



Firearm-related behaviors following firearm injury: changes in ownership, carrying and storage

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Abstract Individuals who sustain nonfatal gunshot wound (GSW) injuries are at substantially increased risk of subsequent firearm injury. There is a dearth of literature examining what, if any, firearm-related behavior changes occur among adults as a result of GSW injuries. Using survey data on firearm-related behaviors from an ongoing randomized controlled trial, we sought to describe changes in reported firearm-related behaviors among GSW patients following their injury. Our results suggest that patients with a GSW, especially firearm owners, may change their firearm-related behaviors following injury, some by increasing firearm-related safety and others by increasing frequency of behaviors that may place them at increased risk of subsequent injury. This study highlights the need for further examination of firearm-related behavior change among GSW patients and development of interventions to promote firearm safety among this population.

Keywords Firearm ownership · Firearm carrying · Firearm storage · Gunshot wound · Behavior change

Introduction

Individuals who survive a gunshot wound (GSW) are at substantially increased risk of subsequent firearm injury (Rowhani-Rahbar et al., 2015), potentially due in part to their firearm-related behaviors such as ownership, carrying and storage. Sustaining a GSW may serve as a sentinel event for behavior change; as such, these individuals may also benefit from hospital-based interventions focused on reducing risk of subsequent firearm injury or perpetrating firearm-related crime (Boudreaux et al., 2012; Carter et al., 2015). Prior studies have highlighted the promise of providing interventions among trauma patients for reducing high-risk behavior or subsequent injury. One randomized trial of a brief motivational interview provided at bedside among injury patients with a positive blood alcohol level found a reduction in alcohol consumption and approximately 50% reduction in the risk of subsequent injuries 12 months later (Gentilello et al., 1999). Another randomized trial of a 12-month collaborative care intervention of a multidisciplinary care management team found a significant reduction in weapon carrying among injured youth (Zatzick et al., 2014).

There is a dearth of literature examining what, if any, firearm-related behavior changes occur among adults following a GSW. To our knowledge, there is currently no standardized and widely-adopted hospital-based assessment of firearm-related behaviors nor hospital-based intervention specifically to promote firearm safety among GSW patients. In this study, we sought to describe changes in firearm-related behaviors among GSW patients follow-

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ing their injury. Understanding if, and what type of, firearm-related behavior change occurs following a GSW can support development of interventions to improve firearm safety among these patients, potentially decreasing their elevated risk of subsequent GSW injury or death.

Methods

Study population and data

All study procedures were approved by the University of Washington Human Subjects Division (Institutional Review Board), and study participants provided informed consent for all study procedures. This study was nested within an ongoing randomized controlled trial of GSW patients that began in March 2016, with recruitment ending December 2018 and follow up continuing through June 2019. Patients 18 years of age or older who had sustained an assault or unintentional firearm injury were enrolled following presentation for a GSW to Harborview Medical Center, the regional Level 1 Trauma Center in Seattle, WA. To be eligible, patients needed to reside in one of five counties in Washington State that could be reached by the study interventionist. Regular survey follow-ups are conducted as part of the trial at 1, 3, 6, 9 and 12 months following hospital discharge, with a baseline survey conducted as soon as possible after injury. We added a firearm-related behavior survey supplement to the regular follow-up surveys in March 2017. At the time of this analysis, 232 patients had been enrolled in the trial (5 of whom had completed the study prior to the addition of these questions and who did not have an opportunity to respond) and 163 answered the firearm-related behavior survey supplement. The study intervention, consisting of case-management for 6 months using an adapted Critical Time Intervention, is designed to improve patients' general health and wellbeing following injury, with a focus on reducing recidivism, but is not focused specifically on firearm-related behaviors (Coalition for Evidence Based Policy, 2018). Among patients who answered the firearm survey supplement, there were a total of 86 patients (52.8%) enrolled in the intervention arm of the study.

After the addition of the firearm-behavior survey supplement, patients were given questions on both pre-injury and post-injury firearm ownership, carrying and storage practices at the next regular follow up, regardless of whether the next follow up post survey roll out was 1, 3, 6, 9 or 12 months post-discharge. Pre-injury firearm behavior questions pertained to their firearm related behavior in the 30 days prior to their injury, while post-injury firearm behavior questions pertained to the 30 days prior to this survey. The firearm-related behavior survey supplement

also included a comment box that some patients used to provide additional thoughts and feedback (Appendix A).

Demographic data and injury characteristics

Patient age, sex, race, ethnicity and injury intent (assault or unintentional) were abstracted from the patient's electronic medical record of the initial hospital encounter for the GSW. Employment, marital status, income, housing stability, and arrest in the past year were self-reported in the baseline survey. Injury severity scores (ISS) were obtained from the Harborview Trauma Registry following comprehensive review of patient charts; higher scores represent more severe injuries (scores range from 1 to 75).

Standardized assessments

To assess post-traumatic stress disorder (PTSD), we used the PTSD Checklist developed by the United States Department of Veterans Affairs for civilian use with higher scores indicating more PTSD symptoms (scores range from 17 to 85) (Weathers et al., 1993). We used the 8 question Patient Health Questionnaire (PHQ) to measure depression where a score ≥ 10 is considered major depression (scores range from 0 to 24) (Kroenke et al., 2001). To assess perceived social support, we used the Multidimensional Scale of Perceived Social Support total scale which includes questions assessing relationships with significant others, family, and friends where higher scores indicate greater perceived social support (scores range from 1 to 7) (Zimet et al., 1988). We used the 16 item Happiness Scale from the Community Reinforcement Approach to measure happiness, with higher scores indicating greater happiness (scores range from 16 to 160) (Meyers et al., 2011). General physical and mental health were assessed using the Short Form Health Surveys (SF-12) for physical health and mental health where higher scores indicate higher levels of health (scores range from 0 to 100 for both physical and mental health) (Ware et al., 1995). We used the World Health Organization's Alcohol Use Disorders Identification Test (AUDIT) to assess risky alcohol use with scores of 0–7 indicating low-risk, 8–15 indicating risky or hazardous alcohol consumption, 16–19 indicating high-risk and a score of ≥ 20 indicating alcohol dependence (scores range from 0 to 40) (Babor et al., 1992). Lifetime drug use was assessed using the World Health Organization's Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) modified by the National Institute on Drug Abuse to assess any lifetime drug use by drug type (Humeniuk et al., 2010).

