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Original article

## Epidemiology of gunshot wounds to the hand

### Épidémiologie des blessures par balle à la main



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#### ABSTRACT

Due to increased gun availability/prevalence in current times, low-velocity firearm injuries have risen dramatically. This study describes the epidemiology of gunshot wounds (GSW) to the hand. We identified all patients (January 2005 – August 2015) who presented to our Level 1 trauma center with GSW's to the hand. Analysis of each record was performed to collect epidemiological variables. Cross-sectional analyses were performed to quantify the results.

Following inclusion/exclusion criteria, 97 patients were selected. Individuals who sustained GSW's to the hand were typically male (93.8%) between the ages of 18 and 30 (48.5%). Injuries were mostly self-inflicted (81.4%), and isolated (89.7%) to the digits (55.7%) or metacarpals (35.1%) of the left hand (74.2%). Most were fired from BB/pellet guns (45.4%) or handguns (33.0%), while cleaning/loading them (65.1%). Over one-half of patients (58.8%) were uninsured. Surgery was required in 35.1% of patients. Patients shot with something other than a BB/Pellet gun (e.g., handgun, shotgun) required surgery significantly more than those shot with a BB/Pellet gun ( $P < 0.0001$ ). An odds ratio further describing this relationship was 0.13 ( $P = 0.0002$ ), reflecting an 87% reduction in the odds of surgery for individuals shot by a BB/pellet vs. a different type of gun. The typical GSW to the hand involves a middle-aged male receiving an isolated injury to the digits or metacarpals of the left hand, from a BB/Pellet gun or handgun while they are cleaning/loading the firearm. Patients sustaining injury by a BB/pellet gun are least likely to require surgery.

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#### R É S U M É

En raison de l'augmentation de la disponibilité et de la prévalence des armes à feu à l'heure actuelle, les blessures par arme à feu à basse vitesse ont considérablement augmenté. Cette étude décrit l'épidémiologie des blessures par balle (GSW) à la main. Nous avons identifié tous les patients (de janvier 2005 à août 2015) qui se sont présentés à notre centre de traumatologie de niveau 1 avec des GSW à la main. L'analyse de chaque enregistrement a été effectuée pour recueillir des variables épidémiologiques. Des analyses transversales ont été effectuées pour quantifier les résultats. Suivant les critères d'inclusion/exclusion, 97 patients ont été sélectionnés. Les personnes qui ont reçu des GSW à la main étaient généralement des hommes (93,8 %) âgés de 18 à 30 ans (48,5 %). Les blessures étaient principalement auto-infligées (81,4%) et isolées (89,7 %) aux doigts (55,7 %) ou aux métacarpiens (35,1 %) de la main gauche (74,2 %). La plupart ont été tirés à partir d'armes à balles BB/plombs (45,4 %) ou d'armes de poing (33,0 %), en les nettoyant/chargeant (65,1 %). Plus de la moitié des patients (58,8 %) n'étaient pas assurés. La chirurgie était nécessaire chez 35,1 % des patients. Les patients blessés avec autre chose qu'un pistolet BB/plombs (par exemple, pistolet, fusil de chasse) ont nécessité une intervention chirurgicale significativement plus importante que ceux avec un pistolet BB/plombs

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( $P < 0,0001$ ). Un rapport de cotes décrivant davantage cette relation était de 0,13 ( $P = 0,0002$ ), reflétant une réduction de 87 % des risques de chirurgie pour les individus touchés par un BB/Pellet par rapport à un autre type de pistolet. Le GSW typique à la main implique un homme d'âge moyen qui reçoit une blessure isolée aux doigts ou aux métacarpiens de la main gauche, à partir d'un pistolet BB/plombs ou d'une arme de poing pendant le nettoyage/chargement de l'arme à feu. Les patients qui subissent une blessure par un pistolet BB/plombs sont moins susceptibles d'avoir besoin d'une intervention chirurgicale.

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## 1. Introduction

In the United States, one third of all residents are gun owners [1]. Despite the US population comprising less than 5% of the total world population, the citizens own more than 40% of the world's firearms [2]. Compared to other high-income countries, the US report the highest rates of firearm-related fatalities, including homicides, suicides, and unintentional deaths [3]. Most firearm injuries have been found to involve the extremities, with nearly half of these cases having been related to intoxication [4,5].

