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Correlates of the Number Shot and Killed in Active Shooter Events

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Abstract
Active shooter events have captured the public's attention since the Columbine High School shooting in 1999. Although there has been research on various aspects of these events, only a single study has attempted to identify factors that are related to the number of people injured or killed in these events. This study was limited in that it only considered the presence or absence of a semi-automatic rifle. This paper expands on the existing research by examining several other factors that may impact the total number of people shot or killed during active shooter events.

Keywords
active shooter, mass murder, subtypes, school shootings, gun violence, rural, active attacks, active threat

On February 23, 2010, at around 3:30pm, a man walked up to two students outside of Deer Creek Middle School in Colorado and asked them if they attended the school. When the two students responded that they did the man shot them both with a rifle. A nearby math teacher named David Benke, witnessed the attack and decided to take action. While the attacker attempted to reload his weapon, Mr. Benke tackled him. Seeing this encounter, a bus driver, Steve Potter, and another man ran over to help Mr. Benke. They kept the attacker on the ground until the authorities arrived. The two students were injured, but no one was killed. (Blair & Schweit, 2014; Deer Creek Middle School, 2010)

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On March 29, 2009, at around 10:00am, a man walked into the Pinelake Health and Rehabilitation Center located in Carthage, North Carolina. Looking for his estranged wife the man began shooting at every individual he came across. By the time law enforcement arrived, he had shot 10 people, killing eight. The man was eventually shot and injured by a police officer, but not before he shot and wounded one of the responding officers (Blair & Schweit, 2014).

Active shooter events such as these have captured the public's attention since the Columbine High School shooting in 1999 (Addington, 2003; Larkin, 2009; Schildkraut & Muschert, 2019). These events call to question why there are such dramatic differences in the number shot and killed. Although there has been much research on various aspects of these events, to our knowledge, little attention has been given to identifying factors related to the number of people shot or killed in active shooter events. The most recent and related study was a research note that appeared in the Journal of the American Medical Association which focused on the impact of the presence or absence of a semiautomatic rifle on the number of people injured or killed. This paper will expand on that study by examining several other factors that may impact the total number of people shot or killed during active shooter events.

Literature Review

Defining Active Shooter Events

Active Shooter events are best defined in the 2014 report released by the Federal Bureau of Investigation (FBI) titled: *A Study of Active Shooter Incidents in the United States between 2000 and 2013* (Blair & Schweit, 2014). In that report, the following description of active shooter events is given: "an individual actively engaged in killing or attempting to kill people in a confined and populated area" (Blair & Schweit, 2014, p. 5). Another way to look at this is that an active shooter is someone actively attempting to commit mass murder in a public space (Martaindale et al., 2017).

It is important to note that the above definition does not include a minimum number of people shot or killed. The median number of people shot in these events is four and of the four people shot, two die. Additionally, the definition excludes gang-related violence and shootings that do not place others in peril (e.g., accidental discharges). In total, 250 events were identified between 2000 and 2017 (hereafter we refer to these events as the FBI data).

These data are not without limitations, and some commentaries have addressed the issues (see e.g., Blair & Martaindale, 2015; Fox & Levin, 2015; Lott, 2015). One of the primary strategies used to locate active shooter cases was a search of archival news sources. Because these databases have continually improved, it is possible that older cases were missed. It has been suggested that this means the increase in active shooter events may be illusory (Fox & Levin, 2015). The use of archival news searches also makes it more likely that events with fewer people injured or killed would have been missed because these events tend to have less media coverage (Schildkraut & Muschert, 2014; Schildkraut et al., 2018).

Distinguishing Active Shooter Events from Mass Shootings and Mass Murder

This paper seeks to examine correlates of the number of people shot and killed in active shooter events. We are not examining mass murders or mass shootings. There has been substantial confusion in the media regarding the distinction between active shooter events, mass murder, and mass shootings (Blair & Martaindale, 2015; Fox & Levin, 2015; Lott, 2015). Part of the confusion surrounding mass murder and mass shooting is that there are a variety of definitions used (Holmes & Holmes, 2001). One of the key differences in these definitions is how many people must be killed or shot for a case to be included. Traditionally, the mass murder literature has required that, for the event to qualify, at least four people must be killed in a single event (Krouse & Richardson, 2015; Levin & Fox, 1985, 2017). However, in 2013, the federal government redefined mass killing as three or more people killed in a single event (Investigative Assistance for Violent Crimes Act of 2012, 2013) and some researchers have suggested that this should be adopted as the new mass murder standard (Levin & Fox, 2017).

As noted above, active shooter events do not require a certain number of people to be shot or killed for an event to be counted. Using the four-or-more-people-shot definition of mass shootings, only 57% of the active shooter events identified in the FBI data set would count as mass shootings and only 24% would be counted as mass murders.

Active shooter events also do not include events that happen solely in private residences (e.g., family annihilations) that are included in many definitions of mass murder. Additionally, the active shooter definition specifically excludes gang-related shootings which are typically included in mass murder and mass shooting research. Therefore, while there is substantial overlap between mass murders, mass shootings, and active shooter events, each of these topics is also distinct and we can gain insight from considering them separately.

Active Shooter Related Research

Active shooter research is relatively new and covers a number of diverse topics related to such events. Numerous active shooter response training manuals and survival guides are available (see for example Blair et al., 2013; Doss & Shepherd, 2015). There is also literature that examines the development and effectiveness of specific response tactics (Blair & Martaindale, 2013, 2014, 2017; Blair et al., 2011; Martaindale & Blair, 2019). As this type of crime becomes more prevalent, more research can improve the response to and survivability during active shooter attacks.

Descriptive studies of active shooter events in schools and businesses have also been published (Blair et al., 2014; Majeed et al., 2019; Martaindale et al., 2017; Schildkraut et al., 2018; Schildkraut & Muschert, 2014). Other research has examined media coverage of these events (Majeed et al., 2019; Schildkraut et al., 2018; Schildkraut & Muschert, 2014), and the possibility of contagion effects (Kissner, 2016; Lankford & Madfis, 2018; Meindl & Ivy, 2017; Towers et al., 2015). Researchers have additionally examined the impact of these shootings on survivors and communities (Jordan, 2003; Richardson et al., 1996; Shultz et al., 2014; Smith et al., 2019).