Defining firearm behavior

Using the pre-injury and post-injury surveys, we defined a series of firearm-related behavior change variables. *Firearm ownership change* was defined as becoming a firearm owner or conversely selling or giving away all of their firearms after injury. Remaining a firearm owner, but changing the number of firearms owned was not included as ownership change. *Change in carrying behavior* was defined as either beginning to carry a loaded handgun in public, changing the frequency of carrying a loaded handgun in public including stopping any carry, obtaining a concealed carry weapons (CCW) permit, changing how frequently a loaded handgun was carried concealed, or changing the primary reason for carrying a firearm in public. Change in carrying behavior focuses specifically on handguns, as long guns are not as often carried in public. *Change in storage behavior* was defined as changing the location of firearm storage or initiation of safe storage (i.e. all firearms stored locked and unloaded). We then categorized behavior change into three categories: increasing firearm exposure, decreasing firearm exposure and no change in firearm-related exposure. *Increasing firearm exposure* included becoming a firearm owner, initiating carrying a loaded handgun in public, increasing the number of days a loaded handgun was carried in public, increasing frequency of carrying a loaded handgun concealed and obtaining a concealed weapons permit. *Decreasing firearm exposure* was categorized as becoming a non-firearm owner, ceasing to carry a loaded handgun in public, decreasing the number of days a loaded handgun was carried in public, carrying a loaded handgun concealed less frequently, and initiating safe storage. *No change in firearm exposure* was defined as having neither increasing or decreasing firearm exposure. No patients included in our study reported both increasing and decreasing firearm exposure, thus these categories represent mutually exclusive groups.

We additionally defined 6 mutually exclusive and collectively exhaustive groups for both pre-injury and post-injury firearm-related behavior separately to allow exploration of movement between pre-injury group membership and post-injury group membership. These groups were: (1) non-firearm owners, (2) firearm owners who do not carry a loaded handgun in public and who practice safe storage of all firearms, (3) firearm owners who carry a loaded handgun in public and who practice safe storage of all firearms, (4) firearm owners who do not carry a loaded handgun in public and who do not practice safe storage of all firearms, (5) firearm owners who carry a loaded handgun in public and who do not practice safe storage of all firearms, and (6) firearm owners with unknown carrying and storage

behavior. Patients who owned only long guns were placed into groups 2, 4 or 6 depending on their storage behavior.

Analysis

We used descriptive statistics to assess any firearm-related behavior change among the 163 patients who responded to the firearm-related behavior survey supplement during one of their regular follow-up surveys. Using the Pearson's Chi squared test, we tested for an intervention effect, comparing patients in the intervention arm to patients in the control arm of the parent study, and tested if reported-firearm related behavior change varied by the time between sustaining a GSW and survey completion. Among patients who reported owning a firearm at the time of injury, we calculated the proportion and 95% confidence intervals (CI) of each firearm-related behavior change. To illustrate patient flow between firearm behavior groups at pre-injury and post-injury assessment points, we used a Sankey diagram (Schmidt, 2008). Finally, we qualitatively described GSW incident circumstances as well as pre-injury and post-injury firearm-related behavior for a non-random selection of patients reporting behavior change to illustrate the variety of responses and reported incident characteristics. Analyses were conducted in Stata 14.2 and Highcharts (StataCorp, 2015; Highcharts, 2019).

Results

As stated above, of the 232 patients enrolled in the parent study, 163 completed the firearm-related behavior survey (response proportion of 70.3%). There was no statistically significant intervention effect on firearm-related exposure change ($p = 0.312$). Among intervention patients, 4.7% reported increasing firearm exposure, 18.6% reported decreasing exposure and 76.7% reported no change in firearm exposure compared to 3.9% of control patients who reported increasing exposure, 11.7% who reported decreasing exposure and 84.4% who reported no change ($p = 0.445$). Therefore, for the remainder of the analysis, the intervention and control groups were combined. About one-half of patients completed the survey 1 month following hospital discharge (54.0%), with a mean time from hospital discharge to survey completion of approximately 4 months, with the majority completing the survey at the one-month follow up (54.0%) and only 12.3% completing the survey 12 months after their GSW (Table 4 in Appendix B). The timing of survey completion also did not appear to be associated with reporting firearm-related exposure change ($p = 0.664$).

The majority of patients reported no change in firearm exposure (80.4%); 4.3% of patients reported an increase in

firearm exposure and 15.3% of patients reported a decrease in firearm exposure. PTSD scores were highest among patients with decreasing firearm exposure compared to patients with increasing firearm exposure and patients with no change in firearm exposure. A greater proportion of patients who reported no change in firearm exposure had an assault-related GSW compared to patients with increasing firearm behavior and patients with decreasing firearm behavior. Fewer patients with decreasing firearm exposure reported arrest in the year prior to their GSW, while arrest in the prior year was more common among patients with increasing firearm exposure and no change in firearm exposure (Table 1).

In part as a reflection of how we categorized firearm exposure groups, a smaller proportion of patients who reported no change in firearm ownership owned a firearm at the time of injury (16.8%) compared to patients who increased firearm exposure or decreased firearm exposure (Table 1). Patients who were non-firearm owners at the time of their injury would not have been eligible for a change in firearm carrying or storage practices unless they became a firearm owner, whereas patients who were firearm owners at the time of injury were eligible to change ownership, storage and carrying practices.