Literature describing epidemiology and management of gunshot wounds of the hand stems largely from war-time experiences and typically involves high-velocity missile injury [6–8]. However, most civilian injuries are sustained from low-velocity projectiles [9]. Epidemiological studies detailing civilian firearm injuries to the hand are sparse [10,11]. These studies describe the majority of patients within this group as middle-aged males who receive gunshot wounds to the phalanges or metacarpals as part of a multi-trauma injury, with the right and left hands almost equally involved. Optimal treatment most often involves early debridement, antibiotic treatment, reconstruction, and rehabilitation [12,13].

We sought to characterize the demographics, injury-characteristics, timing of injury and presentation, surgical management, psychosocial and occupational variables influencing gunshot wounds to the hand at a large academic level 1 trauma center. In addition to assisting physicians to understand the immediate injury/treatment plan of gunshot wounds to the hand, this study will allow them to holistically evaluate this patient population, thus ensuring optimal continuity of care. Our hypothesis was that our findings would corroborate existing literature and that the chief demographic would be the young unemployed male with accidental self-inflicted gunshot wounds to the hand sustained while intoxicated.

## 2. Materials and methods

Following IRB approval, the electronic medical record of our large academic level 1 trauma center was queried for all patients diagnosed with gunshot injuries (international disease classification 9th iteration (ICD-9) code 882.20 “open wound of hand except finger(s) alone, with tendon involvement,” with supplemental codes E922.0 “accident caused by handgun,” E922.1 “accident caused by shotgun,” E922.2 “accident caused by hunting rifle,” E922.3 “accident caused by military firearm,” E922.4 “accident caused by air gun,” E922.5 “accident caused by paintball gun,” E922.8 “accident caused by other specified firearm missile, and E922.9 “accident caused by unspecified firearm missile”). We included all patients who presented to the emergency department from January 2005 to August 2015. From this dataset, the authors subsequently performed a chart review to identify and include all patients who sustained gunshot injuries to the hand, including all soft tissue, neurovascular, and osseous injuries. Patient-

s > 88 years old, those with incomplete medical records or who indicated “no” under the publicity indicator, and those having sustained gunshot injuries to other parts of the body were excluded.

Following generation of this dataset, the electronic and written medical records of the patients meeting the inclusion and exclusion criteria were retrospectively reviewed. The authors reviewed the complete emergency department records, inpatient physician notes, inpatient labs, radiology reports, and operative reports. Line-by-line analysis of the entire medical record was performed for each patient in order to collect demographic (sex, age, ethnical origin), injury-related (isolated vs. multi-trauma, left vs. right hand involvement, single vs. bilateral hand involvement, dominant vs. non-dominant hand, hand zone involvement, related injuries and complications at the time of presentation or surgery, type of gun, mechanism of injury, self vs. external shooter), temporal (admission time, day of week), psychosocial (occupation, insurance status, alcohol/toxicology status, psychiatric history, suicide attempt), and surgical variables (operations performed).

Cross-sectional analyses were performed using SAS 9.3 software (SAS Institute, Inc., Cary, North Carolina). Neurologic injury and surgical management were both defined as dichotomous variables. Neurological injury constituted impairment of the digital, median, radial, and/or ulnar nerves and/or documentation of nerve repair. Chi<sup>2</sup> or Fisher's exact tests were performed as appropriate with a significance defined as  $P < 0.05$ . Given the low ratio of outcome events to the number of predictor (risk factor) variables [14], exact logistic regression rather than traditional logistic regression or log-binomial regression was used to analyze the data [15,16]. Adjusted exact prevalence odds ratios (OR) were calculated using the LOGISTIC Procedure with the EXACT statement [17]. Ninety-five percent mid- $P$  confidence intervals (CI) and  $P$ -values were reported along with the exact OR's. Risk factors of clinical and/or epidemiological importance were entered into the multiple logistic regression models.

## 3. Results

From 2005–2015, a total of 438 records were initially identified. Of these, 6 patients were excluded due to the indication of “no” under the publicity indicator, 3 patients due to incomplete medical records, and 332 patients due to gunshot injuries not primarily involving the hand(s). Following application of the inclusion/exclusion criteria, 97 patients remained, with 98 hands injured in total.

