
Evolution of Firearm Violence over 20 Years: Integrating Law Enforcement and Clinical Data



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- BACKGROUND:** Data linking ballistics to injury are lacking. To address this data chasm, a partnership with law enforcement was developed to describe clinical outcomes from specific firearms.
- STUDY DESIGN:** A random sample of patients with gunshot wounds over a 20-year period ending in 2015, was identified. Circumstances of incident, firearm type, and/or caliber were extracted from police reports. Data on demographics, mortality, injury severity, and clinical outcomes were collected from the trauma registry, and these datasets were linked. Firearms were stratified by velocity (high > 2,500 ft/sec; low < 1,200 ft/sec) and caliber (large = .40 and .45; small = .20 and .25) and compared over time.
- RESULTS:** Police reports were obtained on 366 patients who had a gun type or caliber documented. The majority were male (82%) with a median age of 28 years. Twenty-one percent of patients had an Injury Severity Score > 25, 60% required immediate operative intervention, and overall mortality was 13%. The use of large caliber firearms increased from 4% (1996 to 2000) to 33% (2011 to 2015); small caliber guns decreased from 33% to 7% over the same time period ($p < 0.0001$). High velocity firearm usage significantly increased ($p = 0.0320$). Recovered shell casings doubled from the first decade to the second (2 vs 4; $p = 0.0006$). Both median New Injury Severity Score ($p = 0.0488$) and hospital days ($p = 0.0321$) increased from 1996 to 2015.
- CONCLUSIONS:** Larger caliber and higher velocity firearms have significantly increased over the past 20 years in conjunction with injury severity, hospital days, and mean number of gun-related homicides per year (112 in 1996 to 2000 vs 143 in 2011 to 2015). Robust data sharing partnerships can be built between police and trauma centers to address the dearth of data on firearm crime and resulting injury. (J Am Coll Surg 2019;228:427–436. © 2019 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)
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Gun violence in America is a public health problem¹ that is both understudied and underfunded.²⁻⁴ Despite calls for integration of law enforcement with clinical data to document how specific firearms result in clinical injury,^{5,6} linked data sources are still lacking as a result of federal restrictions on firearm research coupled with a disconnect between law enforcement and trauma centers.⁷

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Previous work at our institution showed that our trauma registry did not reliably capture the type of firearm designation resulting in gunshot wound admissions.⁸ Later, our group analyzed more than 20 years of Federal Bureau of Investigation (FBI) homicide data to document types of firearms resulting in gun deaths in our city.⁹ Despite our efforts, we were unable to link weapon type to significance of clinical injury due to the anonymity of the FBI data. In addition, generic firearm designations commonly used among existing surveillance systems like the FBI database¹⁰ (eg “handgun,” “rifle,” and “shotgun”) lack the detail necessary to adequately study resulting injury patterns or to design effective prevention measures. For example, the designation of “handgun” can encompass a variety of firearms, ranging from semi-automatic pistols with high magazine capacity to revolvers, which

Abbreviations and Acronyms

AIS = Abbreviated Injury Scale
ISS = Injury Severity Score
NISS = New Injury Severity Score

have significant implications for potential wounding patterns. Also, analyzing firearm deaths only, an important limitation of the National Violence Death Reporting System,¹¹ grossly underestimates firearm injury not resulting in death, which occurs much more frequently^{12,13} and greatly affects our society.

Because existing and publicly available data sources lack the granularity on specific types of firearms used in incidents of gun violence, we sought to partner with local law enforcement to share data and describe how specific firearm calibers and velocities result in clinical injuries and death. Therefore, the objective of this study was to document the types of firearms most commonly used in local incidents of firearm violence and to document any changes in weaponry used in Memphis, TN over the past 20 years. A secondary goal was to examine the feasibility of a data sharing partnership between local law enforcement and our trauma center. We hypothesized that higher velocity and larger caliber weapons have resulted in more destructive wounding patterns and higher mortality over the past 20 years.