As shown in Table 2, among the 53 patients who reported owning a firearm at the time of their injury, 60.3% (95% CI 46.5–72.7) reported any firearm behavior change since hospital discharge. A total of 28.3% (95% CI 17.7–42.0) became non-firearm owners and 5.7% (95% CI 1.8–16.4) initiated safe firearm storage (all firearms locked and unloaded), with one of the patients initiating safe storage using the open text field to write ‘safety first!’. Fifteen patients, of whom 7 also became non-firearm owners, stopped carrying a loaded handgun in public (28.3%, 95% CI 17.7–42.0). Among the 110 patients who were non-firearm owners at the time of injury, 1 patient reported change in firearm-related behavior by becoming a firearm owner (0.9%, 95% CI 0.1–6.3).

Among patients who became non-firearm owners ($n = 15$), patients cited a personal concern for safety, their partner’s concern for safety, or concern for the safety of children in the house as the primary motivation. Patients also describe initiation of safe storage practices, and in one case, indicate that their firearm-related behavior change was non-voluntary (firearms were seized as parole violation) (Table 3). While Table 3 does not include every patient who reported behavior change, it does describe behavior change in the context of injury circumstances and illustrates the variety of patient behavior and firearm-related behavior responses to a non-fatal GSW.

The Sankey diagram (Fig. 1) illustrates the diversity of firearm-related behavior change following GSW among patients who reported owning a firearm at the time of

injury. Patients who shared the same firearm-related behavior group pre-GSW did not all report the same type of firearm-related behavior change or group membership post-GSW. The figure also visually demonstrates that there were more patients with decreasing firearm exposure than increasing firearm exposure. There was a single individual in both the pre- and post-GSW firearm behavior groups who was a firearm owner who carried a loaded handgun in public and practiced safe storage, these were not the same people. The Sankey diagram illustrates that patients who were firearm owners, carried loaded handgun in public and did not practice safe storage reported more diversity in behavior change than patients in other pre-GSW firearm behavior groups, splitting into four different firearm behavior groups post-GSW. There was also diversity in pre-GSW firearm-related behavior group membership among patients who became non-firearm owners, patients were owners who carried in public and practiced safe storage, owners who carried a loaded handgun in public and did not practice safe storage and owners with unknown carrying and storage behavior.

Discussion

While some prior literature has examined firearm-related behavior among youth following an assault-related injury (Carter et al., 2015), this study offers one of the first descriptions of change in firearm-related behavior among adults following a GSW. Our results suggest that while most patients with a GSW do not change their firearm-related behavior following injury, some firearm owners with a GSW may change their firearm-related behaviors following injury either by decreasing firearm exposure (i.e. removal of firearms and/or initiating safe storage) or increasing firearm exposure (i.e. increasing frequency of carrying a loaded handgun in public).

Patients who sustain a GSW may be well suited for either brief hospital-based interventions or integrated collaborative care interventions with a focus on increasing firearm safety, potentially including education and provision of safe storage options, and using the GSW as a sentinel event. Such an intervention would likely be most effective if provided exclusively to patients who own a firearm at the time of their injury as they are in a position to make changes to their firearm practices and over half reported some change in firearm-related behavior (60.3%). Non-firearm owners, on the other hand, are likely to remain non-firearm owners and thus, not likely to report any change in firearm-related behavior. Demographic differences between patients with and without any firearm-related behavior change may indicate a subpopulation of GSW patients who may be most receptive to a targeted

Table 1 Demographic information by self-reported firearm-related behavior change following GSW

	Increasing firearm exposure N = 7	Decreasing firearm exposure N = 25	No change in firearm exposure N = 131	Total N = 163
Patient age, years [\bar{x} (SD)]	25.9 (9)	31.0 (12)	29.9 (10)	29.9 (10)
Male [N (%)]	7 (100.0)	22 (88.0)	108 (82.4)	137 (84.0)
Race [N (%)]				
White	4 (57.1)	13 (52.0)	56 (44.1)	73 (45.9)
Black	2 (28.6)	10 (40.0)	54 (42.5)	66 (41.5)
Asian	0 (0.0)	1 (4.0)	6 (4.7)	7 (4.4)
Hawaiian/Pacific Islander	0 (0.0)	0 (0.0)	3 (2.4)	3 (1.9)
American Indian	1 (14.3)	1 (4.0)	8 (6.3)	10 (6.3)
Hispanic [N (%)]	3 (42.9)	3 (12.0)	15 (11.5)	21 (12.9)
Employment [N (%)]				
Working	5 (71.4)	14 (60.9)	71 (55.9)	90 (57.3)
Laid Off	1 (14.3)	4 (17.4)	25 (19.7)	30 (19.1)
Student	0 (0.0)	2 (8.7)	14 (11.0)	16 (10.2)
Homemaker	0 (0.0)	1 (4.3)	2 (1.6)	3 (1.9)
Retired	0 (0.0)	0 (0.0)	1 (0.8)	1 (0.6)
Other	1 (14.3)	2 (8.7)	14 (11.0)	17 (10.8)
Patient marital status [N (%)]				
Single	1 (33.3)	11 (47.8)	57 (50.0)	69 (49.3)
Married	0 (0.0)	3 (13.0)	17 (14.9)	20 (14.3)
In a relationship or dating	2 (66.7)	9 (39.1)	40 (35.1)	51 (36.4)
Patient household income [N (%)]				
< \$25 K	1 (20.0)	4 (23.5)	45 (51.1)	52 (43.3)
25–50 K	3 (60.0)	4 (23.5)	28 (28.6)	35 (29.2)
50–100 K	0 (0.0)	7 (41.2)	14 (14.3)	21 (17.5)
> 100 K	1 (20.0)	2 (11.8)	9 (9.2)	12 (10.0)
Stable housing [N (%)]	5 (71.4)	18 (72.0)	91 (70.0)	114 (70.4)
Arrested in past year [N (%)]	1 (14.3)	2 (8.3)	23 (17.6)	26 (16.0)
PCL-C score [\bar{x} (SD)]	24.6 (8)	40.4 (22)	33.7 (16)	34.4 (17)
PHQ-8 depression score [\bar{x} (SD)]	4.3 (5)	8.0 (7)	6.1 (6)	6.3 (6)
MPSS total score [\bar{x} (SD)]	5.9 (1)	4.9 (1)	5.3 (1)	5.2 (1)
Happiness score [\bar{x} (SD)]	89.7 (28)	80.8 (25)	83.5 (26)	83.4 (26)
SF12 physical score [\bar{x} (SD)]	54.3 (3)	52.4 (8)	50.0 (11)	50.6 (10)
SF12 mental score [\bar{x} (SD)]	54.3 (7)	47.5 (15)	48.5 (13)	48.9 (13)
Alcohol AUDIT score [\bar{x} (SD)]	3.0 (4)	3.8 (3)	3.0 (3)	3.1 (3)
ASSIST lifetime drug use [N (%)]				
Cannabis	6 (85.7)	19 (79.2)	114 (87.0)	139 (85.8)
Cocaine	3 (42.9)	15 (62.5)	56 (42.7)	74 (45.7)
Prescription stimulants	0 (0.0)	6 (25.0)	32 (24.6)	38 (23.6)
Methamphetamine	0 (0.0)	7 (29.2)	25 (19.1)	32 (19.8)
Inhalants	0 (0.0)	2 (8.3)	5 (3.9)	7 (4.4)
Sedatives or sleeping pills	1 (14.3)	5 (21.7)	33 (25.6)	39 (24.5)
Hallucinogens	2 (28.6)	7 (29.2)	47 (35.9)	56 (34.6)
Street opioids	0 (0.0)	2 (8.3)	17 (13.1)	19 (11.8)
Prescription opioids	3 (42.9)	8 (33.3)	60 (45.8)	71 (43.8)