Individuals who sustained gunshot wounds to the hand were typically male ( $n = 91$ , 93.8%) between the ages of 18 and 30 ( $n = 47$ , 48.5%). Injuries were most often self-inflicted ( $n = 79$ , 81.4%), though none were related to attempted suicide. Most injuries were furthermore isolated injuries ( $n = 87$ , 89.7%) to the digits ( $n = 54$ , 55.7%) or metacarpals ( $n = 34$ , 35.1%) of the left hand ( $n = 72$ , 74.2%), and fired from a BB/pellet gun ( $n = 44$ , 45.4%) or handgun ( $n = 32$ , 33.0%). Shotgun wounds accounted for 6.2%

( $n = 6$ ) of patients presenting with GSW's to the hand. Further characterization of the injuries to the digits revealed that the majority of injuries involved either the middle (31%) or index (28%) fingers. Of those records specifying hand dominance ( $n = 61$ ), 86.95% ( $n = 53$ ) involved the non-dominant hand. In regard to the mechanism of injury, of those documented ( $n = 55$ ), 61.5% of all GSW's of the hand were due to cleaning/loading a gun.

Admission most often occurred on Saturday or Sunday ( $n = 40$ , 41.2%), and almost equally throughout the day, with 52.1% patients ( $n = 51$ ) admitted between 05:01 and 17:00, and 47.9% ( $n = 46$ ) hospitalized between 1701 and 0500. In regard to employment status, two-thirds (66.0%) were classified as employed ( $n = 64$ ), 27.9% ( $n = 27$ ) unemployed, and 6.1% ( $n = 6$ ) unspecified. Over one-half ( $n = 57$ , 58.8%) were uninsured. Fourteen percent ( $n = 14$ ) were documented as being intoxicated with an alcohol serum level above the legal limit of  $> 80$  mg/dL ( $n = 7$ ), or illegal drugs noted on positive toxicology serum screening ( $n = 7$ ) at the time of admission.

GSW's were complicated by neurologic injury in 16.5% ( $n = 16$ ) of cases, with the majority attributable to digital nerve injury ( $n = 10$ ), and half ( $n = 8$ ) of these cases being caused by handgun (Fig. 1). Characteristics of the sample by the presence of neurological injury are reported in Table 1. Overall, a statistically significant association was not detected between the type of gun and associated neurological injury (Fisher's exact test  $P = 0.13$ ). The results of the multivariate analysis of neurological injury are shown in Table 2. None of the exact ORs were statistically significant at the 0.05 level. Compartment syndrome resulted in only one case (1%).

Although the majority ( $n = 63$ , 64.9%) of all gunshot wounds to the hand were managed non-operatively, 35.1% ( $n = 34$ ) required surgery, with formal irrigation and debridement (I&D) performed as a part of surgical management in 33 of the 34 cases (97.1%). Of the surgically repaired injuries, 26 (76.5%) required a single trip to the operating room, while the remaining 8 injuries (23.5%) required at least 2 or more operations during the index hospitalization (Fig. 2). Of these, five patients required initial external fixation followed by definitive fixation with plate and joint fusion (1), phalanx amputation (1), groin flap (1), bone graft (1), bone graft and joint fusion with tendon repair (1). The other three patients did not receive external fixation, but one required amputation followed by full thickness skin graft, another was treated with K-wire fixation and tendon repair, and the last was managed with a groin flap followed by bone graft and nerve repair.

Table 3 summarizes the characteristics of the sample by surgery status. The univariate association between the type of gun and the outcome of surgery on the effected hand was statistically significant ( $P < 0.0001$ ): 82.4% of the patients who had surgery were shot with something other than a BB/pellet gun (e.g., a handgun) versus 40.0% who did not have surgery.

After controlling for the patient's age, sex, Hispanic ethnicity and race, health insurance status, and employment status, the relationship between the type of gun and surgery status remained statistically significant (Table 4): adjusted exact OR = 0.13,  $P = 0.0002$ . The OR of 0.13 reflects a reduction in the odds of surgery of 87% for those individuals who were shot by a BB/pellet gun in comparison to individuals who were shot with a different type of gun.

#### 4. Discussion

In agreement with previous epidemiologic studies of GSW's of the hand, the majority of victims were middle-aged (avg. 29.0 years old SD 15.54) men (93.8%) [13]. Most patients (90.7%) injured the metacarpals or digits. This pattern is consistent with past literature describing 91% of all gunshot related hand fractures involved the metacarpals or digits [11,18,19]. We further characterized the injuries to the digits, which revealed that the majority of injuries involved either the middle (31%) or index (28%) fingers. The overwhelming majority of our patients were treated successfully non-operatively (64.9%), which is almost identical to the 64.8% of cases treated non-operatively in the literature [11]. In contrast to past findings, the majority of our patients sustained the gunshot wounds to the left hand (74.2%) as isolated injuries (89.7%), as opposed to literature reports of the majority of these incidences occurring as part of a multi-trauma (61.5%), with virtually equal involvement of both the right and left hands [11,20]. Of those records specifying hand dominance ( $n = 61$ ), 86.9% involved the non-dominant hand. Our findings suggest that the majority of gunshot wounds to the hand may not be as debilitating at previous studies suggested, as preservation of the dominant hand and thumb digit in the majority of cases offer significant functioning capacity.