METHODS**Identification of patients**

All patients admitted to the Elvis Presley Memorial Trauma Center with a chief complaint of “gunshot wound,” over the time period 1996 to 2015, were identified in our trauma registry. Readmissions were excluded. A list of all adult patients (≥ 18 years old) who had an injury in the city of Memphis, TN was then created. A random sample of patients was selected from this list and these patients were queried in a local law enforcement database. Specific variables obtained from our trauma registry included demographics, Abbreviated Injury Scale (AIS) scores, Injury Severity Score (ISS), New Injury Severity Score (NISS), trauma emergency department disposition, hospital length of stay, and hospital disposition. Specific variables obtained from the law enforcement database included circumstance of incident, firearm type and number, and type of shell casings recovered from the crime scene. Only incidents with a recovered firearm type and/or shell casing were included in the final analysis. The clinical and law enforcement data were then merged into a combined database for statistical analysis.

Definitions and assumptions

Interpersonal circumstances included all forms of aggravated assault, burglary, carjacking, murder, justifiable homicide, and all forms of robbery. Noninterpersonal circumstances included accidental circumstances, suicide, attempted suicide, and weapons law violations (all of which resulted in self-inflicted injuries). Any AIS > 0 in 3 or more AIS body regions was used as a proxy for multicompartmental injury.^{7,8,14} Shotguns and incidents involving noninterpersonal circumstances were excluded from these multicompartmental injury calculations. Firearms were stratified by velocity and caliber based on the literature and consensus among our law enforcement colleagues.¹⁵⁻¹⁷ High velocity firearms were defined as those that fire at $> 2,500$ ft/sec (.223 and 7.62 mm), medium velocity as 1,200 to 2,500 ft/sec (9 mm and .357), and low velocity as $\leq 1,200$ ft/sec (.22, 25, .32, .38, .380, .40, and .45). Large caliber firearms were defined as .40 and .45, medium caliber as .32, .357, .38, 380, 7.62 mm and 9 mm, and small caliber as .20 and .25. If more than one type of firearm or shell casing was obtained from a crime scene, the larger caliber and/or higher velocity firearm was assumed to be the weapon resulting in injury. There was no change in crime scene investigation or reporting of crime scene information in the police database over the study period. Shotguns were excluded from velocity and caliber trend analyses. An ISS or NISS ≥ 25 was considered a severe injury.

Comparisons and trend analysis

Comparisons were made among the caliber and velocity categories of firearms for ISS, NISS, the proportion of multicompartmental injuries, hospital length of stay, and the proportion of patients who went immediately to the operating room from the trauma emergency department over time. Temporal changes in firearm velocity and caliber were assessed by 5- or 10-year increments. Total firearm homicides over the study period were reported using Memphis firearm homicide data obtained from the City of Memphis Public Records Office using the Freedom of Information Act.

Statistical analysis

Statistical analyses were performed using a Student's *t*-test, Wilcoxon Rank Sum test, and chi-square, Mantel-Haenszel chi-square, or Fisher's exact test, where appropriate. The Kolmogorov-Smirnov Test for Normality was performed on all continuous variables; those that were normally distributed are presented with means and standard deviations and those that were not normally distributed are presented as medians and interquartile ranges. Kaplan-Meier survival analysis and the

Generalized Wilcoxon test were used to compare time to discharge based on velocity of firearms over the study period. All statistical analysis was done using SAS 9.4 (SAS Institute). A p value < 0.05 was considered statistically significant.