Table 1 continued

	Increasing firearm exposure N = 7	Decreasing firearm exposure N = 25	No change in firearm exposure N = 131	Total N = 163
Injury intent [N (%)]				
Assault	5 (71.4)	13 (52.0)	101 (77.7)	119 (73.5)
Unintentional	2 (28.6)	11 (44.0)	20 (15.4)	33 (20.4)
Undetermined	0 (0.0)	1 (4.0)	9 (6.9)	10 (6.2)
Injury severity score [\bar{x} (SD)]	12.7 (9)	8.8 (6)	9.3 (8)	9.4 (8)
Gun owner at time of injury [N (%)]	6 (85.7)	25 (100.0)	22 (16.8)	53 (32.2)

Stable housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was their address. Transitional housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was not their address. Unstable housing includes individuals who indicated that they were couch surfing, homeless, or in a shelter

SD, standard deviation; PCL-C, PTSD Checklist Civilian Version (post-traumatic stress symptoms); PHQ-8, Patient Health Questionnaire (depression); MPSS, multidimensional scale of perceived social support (social support); SF-12, short form health survey (health-related quality of life); AUDIT, The Alcohol Use Identification Test (alcohol use); ASSIST, Alcohol, Smoking and Substance Involvement Screening Test (drug use)

Missingness Race (n = 4), employment (n = 6), marital status (n = 23), income (n = 43), arrest in prior year (n = 1), MPSS (n = 1), happiness (n = 1), SF-12 physical (n = 4), SF-12 mental (n = 4), ASSIST cannabis (n = 1), cocaine (n = 1), prescription stimulants (n = 2), methamphetamine (n = 1), inhalants (n = 5), sedatives (n = 4), hallucinogens (n = 1), street opioids (n = 2), prescription opioids (n = 1), injury intent (n = 1), ISS (n = 2)

Table 2 Firearm-related behavior change observed among firearm owners at time of injury

	Firearm owners at time of injury N = 53	
	N	Proportion (95% confidence interval)
Any firearm behavior change	32	60.3 (46.5–72.7)
Became a non-firearm owner	15	28.3 (17.7–42.0)
Carrying change	15	28.3 (17.7–42.0)
Began carrying in public	1	1.9 (0.3–12.6)
Stopped carrying in public	15	28.3 (17.7–42.0)
Increased number of days carried in public	1	1.9 (0.3–12.6)
Increased frequency of concealed carry	2	3.8 (0.9–14.2)
Changed primary reason for carrying	9	17.0 (9.0–29.8)
Obtained a CCW permit	7	13.2 (6.3–25.5)
Storage change	7	13.2 (6.3–25.5)
Changed storage location	4	7.5 (2.8–18.7)
Initiated safe storage	3	5.7 (1.8–16.4)

One patient became a firearm owner following their injury, they are not included in this table as they were not a firearm owner at the time of injury

intervention. Patients with behavior change were likely to have higher mean PTSD symptom scores and have a non-assault related GSW when compared to patients without any reported behavior change. Given our small sample size, observed differences between our firearm behavior groups are quite sensitive to individual patient responses and may be different in a larger population of patients with a GSW. However, if true, the higher mean PTSD symptom score among patients with reported behavior change would warrant future study and investigation to determine its

relationship with injury characteristics and firearm-related behavior.

Among patients with firearm-related behavior change, patients either increased or decreased their firearm exposure following their GSW. These behavior changes may not necessarily be related to perceived risk of future injury. Patients with increasing firearm exposure may be driven by a fear-based response, as they may see increasing firearm use as a method for deterring future firearm-based violence (Rappaport & Thomas, 2004). This motivation for

Table 3 Description of firearm behavior change for a selection of patients with self-reported firearm behavior change