We additionally evaluated a number of other variables that have not been previously reported in the literature, including self vs. external shooter, mechanism of injury, day of presentation, insurance status, employment, toxicology status, psychiatric history, and suicide attempt. In regard to the shooter, most

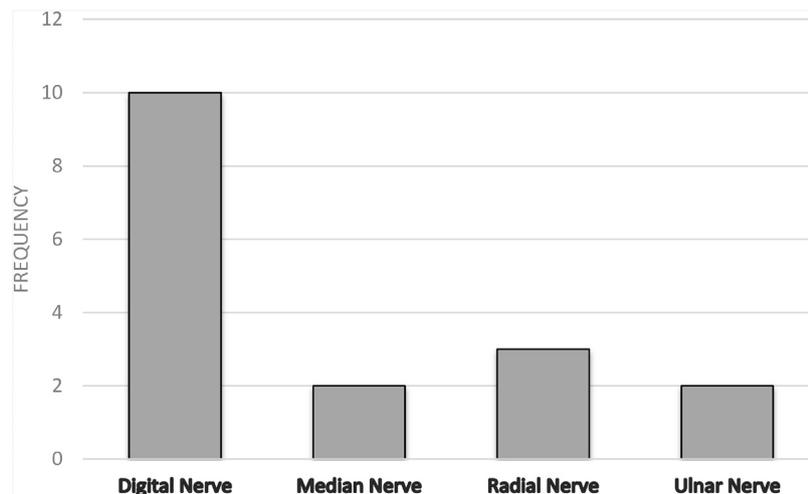


Fig. 1. Bar graph demonstrating frequency of nerve involved.

**Table 1**  
Characteristics of the sample by the patient's age ( $n = 97$ ).

Variable	Neurological injury <sup>a</sup>		Fisher's exact <i>P</i> -value
	Present $n = 16$	Absent $n = 81$	
	Number (%)	Number (%)	
Age (years)			0.29
< 18	1 (6.3)	17 (21.0)	
≥ 18	15 (93.8)	64 (79.0)	
Sex			1
Female	1 (6.3)	5 (6.2)	
Male	15 (93.8)	76 (93.8)	
Ethnicity			0.74
Hispanic	12 (75.0)	64 (79.0)	
Non-Hispanic	4 (25.0)	17 (21.0)	
Type of gun			0.13
Handgun	8 (50.0)	24 (29.6)	
Shotgun	0 (0.00)	6 (7.4)	
Other (nail gun, paint gun, or other)	4 (25.0)	11 (13.6)	
BB/pellet	4 (25.0)	40 (49.4)	

<sup>a</sup> Defined as impairment of the digital, median, radial, and/or ulnar nerves and/or documentation of nerve repair.

**Table 2**  
Adjusted<sup>a</sup> exact odds ratios (OR), 95% mid-*P* confidence intervals (CI), and *P*-values for the outcome of neurological injury<sup>b</sup> in patients that experienced neurological injury.