Correlates of Number Shot and Killed

As previously noted, there is a dearth of literature exploring the correlates of the number shot and killed during active shooter events. There has been research, however, examining factors contributing to the number shot and killed in the mass shooting and mass murder literature. Some scholars have examined how the lethality of mass shooters is associated with various attacker characteristics (Capellan et al., 2019; Lankford, 2015, 2016c). Others focused on issues related to the firearms used in violent encounters (Blau et al., 2016; Libby & Corzine, 2007). de Jager et al. (2018) published a research letter in the Journal of the American Medical Association using the FBI data with the goal of assessing the impact of the presence or absence of a semiautomatic rifle on the number of people injured or killed, not just fatalities. A negative binomial regression was performed controlling for various factors, and the researchers found that the presence of a semiautomatic rifle was significantly associated with more people being shot (Incidence Response Rate 1.91) and killed (IRR 1.97).

The de Jager et al. (2018) study was limited in that other factors that could have affected the number injured or killed were not explored or reported (the corresponding author did not respond to our requests for information). Among these were the characteristics of the offender(s), the impact of the type of location and time of attack, how the event ended, (e.g., suicide of the offender) and the number of each type of weapon that was present. The current paper seeks to expand on the previous findings of de Jager et al. (2018) by exploring these factors.

Conceptual Approach

The purpose of this paper is not to provide a complete theory regarding how many people are shot or killed during these events. Rather, the paper is an initial look at variables that may be correlated with the number of people shot and killed, which may ultimately lead toward theoretical development. That being said, we believe that routine activity theory (RAT) may provide a useful starting framework (Cohen & Felson, 1979). RAT posits that three elements are needed for a crime to occur: (1) a motivated offender, (2) an attractive target, and (3) absence of a capable guardian (Cohen & Felson, 1979). RAT research has been applied to a variety of research topics including, but not limited to, predicting stalking victimization likelihood for women (Mustaine & Tewksbury, 1999), internet fraud targeting (Pratt et al., 2010), street robbery (Groff, 2007), and even explaining annual temperature variations and U.S. crime rates (Rotton & Cohn, 2003).

This paper is not considering whether or not crime occurs, rather we are considering how devastating the crime is, and therefore, we use the RAT framework only loosely. We group our variables into three groups that are similar to, but distinct from, the elements identified by RAT.

Offender. It is logical that characteristics of the offender may affect how many people are shot or killed in these attacks. Clearly, the research of de Jager et al. (2018) posits that how an offender is armed affects the number of people who are injured. Weapons with larger magazine capacity (like many semi-automatic rifles) may allow the attacker to shoot more victims. Weapon type might also affect lethality of being shot. The bullet of a rifle round generally travels much faster and delivers more energy than a pistol bullet. For example, a .223 Remington rifle round (a cartridge frequently used in AR-15s), leaves the barrel of a rifle traveling about 3,240 feet per second and has a muzzle energy of about 393 foot/pounds. A 9 mm pistol round leaves the pistol barrel traveling at about 1,145 feet per second and has a muzzle energy of about 335 foot/pounds (Remington, 2019). The rifle bullet is traveling about 2.8 times faster and has about 1.2 times more energy than the pistol bullet. There are frequent debates about the stopping power and lethality of various pistol and rifle rounds (see Callahan, 2018; Fairburn, 2015, 2017 e.g.). Some weapon types may be more deadly than others.

Many of the attackers also have a relationship or connection to the place that they attack. This relationship might give the attacker more knowledge about the normal (routine) activities and layout of the attack location and this knowledge could contribute to the attacker being able to injure or kill more people. It is also possible that this relationship is part of the motivation for the attack (such as a student being bullied in school) and that this motivation could impact the number of people shot or killed.

We additionally consider the demographic information of the attacker (race, sex, age) to see if these are related to the number of people shot or killed. We don't have any prior predictions about how these may be related.

Target features. We believe the features of the target could affect the ability of the attacker to find and shoot victims. Different types of locations might offer the attacker access to more victims or access to victims in spaces where they are less effective at taking protective actions. For example, there may be a lot of potential victims in the open area of a shopping mall, but these victims might be able to easily flee because the mall is designed to allow people free movement from store to store. A school, on the other hand, may allow access to fewer victims in one space (such as a classroom), but these victims may be less able to take protective actions because the classroom does not have an alternate exit or places for the students to hide. Ideally, we would have specific information about the space(s) where the attack occurred and how many people were in the space(s) at the time of the attack; however, the FBI data only contains information on the general facility type (school, retail, etc.).

The time of day and day of the week also affect the activity patterns of different locations. More people are in a school during the daytime than at night. Many factories have fewer people working on the weekend. These different activity patterns might also impact how many people the attacker can find and shoot.

The year in which the event occurs could impact the number of people shot and killed. A substantial amount of effort and money have gone into attempts to better prepare both first responders and potential victims to respond effectively when these attacks occur. The number of people trained will increase over time, and this preparation could reduce the number of people shot and killed as the year of the attack increases; however, there is also evidence some attackers study previous events in attempt to learn from these events and kill more people. This could cancel out the effects of better preparation.

Attackers sometimes go mobile. They start the attack in one location, move, and then continue the attack in another. This change in attack locations could impact the number of people injured. It is possible that each change in location allows the attacker access to a new group of potential victims that are unaware that an attack is about to occur and are therefore more vulnerable than potential victims who are at a site where they are aware that an attack is ongoing.

Guardianship. In many crime situations, guardianship is simply someone who could observe the criminal in commission of the crime and therefore the crime does not occur. In active shooter events, guardianship deals with someone who can stop the attacker. In an unarmed attack at a school, a teacher would generally be a capable guardian. However, because a firearm is present, the teacher is now less capable of stopping the offender.

In other cases, unarmed people have physically restrained the attacker and stopped anyone else from being harmed. For example, in the Congresswoman Giffords shooting, victims tackled the attacker when he was reloading his gun. In fact, potential victims stop the attackers in about one out of every six attacks in the FBI data. It is possible for even unarmed people to provide their own guardianship.