Patient	Firearm behavior pre-GSW	Description of incident	Firearm-related behavior post-GSW
A	<p><i>Firearm ownership</i> Multiple firearms, multiple types</p> <p><i>Ownership primary reason</i> Protection</p> <p><i>30-day carry</i> Every day</p> <p><i>Carried concealed</i> Always</p> <p><i>CCW permit</i> Yes</p> <p><i>Storage type</i> Not practicing safe storage</p> <p><i>Storage location</i> Multiple locations</p>	<p><i>Incident type</i> Intentional inter-personal.</p> <p><i>Notes</i> Patient was carrying one of the firearms at the time and both displayed the gun and shot the gun in an attempt to defend themselves</p>	After the injury, patient began storing all guns either loaded and locked or loaded and unlocked. Patient's carrying practices did not change
B	<p><i>Firearm ownership</i> Multiple firearms, multiple types</p> <p><i>Ownership primary reason</i> Protection</p> <p><i>30-day carry</i> Every day</p> <p><i>Carried concealed</i> 75% of the time</p> <p><i>CCW permit</i> No</p> <p><i>Storage type</i> Safe storage</p> <p><i>Storage location</i> Home</p>	<p><i>Incident type</i> Intentional inter-personal</p>	After the injury, patient was arrested on a violation of parole and no longer have any of their firearms. States now trying to change their life
C	<p><i>Firearm ownership</i> Single firearm</p> <p><i>Ownership primary reason</i> Protection</p> <p><i>30-day carry</i> Every day</p> <p><i>Carried concealed</i> Always</p> <p><i>CCW permit</i> Yes</p> <p><i>Storage type</i> Not practicing safe storage</p> <p><i>Storage location</i> Home</p>	<p><i>Incident type</i> Unintentional self-inflicted</p> <p><i>Notes</i> Thought the firearm was unloaded</p>	After the injury, patient got rid of the firearm (unknown how)
D	<p><i>Firearm ownership</i> Multiple firearms, multiple types</p> <p><i>Ownership primary reason</i> Collection</p> <p><i>30-day carry</i> Every day</p> <p><i>Carried concealed</i> Always</p> <p><i>CCW permit</i> Yes</p> <p><i>Storage type</i> Not practicing safe storage</p> <p><i>Storage location</i> Home</p>	<p><i>Incident type</i> Unintentional self-inflicted</p> <p><i>Notes</i> Shot while hunting</p>	Since being shot, patient has not carried a loaded handgun in public and the handgun that was stored loaded and unlocked is now stored loaded and locked
E	<p><i>Firearm ownership</i> Owner, unknown type or number</p> <p><i>Ownership primary reason</i> Unknown</p> <p><i>30-day carry</i> Unknown</p> <p><i>Carried concealed</i> Unknown</p> <p><i>CCW permit</i> Unknown</p> <p><i>Storage type</i> Unknown</p> <p><i>Storage location</i> Unknown</p>	<p><i>Incident type</i> Intentional inter-personal</p>	Patient sold the firearm after the injury as patient was worried 'they might shoot somebody'
F	<p><i>Firearm ownership</i> Single firearm</p> <p><i>Ownership primary reason</i> Protection</p> <p><i>30-day carry</i> Every day</p> <p><i>Carried concealed</i> Always</p> <p><i>CCW permit</i> Yes</p> <p><i>Storage type</i> Not practicing safe storage</p> <p><i>Storage location</i> Home</p>	<p><i>Incident type</i> Unintentional self-inflicted</p>	Since the injury, patient has not carried the firearm in public. The firearm is now stored unloaded and locked
G	<p><i>Firearm ownership</i> Multiple firearms, multiple types</p> <p><i>Ownership primary reason</i> Protection</p> <p><i>30-day carry</i> No</p> <p><i>CCW permit</i> No</p> <p><i>Storage type</i> Safe storage</p> <p><i>Storage location</i> Home</p>	<p><i>Incident type</i> Unintentional self-inflicted</p> <p><i>Notes</i> Thought the safety was on</p>	After the injury, patient sold old firearms and purchased new firearms for collection purposes. Patient began carrying a loaded handgun in public every day for protection and always carried it concealed. Patient obtained a concealed carry weapons permit. Patient's storage practices have not changed

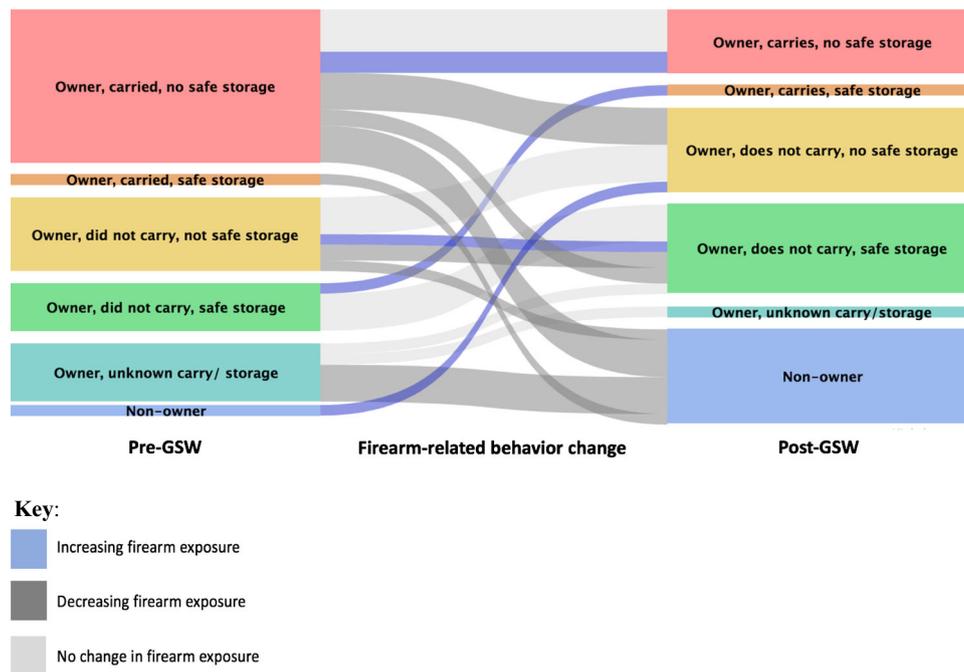


Fig. 1 Sankey diagram of firearm-related behavior change before and after GSW among patients who owned a firearm either at the time of their injury or subsequently (n = 54). *Interpretation* The left and right-hand side of the Sankey diagram display the firearm behavior group that patients belonged to pre- and post-GSW, respectively, among patients who reported owning a firearm at the time of injury. The thickness of the lines connecting the left and right-hand sides of the diagram illustrate the absolute number of patients who moved from each pre-GSW firearm behavior group to each post-GSW firearm behavior groups. The colors used for the lines that connect the pre- and post-GSW firearm behavior groups indicate the whether or