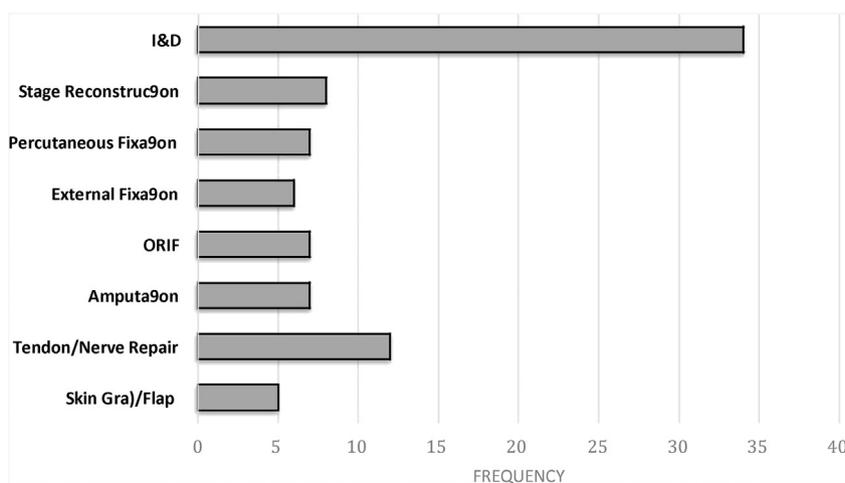
Variable	OR	95% CI	<i>P</i>
Age ≥ 18 vs. < 18 years	2.21	0.28–55.99	0.53
Males vs. females	1.25	0.15–34.19	0.91
Hispanic (white race) vs. other race-ethnicity	0.67	0.18–2.92	0.56
Type of gun			
Handgun	2.52	0.64–11.54	0.2
Shotgun	1.02	0–4.95	0.51
Other (nail gun, or other)	2.96	0.56–15.76	0.2
BB/pellet	1	(Referent)	–

<sup>a</sup> Each adjusted odds ratio is adjusted for the remaining variables found in the table.

<sup>b</sup> Defined as impairment of the digital, median, radial, and/or ulnar nerves and/or documentation of nerve repair.

( $n = 79$ , 81.4%) were self-inflicted, contrary to existing data that propose only 3% of all firearm-related injuries are self-inflicted [5]. Our findings suggest that self-inflicted gunshot wounds to the hand likely make up a large portion of the total self-inflicted GSW injuries each year in the US. Treating physicians presented with a patient with GSW to the hand may need to have a high level of suspicion for close range injury. Of those documented ( $n = 55$ ), 61.5% of all GSW's of the hand were sustained during cleaning or

loading a weapon. Perhaps the combination of high percentages of both self-inflicted wounds and this mechanism of action mean that many of these injuries are sustained at close range, and therefore the surgeon should consider these as high-velocity and treat them as such with surgical debridement and IV antibiotics as opposed to bedside I&D and discharge on PO antibiotics from the emergency room. Most patients furthermore presented on the weekend ( $n = 40$ , 41.2%). As many OR's have decreased staff and many

**Fig. 2.** Frequency of type of procedure performed.

**Table 3**Characteristics of the sample by the patient's age ( $n = 97$ ).

Variable	Surgery	No Surgery	P-value <sup>a</sup>
	$n = 34$ Number (%)	$n = 63$ Number (%)	
Age (years)			0.47
< 18	5 (14.7)	13 (20.6)	
≥ 18	29 (85.3)	50 (79.4)	
Sex			0.42
Female	3 (8.8)	3 (4.8)	
Male	31 (91.2)	60 (95.2)	
Ethnicity			0.4
Hispanic (white race)	25 (73.5)	51 (81.0)	
Other	9 (26.5)	12 (19.1)	
Employment status			0.12
Employed	19 (55.9)	45 (71.4)	
Unemployed or unknown status	15 (44.1)	18 (28.6)	
Health insurance status			0.09
Insured	18 (52.9)	22 (34.9)	
Uninsured	16 (47.1)	41 (65.1)	
Type of gun			< 0.0001
BB/pellet	6 (17.7)	38 (60.3)	
Other type (handgun, shotgun, etc.)	28 (82.4)	25 (40.0)	

<sup>a</sup> P-value from a Chi<sup>2</sup> or Fisher's exact test.

surgeons on call during weekends, one might attribute in part the high percentage of non-surgical treatment of GSW's to the hand to convenience/decreased availability of surgical staff. The majority of patients were uninsured ( $n = 57$ , 58.8%), and either unemployed, laborer, or student (70%). This value is slightly less than the percentage of uninsured patients presenting with gunshot wounds to any part of the body (65%) [5]. People of lower socioeconomic status are often less educated and may be more prone to such injuries. They may live in less safe areas that are cheaper and feel the need to purchase firearms for protection. Also, they may have unregistered guns acquired without any handling training, often for the purpose of gang/drug-related activity, which is rampant among lower socioeconomic groups [21]. Nearly one-sixth of our cohort was intoxicated at the time of injury, and 7% ( $n = 7$ ) were inebriated with some other illegal substance. Both of these values are lower than the percentages recorded in literature describing victims of firearm injuries to any part of the body, with those values being alcohol intoxication (13%), and illegal drug intoxication (27%), for a total of 40% of patients being intoxicated [5]. This suggests that treating physicians can most of the time discuss management, treatment options, and acquire procedural consent directly from the patient without fear of compromised mental status. This also suggests that the majority of GSW injuries to the hand are likely secondary to poor gun handling training/skills. Treating physicians may consider counseling their patients who