RESULTS

Study population

Figure 1 illustrates the breakdown of patients who were included in the study. Overall, there were 11,294 gunshot wound admissions in our trauma registry over the study period, 3,546 of which met inclusion criteria. Of the 745 randomly sampled patients queried in the police database, 233 had no firearm data, and another 84 police records were unable to be located. Sixty-two (8%) of the 745 had a generic gun type recorded, with handguns accounting for 95% of that total, followed by sawed off shotguns (3%) and rifles (2%). Therefore, 366 (49%) police records had a documented recovered shell casing or firearm and comprised the study sample with data from both the police database and the trauma registry. One hundred forty-one (39%) of 366 of the police records had a recovered firearm, and the remaining 225 (61%) had at least 1 shell casing recovered that could document the firearm resulting in injury.

Table 1 summarizes characteristics of the 366 individuals wounded with a documented firearm type. The majority of patients were male (82%) and African-American (89%), with a median age and ISS of 28 and 10, respectively. The most common circumstance of injury was aggravated assault (61%), with 12% involving domestic violence. Interpersonal circumstances accounted for the

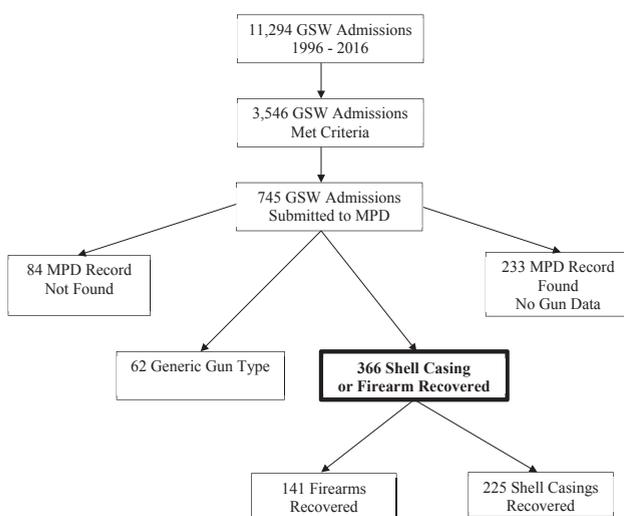


Figure 1. Breakdown of patients included in the study. GSW, gunshot wound; MPD, Memphis Police Department.

majority of injuries (90%), with 12% of patients sustaining multicompartamental injuries. Sixty percent of patients required immediate operative intervention and overall mortality was 13%. Of the 317 survivors, the majority were discharged from the hospital to home (77%), followed by rehabilitation facilities (6%), jail (3%), and psychiatric facilities (1%).

Firearm characteristics

Of the 366 patients, 15 (4%) were wounded with shotguns over the 20-year period, with 12-gauge being the most common shotgun resulting in injury. Of the remaining 351 patients wounded with nonshotgun firearms, low velocity (62%) and medium caliber (61%) guns accounted for the majority. Nine millimeter handguns (27%) most commonly resulted in injury over the study period, followed by .38 (13%), .40 (13%), .380 (11%), and .22 (10%) caliber firearms. High velocity assault rifles (ie 7.62 mm and .223 caliber) accounted for 4% of total firearms documented in the study. There were 31 (9%) multiple gun incidents (ie either more than 1 firearm or shell casing recovered at the crime scene) over the 20-year period (Table 2). The number of multiple gun incidents increased 4-fold, from 3% in 1996 to 2005 to 12% in 2006 to 2015 ($p = 0.0013$).

Overall, the most common firearms used in interpersonal circumstances were low velocity guns (57%), followed by medium velocity (35%), high velocity (5%), and shotguns (4%). The most common caliber used in interpersonal circumstances were medium caliber firearms (57%), with large caliber accounting for 24% and small caliber accounting for the remaining 14%. Noninterpersonal circumstances were also dominated by low velocity (78%) and medium caliber (65%) firearms.

Mortality analysis

Of the 366 patients, 49 (13%) died. Low velocity (51%) and medium caliber (65%) firearms accounted for the majority of deaths (Table 1). Nevertheless, there was no significant difference in mortality based on either weapon caliber ($p = 0.6764$) or velocity ($p = 0.3998$). This finding was most likely related to the relatively small numbers of deaths in the various categories. However, patients involved in interpersonal circumstances had a lower mortality than those involved in noninterpersonal circumstances (12% vs 30%, $p = 0.0047$).