not the change increased firearm exposure, decreased firearm exposure, or did not change firearm exposure. *Note:* There are seven people whose firearm-related behavior increased (indicated with the lavender lines), but only two changed firearm behavior groups. This is because the firearm behavior groups are based on only ownership, whether or not an individual carried a firearm at all in the 30 days prior to the injury and whether or not they practiced safe storage, and did not consider the other firearm-related behaviors (e.g. obtaining a CCW, increasing the number of days they carried a handgun in public)

increasing firearm exposure may be most likely among those with assault related injury. One patient with increasing firearm exposure carried a loaded handgun in public for 5 out of the 30 days prior to their injury, but after their injury began carrying a loaded handgun in public every day “to protect themselves”. Increasing firearm exposure may not necessarily indicate an increased risk of future firearm violence or GSW, but it may suggest one of several mechanisms by which patients with a GSW are at higher risk of subsequent GSW, crime or death. Patients with decreasing firearm exposure may be similarly driven by a fear-based response. In our study, patients with decreasing firearm exposure may have seen their pre-GSW firearm exposure as a cause of their GSW and chosen to decrease their firearm exposure as a means to prevent potential future firearm-related injury.

While there are currently no standardized, widely-adopted interventions specifically tailored toward firearm-related behavior change among GSW patients, behavior change counseling among youth in the emergency department, motivational interviewing among patients with a

motor vehicle crash injury, and stepped collaborative care for trauma patients have all been shown to decrease behaviors associated with subsequent injury (e.g., decreasing alcohol use) (Gentilello et al., 1999; Johnston et al., 2002; Zatzick et al., 2004). It is possible that a focused intervention with similar features might demonstrate similar success at increasing firearm safety behavior among GSW patients (e.g. increasing safe storage) as a means to reduce risk of subsequent injury.

Reliability of responses

This study relies on self-report of firearm-related behaviors, and may be subject to social desirability bias and intentional false-reporting. Two patients disclosed owning firearms to the study interventionist, but told her that they would be reporting they were not firearm owners. We have excluded them from the analysis. We also believe that there may have been some misclassification of injury intent, as some of the behavior change reported does not seem to logically follow in response to the description of the inci-

dent. For example, Patient G described shooting themselves unintentionally while transporting the firearm at their house, thinking the safety was on. Following their GSW, they began carrying a loaded handgun concealed in public every day (and did not change their storage practices) potentially a more logical response to an assault (see Table 3). The misclassification of GSW injury intent, especially for GSW reported as being unintentional, has been discussed in the literature before as potentially driven by “antisnitch” codes of silence and may often be truly assault-related (Rowhani-Rahbar et al., 2016).

Although intentional false-reporting may have occurred among some patients regarding firearm-related behaviors and injury circumstances, we have reason to believe that other patients reported firearm-related behavior change honestly, as evidenced by reporting of illegal carrying practices and additional open-ended comments of their reported-behavior on our survey questions. Patient B reported police seizure of their firearms and disclosed illegal concealed carrying before their GSW (Table 3). An assault patient disclosed considering purchasing a firearm, although they had not yet purchased one at the time of the survey. One patient who reported no longer carrying a loaded handgun in public after their injury voiced concern over the survey firearm questions explicitly: “I am somewhat concerned with this line of questioning, and I am curious what this information is to be used for. It has been my experience in the past that information such as this can be easily used to mislead specific people, or the public, due to the ease at which it can be manipulated.” This concern, and the intentional misreporting of firearm ownership and GSW injury intent, highlight the importance of developing rapport with GSW patients when inquiring about their firearm-related behaviors to improve data quality.

Limitations

As this study is nested within an ongoing study, our patient population represents a subset of the broader GSW patient population and is limited to adult English-speakers residing in five counties in Washington State. Furthermore, we limited our analysis to those who responded to the firearm survey supplement, excluding patients who were lost to follow up. A greater proportion of patients who responded were more likely than patients who did not respond to the survey to have stable housing, not report arrest in the year prior to injury and have a lower ISS score, all of which may impact firearm-related behavior, and may additionally vary with respect to potential firearm-related behavior change (Table 5 in Appendix C). Additionally, there was some missingness in self-reported demographic information and standardized assessment scores that varied by variable. This is reflective of individual patient desire to respond to

that particular question, as each question in our survey was voluntary and often included both a ‘Do not wish to respond’ or ‘Unknown’ option, both coded as missing. Patients with missing responses may be different than patients without missing responses and, given our small sample size, skew our understanding of the underlying patient population. However, there was differential missingness by variable, allowing for improved confidence in variables with low levels of missingness.

We relied on self-report of firearm-related behavior which, as discussed above, may be subject to information bias. Our study may additionally be subject to recall bias, another form of information bias, as patients were asked to report their pre-GSW firearm-related behavior on average 4 months after hospital discharge. However, we believe that the firearm-related behaviors included in our survey (e.g. did they own a firearm at the time of their injury or not) are less vulnerable to recall bias, especially as these behaviors are related to a significant life-event (i.e. GSW).

There was no statistically significant intervention effect observed in this study. This was expected, as while the intervention may indirectly influence firearm exposure through its focus on reducing recidivism, the intervention is not designed to specifically address firearm ownership, carrying practices or storage. However, our study sample was relatively small and the parent study was not powered to look at firearm behavior change specifically. Being underpowered for our outcome of interest may have led us to falsely conclude there was no difference between intervention arm or in the timing between survey completion and reported firearm related behavior change, and prevents a stratified analysis by injury intent. Our small sample size also means each reported proportion is quite sensitive to the number of patients with that particular characteristic or reported firearm-related behavior, and a change in response of one or two patients may alter the observed statistical significance.

Notwithstanding these limitations, this study offers the first look into firearm-related behavior change among adult GSW patients and offers hypothesis generating data for future research. Even without broad generalizability, the findings offer unique insight into behaviors of a population at high risk for subsequent GSW injury.