own guns in the home not only on the importance of gun storage, but also in the necessity of formal gun safety training to prevent these accidents. Among the psychiatric variables, 97% ( $n = 94$ ) of patients had no previous psychiatric history, with no patients attempting suicide at the time of the events. According to the most recent data published by the CDC, gunshots in the U.S. accounted for 33,636 deaths in 2013, with 63% due to suicide [22,23]. As none of our patients attempted suicide, treating physicians likely do not necessarily need to have a high level of suspicion of suicidal intentions when a patient present with an isolated GSW to the hand, and can likely rule out suicide quickly with proper history and physical at time of admission.

Interestingly, we found that while type of gun was significantly associated with surgical management ( $P < 0.0001$ ), which may be

**Table 4**Adjusted<sup>a</sup> exact odds ratios (OR), 95% mid-P confidence intervals (CI), and P-values for the outcome of 34 patients undergoing surgery.

Variable	OR	95% CI	P
Age ≥ 18 vs. < 18 years	0.41	0.07–2.16	0.3
Males vs. Females	0.63	0.08–4.95	0.66
Hispanic (white race) vs. other race-ethnicity	1.1	0.34–3.80	0.89
No insurance vs. Other (commercial, Medicaid, Medicare)	0.68	0.24–1.90	0.46
Unemployed or unknown occupational status vs. Employed	2.34	0.83–6.82	0.11
BB/pellet vs. Other mechanism (handgun, shotgun, etc.)	0.13	0.04–0.41	0.0002

<sup>a</sup> Each adjusted odds ratio is adjusted for the remaining variables found in the table.**Fig. 3.** Pictured are an assault rifle, automatic weapon, and handguns. Credit to Irondale Police Department.

intuitive, it was not significantly associated with injury-related variables such as neurovascular injury. Nonetheless, gun identification or classification may be important in the management of these patients. Fig. 3 illustrates various guns that may contribute to these types of injuries. These statistics seem to validate past reports of air gun pellet injuries to the hand, where of the 24 patients treated, none required surgical intervention [24]. Our findings showed that GSWs were complicated by neurologic injury in 16.5% ( $n = 16$ ) of cases, with the majority attributable to digital nerve injury ( $n = 10$ ), and half ( $n = 8$ ) of these cases being caused by handgun. Although lacking a statistically significant value, the combination of these two findings leads us to suppose that neurologic deficits after GSW to the hand are rarely seen in BB/Pellet gun injuries, and thus further supports the idea of BB/pellet injuries not requiring surgery. The percentage of GSW to the hand injuries causing neurological defects was half of that seen in previous literature, although the percentages of these injuries involving the digital nerves was almost exactly the same [10]. This may be explained by a larger portion of our victims receiving gunshot wounds from BB/pellet guns vs. other firearms, as well as our study containing nearly three times as many study subjects.

Due the nature of retrospective chart reviews, we were limited to the information contained within the existing medical records and history that was obtained during the index admission, thus potentially making us prone to many of the factors that could affect external validity. Additionally, due to the sample size ( $n = 97$ ), this study may have a limited power. Finally, due the cultural and demographic population (81.2% Hispanic/Latino vs. the national average of 17.4%) of the county served at our level 1 trauma center, it is possible that our results could be skewed based on some unidentified underlying cultural/demographic bias [25].

## 5. Conclusion

With the high prevalence of gun ownership among US civilian populations, low-velocity GSW's of the hand will continue to be an area of interest among health care providers. Among our findings, it is important to note that the majority of GSW's to the hand involve the left, non-dominant hand of middle-aged male patients while they were cleaning/loading a gun. The majority of patients were treated successfully non-operatively in the hospital, with 87% reduced odds of needing surgery when presenting with GSW's from BB/pellet guns. These patients most commonly present to the hospital on weekends, and most often are medically uninsured. From our findings, it may be appropriate to investigate the need to increase the required gun handling training required before purchasing a firearm, particularly among BB/pellet gun owners. Also, this expounded understanding of the epidemiology of GSW's to the hand can be used as a guide by physicians to better understand this patient population from both a treatment and also a demographic/social point of view.

## Disclosure of interest

The authors declare that they have no competing interest.

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