When attempting to explore how the presence of a capable guardian affects the number of people shot and killed, it would be useful to know how long it took the police (or other armed person) to arrive on scene and how long it took them to encounter the attacker. This information, however, is not present in the FBI data nor were we able to locate it for most events. We, therefore, use resolution of the event (e.g., cases that ended because the police shot the offender or victims stopped the offender) as a proxy for a capable guardian stopping the event.

We want to be clear that the current paper is focused on description of these events and variables that may be related to the number of people who are shot or killed. We provide a loose conceptual framework to help organize these variables, but we are not trying to provide a comprehensive theory. We hope that the descriptive information and loose framework provided here will provide a foundation upon which theory can be built. We turn now to our methodology.

Method

Data

Data for this study were derived from the active shooter reports published by the FBI (Blair & Schweit, 2014; FBI, 2016, 2018). These reports list all 250 events that were identified by the FBI as active shooter events from 2000 to 2017.

Coding

The bulk of the data used was extracted directly from the FBI reports (i.e., information on the date, demographics of the attacker(s) (sex, age, race), type of location, number and types of weapons, whether the attacker went mobile (i.e., moved from place to place), and how the event ended). The FBI reports sometimes consider victims to be anybody injured during an event regardless of how they were injured (e.g., bullets, glass fragments, or trampling). We recoded all the shot and killed data to reflect only victims that were in fact wounded and/or killed by a bullet. This produces a more accurate representation of victims wounded/killed as a result of being shot. We have included an appendix that indicates where our estimate of the number of people shot during an event is different from the number indicated by the FBI (See Appendix A).

In addition to extracting FBI report data, we also filed information requests with the investigating law enforcement agency, obtained formal After Action Reports (AAR) if available, and sought news articles to gather information. Every case was found on the FBI report and had at least two (2) news articles. We received 38 official reports from the responding law enforcement agency, and we gathered 35 formal AARs. Data sources were surprisingly consistent with each other. One notable exception is when a news report was published immediately following an event. It was common for much of the initial information to either be incorrect or to change. For example, the number of injured or killed often changed as more information became available (e.g., someone that was shot in critical condition could pass away while in the hospital, or victims could drive themselves to the hospital and were not initially accounted for). The information usually became stable after the first few days. We used the most recent data to resolve this issue.

It should be noted that the FBI summaries do not give specifics about the weapons used; rather, they give the general type of weapon (e.g., pistol, rifle, shotgun) and how many of each type were brought to the location. The paper published by de Jager et al. (2018) separates the rifles used into two categories (semiautomatic and other). de Jager et al. were able to classify all the rifles in the FBI data using this scheme. We were able to identify the type of rifle used in all but five of the cases using official records and news reports. We asked the corresponding author from the de Jager et al. (2018) paper for additional information on our missing rifle-type cases, but the corresponding author did not respond. We contacted the FBI active shooter research group for this information, but they did not have information on the specific rifles used. Our total counts of semiautomatic versus non-semiautomatic rifles seem to be substantially different from the number reported in the de Jager et al. (2018) study. We suspect that this is because we used the formal definition of semiautomatic rifle from the United States Code Service, "The term semiautomatic rifle means any repeating rifle which utilizes a portion of the energy of a firing cartridge to extract the fired cartridge and chamber the next round, and which requires a separate pull of the trigger to fire each cartridge [18 USCS SS 921 (28)]." The methodology and discussion of the de Jager et al. (2018) paper suggest they may have considered weapons that are often referred to as assault rifles (e.g., AR-15s and AK-47s) as semiautomatic rifles and other semiautomatic rifles (such as .22s) as other rifles.

To assess reliability, a single coder coded all the cases and then a second coder coded 20% of the cases. Reliability between coders was high (100% agreement: Intraclass Correlation Coefficient = 1.00).

Variables

Number of people shot. This was a count variable indicating the total number of people shot during the attack. This included both those who were injured and those who died.

Number of people killed. This was a count variable indicating the total number of people killed.

Total weapons. The total number of weapons of all types that the attacker brought to the location.

Rifles. The number of rifles the attacker brought to the location.

Pistols. The number of pistols the attacker brought to the location.

Shotguns. The number of shotguns the attacker brought to the location.

Semiautomatic rifles. The number of semiautomatic rifles the attacker brought to the location.

Other rifles. The number of non-semiautomatic rifles the attacker brought to the location.

Male. Referred to the biological sex of the attacker. Males were coded as 1, females as 0. The male variable was not included in analysis due to the low number of female attackers.

White. Attackers were coded as 1 if they were Caucasian and 0 if from any other racial or ethnic group.

Age. The attacker's age in years at the time of the attack.

Relationship. Coded as 1 if the attacker was a current or former student or employee of the location attacked.

Location. Originally coded in the FBI summaries as a factor with eight levels indicating the type of place attacked. Due to low cell counts for some levels, we collapsed this into factory/warehouse, retail, office, outdoors, school, and other. Retail served as the reference level in analysis.

Table 1. Descriptive Statistics.

Variable	*M*	*SD*	Min	Max
Dependent variables				
Number shot	8.38	31.49	0	480
Number killed	3.13	5.94	0	58
Independent variables				
Offender				
Weapons				
Total weapons	1.67	1.15	1	12
Rifles	.41	.93	0	12
Pistols	1.05	.83	0	5
Shotguns	.19	.40	0	2
Semi-Rifles	.31	.91	0	12
Other-Rifles	.05	.22	0	1
Male	.96	.19	0	1
White	.58	.50	0	1
Age	35.62	15.34	12	88
Relationship	.38	.49	0	1
Target features				
Location				
Retail	.24	.43	0	1
Factory	.12	.33	0	1
Office	.13	.34	0	1
Outdoors	.19	.39	0	1
School	.20	.40	0	1
Other	.12	.32	0	1
Year	11.97	4.52	1	18
Weekday	.76	.43	0	1
Daytime	.78	.41	0	1
Mobile	.21	.41	0	1
Resolution				
Suicide after police	.11	.32	0	1
Fled	.11	.31	0	1
Victims Stop	.16	.37	0	1
Police Stop	.37	.48	0	1
Suicide Pre-Police	.25	.44	0	1

Year. Year was coded based upon the year that the attack occurred. Ranged from 1 for the year 2000 to 2018 for the year 2017. (See Table 1). The age data appear to illustrate that active shooters do not follow the same age-crime patterns as other offences in which criminality peaks in late adolescence (i.e., approximately 15–17 y/o) and steadily declines through early adulthood (Shulman et al., 2013).