Conclusion

This study highlights the need for further examination of firearm-related behavior change in GSW patients and development of interventions to promote firearm safety among this population, especially as some of them may already be considering firearm-related behavior change. Additional work should be done to understand specific rationale for firearm-related behavior change to inform

development of interventions that speak specifically to motivators for firearm-related behavior change among GSW patients.

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Compliance with ethical standards

Conflict of interest Vivian H. Lyons, Frederick P. Rivara, Alice Ning-Xue Yan, Cara Currier, Erin Ballsmith, Kevin P. Haggerty,

Lauren Whiteside, Anthony S. Floyd, Anjum Hajat and Ali Rowhani-Rahbar declare that they have no conflicts of interest.

Human and animal rights and Informed consent All procedures followed were in accordance with ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

Appendix A: Firearm Survey Supplement Questions

Note: Branching logic is in italics.

Pre-GSW Firearm-Related Behavior Questions**Ownership Module - Asked of all participants**

This first portion focuses on firearm ownership **at the time you were shot**.

1. Did you personally own a firearm, regardless of whether you carried it with you when you were shot? Yes/No
 - a. *(If they owned a firearms)*
 - i. How many handguns did you own? _____
 - ii. How many long guns did you own? Long guns include rifles, shotguns, semi-automatic rifles: _____
2. *(If they owned a gun)* Please select the primary reason you owned a firearm (check only one):
 - a. For protection against strangers
 - b. For protection against people I know
 - c. For protection against animals
 - d. For hunting
 - e. For other sporting use
 - f. For a collection
 - g. It is my right
 - h. For some other reason
3. *(If they said 'for some other reason' in question 2.h.)* What was the primary reason you owned a firearm? _____
4. *(If they owned a firearm)* Have you acquired a firearm in the past year? Yes/No

Carrying Module - Asked of participants who own a handgun.

Now we would like to ask you about your handgun carrying behavior before your injury.

1. In the 30 days before you were shot, did you ever carry a loaded handgun in public? Yes/No
 - a. *(If yes to question 1)* In those 30 days, about how many days did you carry a loaded handgun in public? _____
 - b. *(If yes to question 1)* What was the primary reason for carrying (check only one)?
 - i. Protection
 - ii. Transporting the handgun between two locations
 - iii. Intimidation
 - iv. Sporting/hunting
 - v. For use at work
 - vi. Other: _____
 - c. *(If they said 'other' for 1.b.vi)* What was your primary reason for carrying: _____
 - d. How often did you carry the handgun concealed (check only one)?
 - i. Always carried it openly
 - ii. Mostly carried it openly (around 75% of the time)
 - iii. Were as likely to carry it openly as concealed (around 50% of the time)
 - iv. Mostly carried it concealed (around 75% of the time)
 - v. Always carried it concealed
2. Did you have a concealed carry weapons permit at the time you were shot? Yes/No

Storage Module - Asked of participants if they owned a gun.

These next questions are about where you stored your firearm(s) at the time of your injury. For these questions, locked can mean the firearm is stored in a lock box, vault or safe or has a cable lock, trigger lock or other personalized lock.

1. Of the firearm/firearms you owned at the time you were shot, where were they usually stored: (please select all that apply)

- a. In your home
 - b. In a garage at your home
 - c. In another building at your home
 - d. In your car or other motor vehicle
 - e. At work
 - f. At a gun club
 - g. Someplace else
2. Of those firearms you owned at the time you were shot, how many were usually stored:
- a. Loaded and unlocked _____
 - b. Loaded and locked up _____
 - c. Unloaded and unlocked _____
 - d. Unloaded and locked up _____

Post-GSW Firearm-Related Behavior Questions

Ownership Module - Asked of all participants

This first portion focuses on firearm ownership **currently**.

1. Do you personally own a firearm now? Yes/No
 - a. (If yes to question 1) How many handguns do you own? _____
 - b. (If yes to question 1) How many long guns do you own? Long guns include rifles, shotguns, semi-automatic rifles: _____
2. (If yes to question 1) Please select the primary reason you own a firearm currently (check only one):
 - a. For protection against strangers
 - b. For protection against people I know
 - c. For protection against animals
 - d. For hunting
 - e. For other sporting use
 - f. For a collection
 - g. It is my right
 - h. For some other reason: _____
3. (If 'for some other reason' to question 2.h) What is the primary reason you own a firearm?

4. (If they own a firearm) Have you acquired a firearm since your last survey? Yes/No
 - a. (If they have acquired a firearm since the last survey) What is your primary reason for acquiring a new firearm (check only one)?
 - i. For protection against strangers
 - ii. For protection against people I know
 - iii. For protection against animals
 - iv. For hunting
 - v. For other sporting use
 - vi. For a collection
 - vii. For some other reason: _____
 - b. (If 'for some other reason' to question 4.a.vii) What is your primary reason for acquiring a new firearm?
5. Have you gotten rid of a firearm since your last survey? Yes/No/Not applicable
 - a. (If they have gotten rid of a gun since their last survey) Please select the primary reason you got rid of the firearm (check only one)?
 - i. Needed the money
 - ii. Didn't see a use for them
 - iii. Concerned about safety of children in the house
 - iv. I felt uncomfortable about them
 - v. My spouse/partner felt uncomfortable about them
 - vi. Concerned that a household member might be suicidal or violent

- vii. Some other reason: _____
- b. (If for 'some other reason' to question 6.a.vii) What is the primary reason you got rid of the firearm?

Carrying Module - Asked of all participants *who own a handgun*.

Now we would like to ask you about your handgun carrying behavior **in the last 30 days**.