Trends in injury severity, hospital days, and multi-compartmental injuries

Table 3 compares trends in injury severity, hospital days, and mortality by 5-year increments. There were no significant differences in the proportion of patients with

Table 1. Patient and Injury Characteristics

Characteristic	Data
Total firearm incidents, n	366
Age, y, median (IQR)	28 (23, 29)
Male, %	82
Race, %	
African-American	89
White	9
Other	2
Incident circumstance, n (%)	
Assault	225 (61)
Robbery	55 (15)
Murder	35 (10)
Suicide	18 (5)
Accidental	15 (4)
Other	18 (5)
Interpersonal circumstance, %	90
ISS, median (IQR)	10 (9, 18)
ISS \geq 25, n (%)	77 (21)
NISS, median (IQR)	17 (9, 29)
NISS \geq 25, n (%)	135 (37)
Multicompartmental injury, n (%)	43 (12)
Immediate operation, n (%)	218 (60)
Hospital days, mean (SD)	9 (13)
Mortality, n (%)	49 (13)
Mortality by caliber, n (%)	
Shotgun	1 (2)
Small	7 (14)
Medium	32 (65)
Large	9 (19)
Mortality by velocity, n (%)	
Shotgun	1 (2)
Low	25 (51)
Medium	21 (43)
High	2 (4)

IQR, interquartile range; ISS, Injury Severity Score; NISS, New Injury Severity Score.

multicompartmental injuries, an ISS \geq 25, or an NISS \geq 25, compared with those without such characteristics. In addition, there was no significant difference over time in the proportions of patients who went directly to the operating room and those who died. However, there was a significant increase in median NISS over the study period ($p = 0.0488$). In addition, total hospital days almost doubled ($p = 0.0321$).

For those with multicompartmental injuries only ($n = 42$), medium caliber firearms accounted for the majority at 57%, followed by large (29%) and small (14%) caliber weapons. Low velocity firearms resulted in the most multicompartmental injuries over the study period (59%),

followed by medium (36%) and high velocity (5%) weapons. There was no statistical difference in the type of firearm categorized by either caliber ($p = 0.6377$) or velocity ($p = 0.3172$) resulting in multicompartmental injuries.

Trends in caliber, velocity, and recovered shell casings

Table 4 illustrates trends in the use of firearms based on caliber and velocity by 5-year increments. The use of large caliber firearms increased from 4% (1996 to 2000) to 33% (2011 to 2015), whereas small caliber guns decreased from 33% to 7% over the same time period ($p < 0.0001$). The use of medium caliber weapons remained unchanged, but accounted for the majority of resulting firearm injuries per quarter ($\geq 60\%$).

There was essentially no change in the use of low and medium velocity firearms over the study period. However, high velocity weapon usage increased from 0% in the first quarter to 9% in the last quarter ($p = 0.0180$). Accounting for lower numbers of high velocity weapons over the entire study period, we compared trends in high velocity weapon usage for the period 1996 to 2005 to 2006 to 2015 and identified a 6-fold increase, from 1% to 6% ($p = 0.0320$). Next, we combined medium and high velocity firearms into 1 category and compared them to low velocity weapons by 5-year intervals. There was a clear change in firearm velocity in the years 2005 to 2006, with combined medium/high velocity firearms increasing 10%, although this did not meet traditional parameters for statistical significance ($p = 0.0984$).

The median number of shell casings recovered from crime scenes doubled from a median of 2 in 1996 to 2005 to 4 in 2006 to 2015 ($p = 0.0006$). This suggests more fired rounds from more efficiently firing weapons. There was no difference in the use of shotguns over the study period ($p = 0.2776$).