Weekday. Coded 1 for attacks that occurred on Monday, Tuesday, Wednesday, Thursday, or Friday, otherwise coded 0.

Daytime. Coded as 1 for attacks that occurred between 7:00 am and 7:00 pm, otherwise coded 0.

Mobile. Coded as 1 if the attacker left the original location of the attack, moved to a new location, and continued the attack (such as starting the attack at one business and then getting in a car and moving to another location and attacking that location), otherwise coded 0.

Resolution. Coded as a categorical variable with five categories (suicide before police arrived on scene, fled, stopped by victims, stopped by police, and suicide after police arrived on scene). Suicide after the police arrived on scene was the reference level in analysis.

Analysis

Analysis was conducted using r version 3.5.2. (R Core Team, 2013). Several R packages were also used. These included MASS (Venables & Ripley, 2002), pscl (Jackman, 2017), AER (Kleiber & Zeileis, 2008), effects (Fox, 2003), and DHARMa (Hartig, 2019).

The general analysis plan began with entering the relevant variables into a linear regression model to examine possible collinearity problems. Because the dependent variables were count variables, a Poisson model was then constructed and tested for over dispersion. When over dispersion was detected, the model was converted to a negative binomial. These models were then examined for fit and outliers. Problematic residuals/high influence cases were removed and the models were recomputed and again examined for fit. Residual and outlier analysis indicated that six cases consistently exhibited extreme residuals/influence. These were: the Harvest Music Festival, Las Vegas, NV, 2017 (480 shot and 58 killed); the Pulse Night Club, Orlando, FL, 2016 (102 shot and 49 killed); Century 21 Movie Theater, Aurora, CO, 2012 (70 shot and 12 killed); Virginia Tech, Blacksburg, VA, 2007 (49 shot and 32 killed); First Baptist Church, Sutherland Springs, TX, 2017 (46 shot and 26 killed); and Fort Hood, Killeen, TX, 2009 (42 shot and 13 killed). These cases were eliminated from analysis in all models and will be further examined in the discussion section.

Results

Number Shot

Table 2 presents the three negative binomial regressions that were performed to examine the impact of the variables of the number of people shot. Each model contains the same variables regarding the offender, attack features, and resolution. The models differ in how the weapons taken to the attack are treated. Model 1 combines all the weapons taken to the attack location together into a single total number of weapons. Model 2 separates the weapons into number of rifles, number of pistols, and number of shotguns variables. Model 3 uses the number of pistols and shotguns from Model 2 but splits the rifles into semiautomatic and other to mirror the analysis conducted by de Jager et al. (2018). As we mentioned above, we were not able to code every rifle as semiautomatic or other as de Jager et al. did. Therefore, this model was computed with five fewer cases than Models 1 and 2.

Vuong's tests of corrected AICs suggested that the difference in fit between Models 1 and 2 was trivial ($z=.47$, $p=.32$). Model 3, as noted above, contained a different number of cases and as such was not directly comparable to Models 1 and 2. Model 1 was recomputed eliminating the cases that were not included in Model 3. This new model resulted in an AIC of 1276.9. A Vuong's test of corrected AIC comparing these models was again not significant ($z=.42$, $p=.34$). None of the models exhibited a superior fit over the others. The principle of parsimony would suggest that Model 1, with fewer variables, should be preferred to the other models, but information on the specific types of weapons used in Models 2 and 3 is also informative.

Table 2 presents conventional significance tests because they are generally expected; however, a strong argument can be made that conventional significance tests are not appropriate for these data. These data are the population of active shooter events and as such there is not another (perhaps larger) population that we are trying to understand, so inferential (significance) tests tell us little. If the data are not accepted as a population, perhaps because cases may be missing, inferential testing is still not justified. The primary search strategy to identify cases relied upon media reporting and as was noted in the literature review, cases with fewer casualties or in more remote areas received less coverage. This would suggest that any missing cases are not missing at random and trying to infer from the included cases to missing cases is not justified. Nonetheless, we have included the significance test for those who still want them.

Table 2 does include Incident Rate Ratios (IRR). These can be interpreted in way that is similar to odds ratios. IRRs >1 indicate a greater number of people shot as the variable increases and those <1 indicate fewer people shot. The IRRs also allow some comparison of the magnitude of effects across variables.

Because many of the variables in this study are either dichotomous or nominal, comparing IRRs can be difficult. We, therefore, focus on the estimated mean number of people shot for the independent variables. The estimated means reflect the number of people that the model computes will be shot (or killed) when the other variables in the model are set at their mean values. These means are exclusively from the data and do not attempt to infer either to a population or causal effects (see Berk, 2004 for a thorough discussion of the differences between using regression for descriptive vs. statistical or causal inference). Estimated means are presented in two ways. First, the estimated means for various levels of the nominal variables are presented in Table 3. Second, a series of estimated means plots is presented for the continuous variables (see Figures 1–3).

As can be seen in Table 3, most of the estimated mean differences are small. The estimated mean differences for the number of people shot for Non-White and White attacker are trivial. The estimated mean number of people shot for attackers of attackers who had a relationship to the location that was attacked was about 0.5 higher than when the attacker did not have a relationship. Mobile attackers were estimated to shoot

Table 2. Negative Binomial Regressions on Number of People Shot.