1. In the past 30 days, did you ever carry a loaded handgun in public? Yes/No
 - a. (If yes to question 1) In the past 30 days, about how many days did you carry a loaded handgun in public? _____
 - b. (If yes to question 1) What was the primary reason for carrying (check only one)?
 - i. Protection
 - ii. Transporting the handgun between two locations
 - iii. Intimidation
 - iv. Sporting/hunting
 - v. For use at work
 - vi. Other: _____
 - c. (If 'other' in question 1.b.vi) What was the primary reason for carrying?
 - d. (If yes to question 1) How often did you carry the handgun concealed (check only one)?
 - i. Always carried it openly
 - ii. Mostly carried it openly (around 75% of the time)
 - iii. Were as likely to carry it openly as concealed (around 50% of the time)
 - iv. Mostly carried it concealed (around 75% of the time)
 - v. Always carried it concealed
2. (If yes to question 1) Have you obtained a concealed carry weapons permit since the last survey? Yes/No

Storage Module - Asked of all participants if they owned a gun.

These next questions are about where you **currently** store your firearm(s). For these questions, locked can mean the firearm is stored in a lock box, vault or safe or has a cable lock, trigger lock or other personalized lock.

1. Of the firearm/firearms you own currently, where are they usually stored: (please select all that apply)
 - a. In your home
 - b. In a garage at your home
 - c. In another building at your home
 - d. In your car or other motor vehicle
 - e. At work
 - f. At a gun club
 - g. Someplace else
2. Of those firearms you own currently, how many were usually stored:
 - a. Loaded and unlocked _____
 - b. Loaded and locked up _____
 - c. Unloaded and unlocked _____
 - d. Unloaded and locked up _____

Appendix B

See Table 4.

Table 4 Timing of survey completion among patients who completed the firearm survey supplement (n = 163)

Time since firearm injury	No change reported N = 130 N (%)	Any change reported N = 33 N (%)	Total N = 163 N (%)
1 month	72 (55.4)	16 (48.5)	88 (54.0)
3 months	22 (16.9)	4 (12.1)	26 (16.0)
6 months	10 (7.7)	4 (12.1)	14 (8.6)
9 months	12 (9.2)	3 (9.1)	15 (9.2)
12 months	14 (10.8)	6 (18.2)	20 (12.2)

Appendix C

See Table 5.

Table 5 Demographic information by firearm-related behavior survey completion

	Completed survey N = 163	Did not complete survey N = 69	Total N = 232
Patient Age, years [\bar{x} (SD)]	29.9 (11)	29.4 (11)	29.8 (11)
Male [N (%)]	137 (84.0)	62 (89.9)	199 (85.8)
Race [N (%)]			
White	73 (45.9)	24 (35.8)	97 (42.9)
Black	66 (41.5)	35 (52.2)	101 (44.7)
Asian	7 (4.4)	3 (4.5)	10 (4.4)
Hawaiian/Pacific Islander	3 (1.9)	5 (7.5)	8 (3.5)
American Indian	10 (6.3)	0 (0.0)	10 (4.4)
Hispanic [N (%)]	21 (12.9)	7 (10.1)	28 (12.1)
Employment [N (%)]			
Working	90 (57.3)	34 (59.6)	124 (57.9)
Laid off	30 (19.1)	11 (19.3)	41 (19.2)
Student	16 (10.2)	2 (3.5)	18 (8.4)
Homemaker	3 (1.9)	1 (1.8)	4 (1.9)
Retired	1 (0.6)	2 (3.5)	3 (1.4)
Other	17 (10.8)	7 (12.3)	24 (11.2)
Patient marital status [N (%)]			
Single	69 (49.3)	19 (47.5)	88 (48.9)
Married	20 (14.3)	9 (22.5)	29 (16.1)
In a relationship or dating	51 (36.4)	12 (30.0)	63 (35.0)
Patient household income [N (%)]			
< \$25 K	52 (43.3)	24 (63.2)	76 (48.1)
25–50 K	35 (29.2)	8 (21.1)	43 (27.2)
50–100 K	21 (17.5)	4 (10.5)	25 (15.8)
> 100 K	12 (10.0)	2 (5.3)	14 (8.9)
Stable housing [N (%)]	114 (70.4)	42 (61.8)	156 (67.8)
Arrested in past year [N (%)]	26 (16.0)	18 (30.5)	44 (19.9)

Table 5 continued

	Completed survey N = 163	Did not complete survey N = 69	
Total N = 232	PCL-C score [\bar{x} (SD)]	34.3 (17)	33.2 (17)
34.0 (17)			
PHQ-8 depression score [\bar{x} (SD)]	6.3 (7)	5.9 (6)	6.2 (6)
MPSS total score [\bar{x} (SD)]	5.2 (1)	5.1 (1)	5.2 (1)
Happiness score [\bar{x} (SD)]	83.4 (26)	82.7 (31)	83.2 (27)
SF12 physical score [\bar{x} (SD)]	50.6 (10)	50.2 (10)	50.5 (10)
SF12 mental score [\bar{x} (SD)]	48.6 (13)	49.2 (13)	48.8 (13)
Alcohol AUDIT score [\bar{x} (SD)]	3.1 (3)	2.7 (3)	3.0 (3)
Injury intent [N (%)]			
Assault	119 (73.5)	53 (77.9)	172 (74.8)
Unintentional	33 (20.4)	8 (11.8)	41 (17.8)
Undetermined	10 (6.2)	7 (10.3)	17 (7.4)
Injury severity score [\bar{x} (SD)]	9.4 (8)	11.9 (9)	10.1 (8)

Stable housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was their address. Transitional housing includes individuals living in a private home, private apartment, or other dwelling (e.g. trailer) who indicated that the dwelling was not their address. Unstable housing includes individuals who indicated that they were couch surfing, homeless, or in a shelter

SD, standard deviation; PCL-C, PTSD Checklist Civilian Version (post-traumatic stress symptoms); PHQ-8, Patient Health Questionnaire (depression); MPSS, multidimensional scale of perceived social support (social support); SF-12, short form health survey (health-related quality of life); AUDIT, The Alcohol Use Identification Test (alcohol use)

Missing information: Race (n = 6), employment (n = 18), marital status (n = 52), income (n = 74), arrest in prior year (n = 11), PHQ-8 (n = 7), MPSS (n = 11), happiness (n = 9), SF-12 physical (n = 14), SF-12 mental (n = 14), injury intent (n = 2), ISS (n = 3)

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