Higher velocity weapons (combined medium and high velocity firearms) resulted in a median increase of 1 hospital day per person over the study period in comparison to low velocity guns ($p = 0.0473$). Although a 1-day increase per person might seem trivial, if this increase is applied to the total number of medium/high velocity gunshot wound admissions per year at our trauma center (approximately 43%), there are an additional 67 total hospital days (a 27% increase) per year resulting from higher velocity guns in comparison to low velocity firearms. This increase has significant implications for hospital costs and the use of already strained resources.

DISCUSSION

This study offers a glimpse into the evolution of firearms used over the past 20 years, despite federal restrictions on

Table 2. Firearm Characteristics

Characteristic	Data
Total firearm incidents, n	366
Nonshotgun firearm incident, n	351
Shotgun, n (%)	15 (4)
12-gauge	11 (3)
20-gauge	2 (0.5)
410-gauge	2 (0.5)
Velocity, n (%)	
Low	216 (62)
Medium	120 (34)
High	15 (4)
Caliber, n (%)	
Small	56 (16)
Medium	213 (61)
Large	82 (23)
Bullet caliber, n (%)	
.22	38 (10)
.223	7 (2)
.25	16 (4)
.32	12 (3)
.357	8 (2)
.380	42 (11)
.38	47 (13)
.40	48 (13)
.44	1 (0.5)
.45	27 (7)
7.62 mm	6 (2.5)
9 mm	97 (27)
Multiple gun incidents, n (%)	31 (9)

firearm research. In this study, we observed a higher use of more destructive weapons over the 20-year study period, with larger caliber and higher velocity firearms more commonly resulting in injuries and subsequent admissions to our trauma center. This tendency toward more destructive firearms is supported by an increased NISS

and an increase in hospital days and recovered shell casings at crime scenes over the study period. In addition, high and medium velocity firearms have resulted in a significant increase in hospital days as a result of worse injuries from guns with more wounding potential, which has significant resource implications for both our trauma center and the community. Although we were unable to detect any significant difference in mortality based on data from this study, using publicly available firearm homicide data from the Memphis Public Records Office, mean number of firearm-related homicides per year in the Memphis Police Departments' jurisdiction increased from 112 in 1996 to 2000 to 143 in 2011 to 2015. [Figure 2](#) illustrates this trend in combination with the increased use of large caliber and high velocity firearms, further suggesting that more destructive weaponry with increased wounding power is resulting in more gun deaths in the jurisdiction immediately serviced by our trauma center. Secondarily, this work provides evidence that strong collaborations can be built between law enforcement and trauma centers to better address the data chasm that prevents all stakeholders from designing effective prevention and intervention strategies.

Although the majority of mass shootings in America are executed with high velocity, high magazine capacity firearms,¹⁸ surprisingly few data exist on the mundane, day-to-day gun-related violence that plagues cities like Memphis. Hargarten and colleagues¹⁶ examined 524 firearm homicides and 175 firearm suicides in Milwaukee, WI in the early 1990s. They observed that inexpensive, short-barreled .25 caliber handguns were the most common weapon type resulting in firearm deaths over the study period (1990 to 1994). This is somewhat counter-intuitive because larger caliber guns are assumed to have higher wounding potential and lethality. Similarly, early in our study period (1996 to 2000), we observed that more small caliber (.20 and .25) guns resulted in firearm injuries and subsequent gunshot wound admissions.

Table 3. Injury Severity, Operating Room, Hospital Day, and Mortality Trends by Quarter