	Model 1			Model 2			Model 3		
Variables	*b*	*SE*	IRR	*b*	*SE*	IRR	*b*	*SE*	IRR
Intercept	1.85	.29		1.82	.29		1.76	.29	
Offender									
Weapon									
Total weapons	.19***	.05	1.21						
Rifles				.27**	.08	1.31			
Pistols				.18**	.06	1.20	.20***	.06	1.23
Shotguns				.12	.13	1.13	.17	.13	1.19
Semi-rifles							.38***	.09	1.47
Other rifles							−.05	.23	.95
White	.00	.10	1.00	.02	.12	1.02	.00	.10	1.00
Age	−.01*	.00	.99	−.01*	.00	.99	−.01	.00	.99
Relationship	.07	.15	1.07	.10	.15	1.26	.11	.15	1.11
Target features									
Location[a]									
Factory	.09	.21	1.10	.06	.21	1.06	.10	.20	1.11
Office	.00	.17	1.00	.00	.17	1.00	.00	.20	1.00
Outdoors	.16	.16	1.18	.16	.16	1.18	.20	.16	1.21
School	−.23	.19	.79	−.25	.19	.78	−.23	.19	.80
Other	.25	.17	1.28	.26	.17	1.29	.18	.19	1.27
Year	−.01	.01	.99	−.01	.01	.99	−.01	.01	.99
Weekday	.05	.13	1.06	.07	.13	1.07	.01	.13	1.01
Daytime	.08	.12	1.09	.08	.12	1.09	.13	.12	1.14
Mobile	−.08	.13	.93	−.07	.13	.93	−.08	.13	.92
Resolution[b]									
Fled	−.12	.24	.88	−.13	.20	.88	.00	.20	1.00
Victims Stop	−.54**	.22	.58	−.53**	.19	.59	−.51**	.19	.60
Police Stop	−.22	.18	.79	−.24	.16	.79	−.25	.16	.78
Suicide Pre-Police	−.28	.20	.76	−.25	.20	.78	−.26	.17	.74
df		243			243			238	
AIC		1302.3			1303.7			1274.2[†]	

Note. Eliminating the cases that are missing in Model 3 from Model 1 results in an AIC of 1276.9. Comparing the models produced an AIC corrected Vuong z-statistic of -.42 which was not significant ($p = .34$). .00 standard errors are not truly .00 they are rounded down to hundredths.
[a]Reference group is retail locations.
[b]Reference group is suicide after the police arrive.
[†]AIC of 1274.2 is based on a sample of 239 verses a sample of 244 for the other models.
*$p < .05$. **$p < .01$. ***$p < .001$.

about 0.4 fewer people than non-mobile attackers. Attacks that occurred on weekends were estimated to result in about 0.3 fewer people shot than those that occurred on weekdays.

Table 3. Estimated Mean Number of People Shot by Variable.

	Model 1	Model 2	Model 3
Variables	Estimated mean	Estimated mean	Estimated mean
Race			
Non-White	5.13	5.07	5.19
White	5.15	5.17	5.14
Relationship			
No Relationship	5.01	4.94	4.93
Relationship	5.36	5.44	5.56
Mobile			
Mobile	4.84	4.86	4.86
Not Mobile	5.23	5.20	5.24
Weekday			
Weekday	5.21	5.21	5.18
Weekend	4.92	4.87	5.10
Daytime			
Daytime	5.23	5.22	5.32
Nighttime	4.81	4.80	4.60
Location			
Retail	5.02	5.04	5.04
Factory	5.52	5.35	5.51
Office	5.02	5.05	5.06
Outdoors	5.91	5.94	6.10
School	3.99	3.94	3.95
Other	6.44	6.52	6.32
Resolution			
Suicide post police	6.63	6.57	6.53
Fled	5.86	5.79	6.84
Victims stop	3.84	3.88	3.92
Stopped by police	5.28	5.19	5.09
Suicide pre-police	5.01	5.12	5.05

More substantial differences were estimated for the location at which the attack took place and how the attack was resolved. Schools are notable for having the lowest estimated mean of people shot (3.99). This is at least one less than the other locations. The "other" locations are notable for having a estimated mean number shot that is one higher than many of the location types.

Events where victim's stop the attacker are estimated to have at least one fewer person shot than events with other resolutions. Events where the attacker commits suicide after the police arrive have the highest estimated mean number of people shot (in the mid sixes), and this estimated mean is about one more than most of the other resolutions.

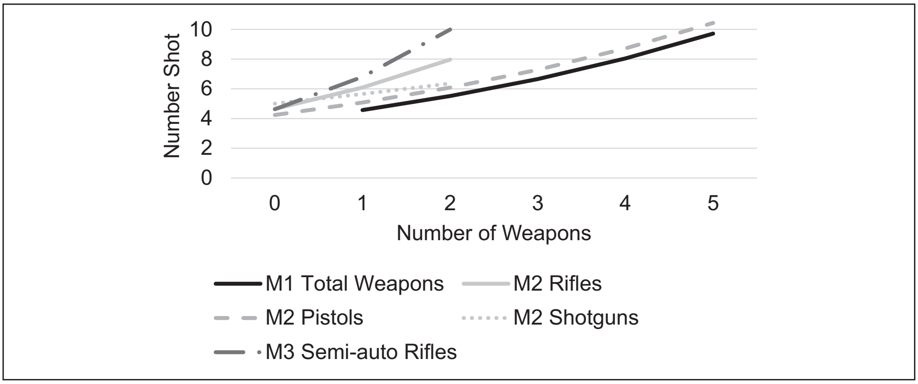

Figure 1. Estimated number of people shot by number and type of weapons.

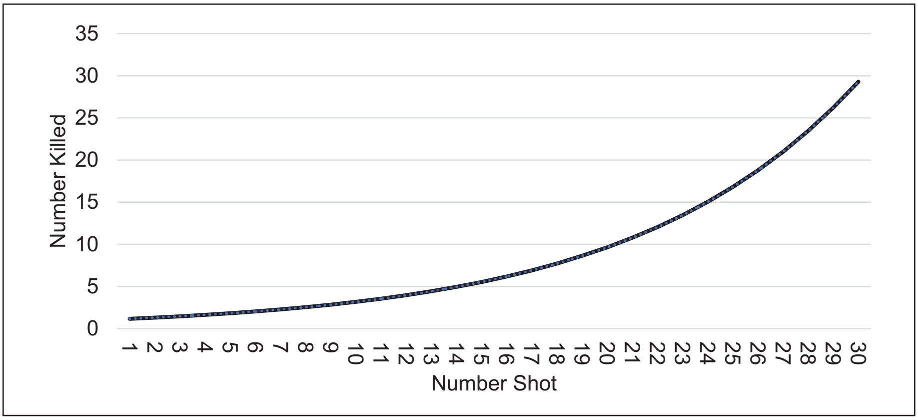

Figure 2. Estimated number killed by number shot.

