2329)	12,960 (2409)	−0.03 [−0.27, 0.21]	.80
	Mean (*SD*)	Mean (*SD*)	*b* (95% CI)	*p*
Cost per readmission, $				
At 30 days	7,465 (1057)	8,498 (1038)	−0.13 [−0.44, 0.18]	.41
At 90 days	8,018 (797)	9,594 (1021)	−0.15 [−0.42, 0.12]	.27
At 180 days	10,377 (1507)	10,965 (1603)	−0.04 [−0.25, 0.18]	.74
	Mean (*SD*)	Mean (*SD*)	*b* (95% CI)	*p*
Total length of stay, days				
At 30 days	3.98 (0.56)	4.04 (0.66)	0.02 [−0.27, 0.31]	.89
At 90 days	4.44 (0.47)	5.03 (0.52)	−0.10 [−0.36, 0.15]	.43
At 180 days	4.68 (0.75)	5.11 (0.79)	−0.06 [−0.26, 0.14]	.54
	Mean (*SD*)	Mean (*SD*)	*b* (95% CI)	*p*
Length of stay per readmission, days				
At 30 days	1.35 (0.09)	1.36 (0.11)	0.01 [−0.14, 0.16]	.88
At 90 days	1.31 (0.08)	1.38 (0.10)	−0.03 [−0.18, 0.11]	.64
At 180 days	1.29 (0.06)	1.31 (0.06)	−0.01 [−0.13, 0.11]	.84

Note. All mean and *SE* are weighted. Since the distribution of cost and length of hospital stay was right-skewed, both were log transformed. Survey linear regression was used for cost and survey poisson regression for number of readmissions; mean and 95% CI is from the model. Number of readmissions considered only those who had a readmission during the specific time period. The multivariable models were adjusted for year, age, household income categories, teaching status, Elixhauser comorbidity score categories, and stratified by NISS. CI = confidence interval; IRR = incidence rate ratio; NISS = New Injury Severity Score; *SD* = standard deviation; *SE* = standard error.

which has been attempted to be corrected by excluding the index injuries after July. Fifth, it was not possible to assess the state-specific differences in injury type due to the lack of state-specific information. Sixth, the low number of cardiovascular readmissions among women in our dataset limits the statistical power of those results. Future studies would benefit from a longer and more informative follow-up time capturing information about mortality and non-hospitalization morbidity, as well as information on race/ethnicity to better identify vulnerable populations.

In summary, males have substantially greater hospital readmission risk during the first 3 months after an index firearm injury hospitalization compared to females. This overall risk discrepancy was no longer observed by 180 days after the index event. However, the specific risks of renal failure and cardiovascular readmissions among males were greater than females at 180 days. The lack of differences in cost of treatment and length of stay during readmissions highlights the continued treatment and costs of firearm violence as a public health problem.

Author contribution

All authors conceived the study and led the writing. Zuo and Kalesan obtained data and performed the analyses.

Declaration of Conflicting Interests

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