Variable	1996–2000	2001–2005	2006–2010	2011–2015	p Value
AIS ≥ 3 , n (%)	1 (5)	11 (11)	16 (15)	14 (15)	0.2729
ISS ≥ 25 , n (%)	4 (17)	25 (22)	28 (25)	19 (19)	0.8724
NISS ≥ 25 , n (%)	7 (29)	44 (39)	47 (42)	34 (33)	0.8647
OR, n (%)	14 (58)	70 (61)	67 (60)	57 (56)	0.5241
Death, n (%)	3 (13)	13 (11)	20 (18)	12 (12)	0.8402
Hospital days, median (IQR)	2.5 (1, 6)	5 (2, 9.5)	6 (2, 10)	4 (2, 10)	0.0321
ISS, median (IQR)	9 (4, 16)	10 (9, 19)	10 (9, 21)	10 (9, 18)	0.1014
NISS, median (IQR)	11.5 (4, 25)	17 (9, 34)	18 (10, 34)	17 (9, 27)	0.0488

AIS ≥ 3 is synonymous with multicompartmental injury.

AIS, Abbreviated Injury Scale; IQR, interquartile range; ISS, Injury Severity Score; NISS, New Injury Severity Score, OR, operating room.

Table 4. Caliber and Velocity Trends

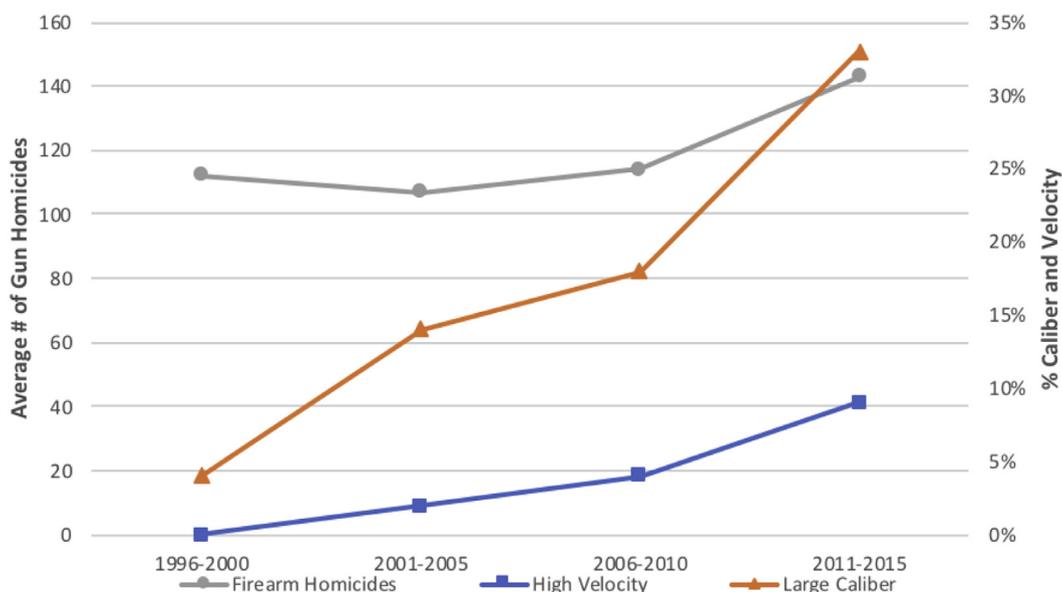
Variable	1996–2000	2001–2005	2006–2010	2011–2015	p Value
Caliber, n (%)					<0.0001
Small	8 (33)	26 (23)	15 (14)	7 (7)	
Medium	15 (63)	68 (60)	69 (62)	61 (60)	
Large	1 (4)	20 (18)	27 (24)	34 (33)	
Velocity, n (%)					0.0180
Low	16 (67)	77 (68)	65 (59)	58 (59)	
Medium	8 (33)	35 (31)	42 (38)	35 (34)	
High	0 (0)	2 (2)	4 (4)	9 (9)	

However, there has been a marked transition from the use of small caliber weapons to large caliber guns (.40 and .45) since the 1990s in our study.