Figure 1 shows the estimated mean number of people shot by the number and type of weapons used. For the sake of clarity, only the semi-automatic rifle variable from Model 3 is included. For Model 1 the total number of weapons variable predicts an increase in the number of people shot as the total number of weapons increases, ranging from 4.57 people shot when a single weapon is brought to the attack location to 9.72 people shot when five weapons are brought. A similar pattern is seen for the number of pistols variable in Model 2, increasing from an estimated 5.08 shot to 10.43 shot when five pistols were brought to the attack location. For Model 2 when one shotgun was brought to the location, the estimated number of people shot was 5.65 and when two were brought the estimated number shot was 6.36. Model 2 predicts that when one rifle is brought to the scene, 6.09 people will be shot and if two rifles are brought 7.97 people will be shot. In Model 3, when a single semi-automatic rifle is brought to the scene, the estimated number of people shot is 6.82 and when two

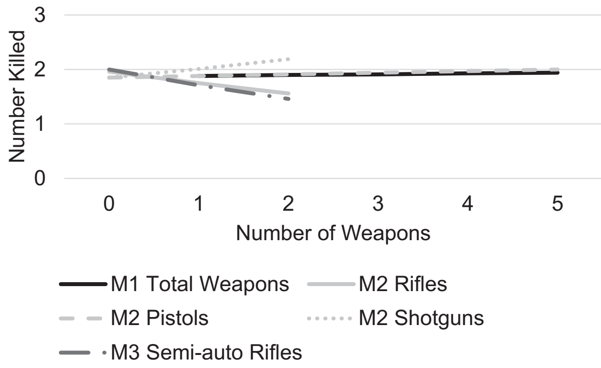

Figure 3. Estimated number killed by weapon number and type.

semi-automatic rifles are brought to the scene, the estimated number of people shot is 9.96. Figure 1 also shows that the estimated increase in number of people shot increases more quickly for both of the rifle variables when compared to other weapons, but is truncated in that, at most, only two rifles were brought in the included cases. When either four or five pistols or total weapons were brought, the estimated number of people shot was similar to when two rifles were brought.

The age of the attacker showed a roughly linear trend with the youngest attackers estimated to shoot about 6.23 people and the oldest 3.97. The year that the attack showed a roughly linear negative relationship between the year during which the attack occurred and the number of people shot. Specifically, 5.86 people were estimated to be shot per event in the year 2000 and 4.79 in 2017.

Number Killed

The next series of models considered the impact of the variables on the number of people killed. We believe that the number of people shot in an event is the best indicator for how devastating an event was. Each person shot is a potential death, and even if the persons does not die, they often suffer lifelong disabilities from their injuries. While there is a substantial chance element to whether a person survives after they are shot, we believe that insight can be gained by looking into the factors that are associated with how many people die. The models in this section include the same variables in Models 1 to 3 with one exception. Models 4 to 6 included the number of people shot as an independent variable (See Table 4). This allows us to look at how the variables specifically contribute to lethality beyond their contribution to the number of people shot.

Across all the models AICs did not significantly vary. For this reason, we focus on the results of the first model. The other models are substantively the same with only minor variations in slope estimates and standard errors.

Table 4. Negative Binomial Regressions on Number of People Killed.

	Model 1			Model 2			Model 3		
Variables	*b*	*SE*	IRR	*b*	*SE*	IRR	*b*	*SE*	IRR
Intercept	.34	.33		.37	.33		.43	.33	
Number Shot	.11***	.01	1.12	.11***	.01	1.12	.11***	.01	1.12
Offender									
Weapon									
Total weapons	.01	.06	1.01						
Rifles				−.12	.10	.89			
Pistols				.02	.06	1.01	.01	.07	1.01
Shotguns				.08	.14	1.09	.04	.14	1.04
Semi-Rifles							−.16	.11	.85
Other Rifles							.11	.25	1.11
White	−.03	.11	.97	−.03	.11	.97	−.01	.11	.99
Age	.00	.00	1.00	.00	.00	1.00	.00	.00	1.00
Relationship	.00	.16	1.00	−.03	.16	.97	.00	.16	1.00
Attack features									
Location[a]									
Factory	.04	.23	1.04	.07	.23	1.07	.02	.23	1.01
Office	.03	.19	1.03	.03	.19	1.04	−.03	.19	.97
Outdoors	−.12	.18	.88	−.10	.18	.90	−.11	.18	.89
School	−.41	.23	.67	−.39	.23	.68	−.44	.23	.64
Other	.24	.19	1.27	.22	.19	1.25	.20	.19	1.22
Year	−.03*	.01	.97	−.03*	.01	.97	−.03*	.01	.97
Weekday	−.01	.14	.99	−.02	.14	.98	−.02	.14	.98
Daytime	.39**	.15	1.48	.39**	.39	1.48	.36*	.15	1.44
Mobile	.12	.13	1.13	.13	.13	1.14	1.14	.13	1.11
Resolution[b]									
Fled	−.05	.21	.95	−.05	.21	.95	−.08	.22	.91
Victims stop	−.65**	.22	.52	−.67**	.22	.51	−.68**	.22	.51
Police stop	−.29	.17	.74	−.30	.16	.74	−.28	.17	.76
Suicide pre-police	−.10	.18	.90	−.12	.17	.88	−.12	.17	.88
df		243			243			238	
AIC		887.8			889.7			875.0[†]	

Note. Eliminating the cases that are missing in Model 3 from Model 1 resulted in an AIC of 872.0. Comparing the models produced a non -significant test (Vuong $z = .66$, $p = .25$). .00 standard errors are not truly .00 they are rounded down to hundredths.
[a]Reference group is retail locations.
[b]Reference group is suicide after the police arrive.
[†]AIC of 875.0 is based on a sample of 239 verses a sample of 244.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 5. Estimated Mean Number of People Killed by Variable.

	Model 1	Model 2	Model 3
Variables	Estimated mean	Estimated mean	Estimated mean
Race			
Non-White	1.92	1.92	1.94
White	1.87	1.86	1.90
Relationship			
No relationship	1.89	1.91	1.90
Relationship	1.90	1.85	1.95
Mobile			
Mobile	2.08	2.08	2.13
Not Mobile	1.84	1.83	1.86
Weekday			
Weekday	1.89	1.88	1.90
Weekend	1.90	1.91	1.97
Daytime			
Daytime	2.05	2.04	2.07
Nighttime	1.39	1.38	1.44
Location			
Retail	2.03	2.00	2.13
Factory	2.11	2.15	2.12
Office	2.09	2.08	2.09
Outdoors	1.79	1.81	1.83
School	1.35	1.35	1.34
Other	1.79	2.51	2.56
Resolution			
Suicide post police	2.42	2.43	2.46
Fled	2.30	2.31	2.41
Victims stop	1.25	1.24	1.24
Stopped by police	1.79	1.80	1.85
Suicide pre-police	2.18	2.15	2.16

As we discussed in the number of people shot section above, these data can be considered the population of active shooter events and, as such, significance tests are not relevant. We therefore focus on the estimated mean number of people killed for the variable in question while controlling for the other variables in the model. Table 5 presents these for the dichotomous and nominal variables, and Figures 2 and 3 present the means for the relevant continuous variables.

As can be seen in Table 5 most of the differences in estimated means for different levels of the variables are small (the levels have estimated means with a difference of $<.5$). Notable exceptions are the Daytime, Location, and Resolution variables. Daytime active shooter events are estimated to have about .7 more deaths than nighttime shootings. Schools are estimated to have about .75 fewer deaths than some other location types (i.e., factories and offices), and events where victims stop the attacker are estimated to have a mean of about one fewer death than events that end with the attacker committing suicide (pre or post police arrival) or fleeing.

Figure 2 shows the estimated mean number of people killed by how many people were shot. The estimated number of people killed is relatively linear up until about 15 people are shot and then begins to increase rapidly. This suggests that as more people are shot, the proportion of people who die increases.

Figure 3 shows the estimated mean number of people killed by weapon number and type for the different models. As can be seen, weapon type has much less effect on the number of people killed (when controlling for the number shot) than on the number of people shot. The slopes for total weapons in Model 1 and pistols in Model 2 are positive, but almost flat. The slope for shotguns in Model 2 is slightly steeper and positive. Interestingly, the slopes for both rifles in Model 2 and semi-automatic rifles in Model 3 are negative and steeper than the other slopes in the graph suggesting that while we found in the number shot analysis that rifles were associated with more people being shot, in this analysis they are associated with a lower proportion of people being killed.

The number of killed per event is also estimated to decrease in a roughly linear fashion across the years included in the analysis. About 2.6 people were estimated to be killed per event in 2000. In 2017, this number decreased to 1.6 per event. The impact of age on the number of people killed was roughly flat with the youngest attackers being estimated to kill about 1.9 people and the oldest about 2.0.

Discussion

This paper set out to examine the impact that a variety of variables had on the number of people shot and killed during active shooter events. Here we consider those variables using the groupings loosely based upon RAT (Offender, Target Features, and Guardianship).

Offender

Several of the offender variables were related to the number of people shot. In general, as the number of weapons brought to the scene increased, the number of people shot also increased. The slopes for the increase in the number of rifles were steeper than the other weapons (Models 2 and 3), but the largest number of rifles brought to the scene, in the cases that we analyzed, was two. The estimated number of people shot when two rifles or two semi-automatic rifles were brought to the scene was similar to the estimated number of people shot when there were five weapons brought (Model 1) or five pistols brought (Models 2 and 3).

Weapon type and number had a smaller impact on the number of people killed than on the number of people shot, when controlling for the number of people shot (Models 4–6). Somewhat surprisingly, an increase in the number of rifles (Model 2) or semi-automatic rifles (Model 3) was associated with a decrease in the number of people killed, suggesting that when controlling for the number of people shot, rifles were somewhat less lethal than other weapons. Our data seem to support the contention that where a bullet strikes someone is more important than the caliber of bullet that struck them.

The only other offender variable that had a large impact on the number of people shot was age. Older attackers were estimated to shoot fewer victims than younger attackers. The youngest attackers were estimated to shoot about two more people than the oldest attackers. While we can speculate that perhaps older attackers were less accurate or mobile than younger attackers because of the effects of aging, most of the attackers in the data set were not elderly.

Target Features

The location that was attacked showed a large impact on the estimated number of people shot. Schools were estimated to have one to two fewer people shot than other location types. While the magnitude is not as large as for the number shot, schools were also estimated to have the fewest number of people killed during active shooter events (when controlling for number shot) compared to the other locations. Schools have been working on their security and responses to active shooter events for some time now and it may be that this work is producing results.

We also found that more recent attacks (as considered by year) were estimated to have about one fewer person shot and one fewer person killed. Active shooter events have been of public concern for some time now and substantial efforts have been made to both improve police and civilian responses. Additionally, for about the last decade, we have seen substantial efforts to train police officers in point-of-wounding care. This training teaches police officers to control bleeding, maintain airways, prevent tension pneumothorax, and avoid hypothermia to prevent death from occurring before patients can be treated by EMTs or higher levels of medical professionals (Martaindale & Blair, 2019). More recently, efforts have been made to train civilians in comparable skills through Stop the Bleed and similar programs (Martaindale & Blair, 2019). Additionally, training for active shooter response has begun to focus on integrating police, fire, and EMS efforts to provide initial medical care and transport victims to the appropriate level of definitive care (e.g., a level one trauma center) (Martaindale & Blair, 2019). While our data cannot provide definitive proof, it is possible that these efforts to save lives are paying off.

Guardianship

As we mentioned earlier, we lack strong measures of guardianship in the data set. We, therefore, used event resolution (how the event ended) as a proxy for guardianship. Events where potential victims stopped the attacker (i.e., where victims were successfully their own guardians) had the fewest estimated number of people shot. When compared to some resolutions, the prediction was for almost three fewer people shot. Events were the victims stopped the attacker also had the fewest estimated number of people killed. This category included both events where the victims were unarmed

Table 6. Data on Excluded Cases.