Adibe and associates¹⁹ also documented increasing caliber trends over the time period 1998 to 2003 in Newark, NJ.¹⁹ In this study, the authors measured bullets recovered during an operation from injured trauma patients with a millimeter ruler, and they documented a significant increase in caliber from 8.47 mm to 9.16 mm over a 5-year period ($p < 0.01$). Interestingly, despite the increase in bullet caliber, they were unable to detect any change in mortality over the 5 years. In our study, we also observed no significant change in mortality when comparing 5-year increments (Table 3). We also observed no difference in mortality based on caliber (small vs medium vs large) or velocity (low vs medium vs high). In addition, there was no significant statistical difference between multicompartmental injuries based on category of firearm caliber or velocity. We were,

however, able to observe a significant increase in all firearm homicides serviced by our local police department and trauma center (Fig. 2). We suspect that many of the true firearm deaths occurring in our community do not survive long enough to be transported to our trauma center, and that is the reason why our dataset is unable to detect a significant change in mortality.

Overall, the data from this study suggest that any type of firearm can result in significant clinical injury and death, regardless of caliber or velocity designation. Theoretically, more destructive weapons (ie larger caliber and higher velocity) should lead to worse clinical injuries based on the fundamental laws of physics, but what really counts for firearm injuries is the number of bullets on target and what anatomic structures they hit. Improved marksmanship, increased number of perpetrators per incident, the ability of a perpetrator to fire more rounds per incident, or some combination lead to more wounds on victims.⁷ We hypothesized that modern firearms with

**Figure 2.** Trends in large caliber, high velocity firearms and firearm homicides 1996 to 2015

higher magazine capacity, which shoot more efficiently, have led to the increase in NISS and more gun deaths in our community over the past 20 years.

One of the greatest challenges in studying gun violence and designing locally relevant prevention and intervention strategies is the lack of pertinent data to even describe the problem. We have previously advocated for better data sharing partnerships between law enforcement and trauma centers to address this data gap.⁸ One of the greatest successes of this project has been the support and interest of our local law enforcement colleagues in investigating our city's gun violence epidemic. However, the manner in which data for this study was collected was very laborious and required countless hours sifting through police incident and evidence reports to extract the data on circumstance and recovered physical evidence that allowed us to categorize firearms by caliber and velocity. What is truly needed to better study local patterns of firearm violence is a prospective surveillance system that gathers data on police circumstances and firearm data in real time. This proposition is fraught with logistical and legal challenges, but continues to be a priority for our research group.

There are numerous limitations to this study. First, because of its retrospective design, there is the possibility of selection bias and unevaluated differences that could be due to confounding variables. Also, the design only allows for associations to be made and cannot account for all potential confounding variables. Second, the data collection process was laborious and resource intensive, which prevented more data from being collected. Closely related to this is the relatively low data yield for being able to document firearm caliber and velocity by recovered physical evidence (only 49% of all records queried in the law enforcement database had a documented firearm type by recovered gun or shell casing). Differences in the level of detail of individual police officer crime scene documentation likely contributed to this. Missing data in both the trauma registry and the police database is also a significant limitation. We know from our previous study⁸ that approximately 67% of all gunshot wound admissions occur within the Memphis city limits and the jurisdiction covered by the Memphis Police Department. However, our trauma registry is missing a significant amount of injury city data for the years 1996 to 2005, which limited the number of patients who could be randomly sampled and queried in the police database by almost 50%. Next, this study captured only gun injuries and deaths that presented to our level I trauma center, and is therefore a gross underestimation of both injuries and deaths resulting from firearm crimes in our community. Finally, because the 366 patients who had both law enforcement

and clinical data were randomly sampled, many deaths were not captured, which could underestimate trends in mortality based on the combined dataset. Purposely sampling all deaths, as well as all patients with multicompartmental injuries, could allow us to detect statistically significant trends and is planned in a future study.

CONCLUSIONS

Larger caliber and higher velocity firearms have significantly increased in our city over the past 20 years in conjunction with injury severity, hospital days, and mean number of gun-related homicides (112 in 1996 to 2000 vs 143 in 2011 to 2015). Robust data sharing partnerships can be built between law enforcement and trauma centers to address the dearth of data on firearm crime and resulting injury patterns. Continued gun violence research is required to better direct prevention efforts and firearm policy, and to reduce gun-related deaths.