Event	Year	Shot	Killed	Pistol	Shotgun	Rifle	Resolution	Location
Harvest music festival	2017	480	58	0	0	12	Suicide pre-police	Outdoors
Pulse night club	2016	102	49	1	0	1	Stopped by police-shot	Retail
Century 21 theater	2012	70	12	1	1	1	Stopped by police-subdued	Retail
Virginia tech	2007	49	32	2	0	0	Suicide post police	School
First Baptist Church	2017	46	26	0	0	1	Stopped by citizens-shot	Other
Fort hood	2009	46	26	2	0	0	Stopped by police-shot	Other

($n=32$) and events where the victims were armed ($n=8$). In the events were the victims were armed, one was an off-duty police officer, two were armed security guards, and five were civilians carrying concealed weapons. The finding that victims were able to successfully stop the attacker and thereby reduce the number of people shot and killed reinforces many of the civilian active shooter response programs that have been advocated for the last several years. These systems teach various options that civilians can use to protect themselves in the event of an attack. The Department of Homeland Security, for example, teaches Run, Hide, Fight, and the Advanced Law Enforcement Rapid Response Training (ALERRT) Center teaches Avoid, Deny, Defend (ALERRT, 2019). The current findings support that fighting or defending are viable strategies for civilians during these events. It should be noted that both programs teach these responses as last resorts and that potential victims should first try to Avoid/Run or Hide/Deny access.

Reconsidering the Outliers

Recall that we excluded six cases from analysis because they were extreme outliers. These were: the Harvest Music Festival, Las Vegas, NV, 2017 (480 shot and 58 killed); the Pulse Night Club, Orlando, FL, 2016 (102 shot and 49 killed); Century 21 Movie Theater, Aurora, CO, 2012 (70 shot and 12 killed); Virginia Tech, Blacksburg, VA, 2007 (49 shot and 32 killed); First Baptist Church, Sutherland Springs, TX, 2017 (46 shot and 26 killed); and Fort Hood, Killeen, TX, 2009 (42 shot and 13 killed). Table 4 displays the data on these attacks. The Harvest Music Festival alone accounts for about one quarter of all the people shot in the data set. Including these cases in the previously discussed models provides an inaccurate picture of what happens in the typical case and an inaccurate picture of the extreme cases. We also feel that it is important to give these cases some consideration. Table 6 presents information on these cases.

Two patterns can be seen in the table. First, most of these cases are more recent. Three of the six are from the last 2 years of data and all of them occur after 2007. Research on active shooters has revealed that many study past attacks in an apparent attempt to learn from them and make their own attacks more devastating (Silver et al., 2018). It appears that while we have not seen a general increase in the number of people shot and killed as time has gone by, we have seen the occurrence of more extreme events.

The second pattern that can be observed is that all but one of these events involved multiple weapons. Some of the cases involved multiple pistols or multiple rifles, or a combination of pistols, rifles, and shotguns. Regardless of the specific combination of weapons, except for the First Baptist Church incident, they all involved multiple weapons. This comports with our suggestion that Model 1, which includes only the total number of weapons, provides a parsimonious account of the number of people shot and killed. This also is consistent with our findings that how the attacker is armed has an impact on the severity of the attack and points to the importance of considering offender related variables.

Beyond what is shown in the table, our read of these cases suggests some additional commonalities that may have impacted the number of people shot and killed. First, each of these cases has many people trapped in the target area who were either unable to or failed to avoid the attacker, deny access to their location, or defend themselves. At the harvest music festival for example, the shooter was across the street in an elevated position. The victims were in a large, outdoor concert venue. Victims were unable to quickly exit the area that the attacker was shooting into because of the large number of people trying to use limited exits. The victims had little way to deny access to their location because they were stuck in an open area, and the victims were unable to defend themselves because they could not reach the attacker to subdue him (the attacker was also beyond the range that most concealed weapon carriers could effectively hit with their pistols). While the Harvest Music Festival shooting is an extreme event among extreme events, each of the other events had a similar situation. Large numbers of people were in the area of the attack and they were either unable or ineffective at taking protective actions. This further suggests that target characteristics are important. Designing environments to allow potential victims to better protect themselves (such as putting more exits in concert venues) might also reduce the severity of these attacks.

Second, in many of these cases, police response was either slower than normal or ineffective. While we were not able to find information on response times for many of the cases, in the cases where we could, the average response time was about 3 minutes (3.28 minutes, $n=42$, $SD=2.18$). During the Harvest Music Festival shooting, it took officers several minutes to identify where the shooting was coming from and then make their way to the location. Officers did not make it onto the floor of hotel that the attacker was shooting from until about 17 minutes after the shooting began. During the Virginia Tech shooting, the attacker chained the doors the building that he was attacking. This slowed the responding police officers' entry into the building and allowed the shooter to continue his attack for about 10 to 12 minutes without police intervention. At the Stoneman Douglas High School shooting, there was an armed officer from the Sherriff's Office on the campus, but he stopped outside and did not enter the building where the shooting was occurring. He also directed law enforcement officers that were arriving in response to the shooting calls to stay away from the building where the shooting was occurring. Slower, or ineffective police response was not a factor in all the extreme cases, but it appears to have played a role in many of them. This further suggests that establishing effective guardianship quickly is important in reducing the amount of damage done.

Limitations

This study, of course, is not without limitations. One of the major limitations is the data that were available. While the FBI active shooter team has engaged in a thorough attempt to identify cases, their method is not perfect. It is likely that some cases have been missed. Lott (2015), for example, identified 20 cases that he felt the FBI missed. While it is not clear that all these cases would meet the definition of an active shooting, at least some of them appear to be relevant. Inclusion of additional cases could obviously affect the results reported here.

The data are also limited in the information that they contain. We do not know, for example, what type of weapon caused each wound. This information would have provided much greater insight into the effects of specific types of weapons on the number of people shot and killed. Instead, we only know what weapons were brought to the scene. The data also do not generally include information about how long the shooter was shooting or how long it took the police to arrive on scene. Both would presumably have a substantial impact on the number of people shot and killed. This data might also substantially change the impact of the different resolutions on how many people are injured and killed because the resolutions appear to be correlated with the duration of the attack. That is, the resolutions that would generally happen more rapidly are correlated with fewer people being shot.

Even with these limitations, the data used here are the best available to explore the phenomena of active shooter events that have captured the public's attention for the last several decades. We believe our research provides valuable insight into the factors that contribute to the number of people shot and killed in active shooter events.

Authors' Note

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Supplemental Material

Supplemental material for this article is available online.

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