Author Contributions

Study conception and design: Manley, Croce, Fabian, Magnotti

Acquisition of data: Manley, Croce, Crowe, Goines

Analysis and interpretation of data: Manley, Croce, Fischer, Crowe, Goines, Sharpe, Fabian, Magnotti

Drafting of manuscript: Manley, Magnotti

Critical revision: Manley, Croce, Fischer, Crowe, Goines, Sharpe, Fabian, Magnotti

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Discussion



DR DANIEL DENT FOR DR RONALD STEWART (San Antonio, TX): These data demonstrate a progressive increase in caliber, velocity of firearms, and number of shell casings on scene over 2 decades, which were also associated with an increased population homicide rate and an increased hospital injury severity and length of stay. The partnership described between trauma surgeons and law enforcement professionals in a single region is unique, encouraging, and promising. For those of us who do not have such a partnership, could you please describe how you developed this partnership, and do you think this could be replicated in partnership with other cities around the US? Approximately 40% of police records had no gun data available. Was this because there were no data available because the firearm or shell casings were not recovered? And could this number be improved if the data were collected prospectively?

There are efforts across the country to make hospital-based violence intervention a reality. From a high-level view, it appears that there are 2 opposing forces, increasing use of more lethal firearms related to interpersonal violence vs the trauma system and the law enforcement community, which are actively trying to reduce the number of injuries while also developing more effective treatment for firearm injury. What are the authors' thoughts, from physicians and law enforcement professionals, on how to use your data to reduce firearm injury death and disability? Have you been able to make any advances in developing a prospectively collected database that could make this type of research and surveillance data more feasible? In an ideal world, what would make this effort a reality?

DR J WAYNE MEREDITH (Winston-Salem, NC): Dr Adams, Dr McMasters, members and guests, I would like to thank the coauthors for this really well-presented and intriguing paper.

In these times, there are a lot of powerful political forces discouraging the study of firearm violence. But there are a few things that are absolutely certain. If you're a trauma surgeon taking calls in trauma centers in America tonight, you're going to see bullet holes in some people. And 100% of those bullet holes are going to have been caused by bullets.

The notion that we would not study those bullets like we would study the germs—if we say we're going to have a certain number of surgical site infections and we are not going to study the bacteria that cause them—now, studying this bacteria does not imply that that's the only source of surgical site infections, right? It might be a poor anastomosis technique. It might be poor metabolism of the patient heading into it. But the bacteria need to be studied, and we need to understand what they are doing, why they are doing it, and how they are causing the damage that they cause. To me, this is such a useful and brilliant study in that context. It's nicely presented. It's very clever. Very few people have done anything like this to combine the law enforcement databases.

You had 11,294 patients, of whom only 3,546 met your inclusion criteria. You then randomly selected 700 and some out of that. Why? What were the exclusion criteria of that? It makes it very hard to generalize your findings if more than half of the patients were not able to be studied. Mortality doesn't go up by velocity or by caliber. I think you alluded to that earlier. Do you have evidence of that? It's instinctively obvious to me that they are dying in the pre-hospital setting, but do you have data to support that? Are we surmising that or do we have a way to know that from your study? The last question involves the mortality. Gunshot wounds in your institution over this time frame have stayed constant despite a rising Injury Severity Score. Is that because trauma center care has gotten better?

I applaud the authors on the idea, the collaboration with law enforcement, and the huge effort this study takes. It's important. The study, however, is fraught with so many data collection problems. So many places where there are incomplete data in the analysis. Though it is interesting and fascinating, it is inconclusive. That means you need to continue this work. You have started something unique. You have started something that our society and we as surgeons need to understand. This is inconclusive, and it mandates further study. We really hope you will do so.