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What does Gunshot Detection Technology tell us about gun violence?

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ABSTRACT

Purpose: Evaluate the sensitivity of Gunshot Detection Technology (GDT) relative to Calls for Service. Existing crime data sources have biases that do not present a complete picture of gun-related crime. GDT may offer a new metric for firearm crimes. However, few studies have assessed the accuracy of GDT and its relationship to other measures of violence.

Methods: GDT and gun crime-related Calls for Service in Washington, DC during 2010 were studied. Using temporal comparisons for month, day of year, weekday, and hour of the day, spatial comparisons on a quarter-mile square grid, and a Poisson-Lognormal-CAR spatial regression model on a combined grid by time period dataset, we examined the sensitivity of GDT activations relative to gunshot-related calls for service.

Results: The results showed that relative GDT sensitivity changed by time and by space. In particular, the relative sensitivity of GDT was much stronger in the evening and at nighttime than in the daytime. In terms of spatial variation, we found that GDT sensitivity decreased with distance from the nearest zone centroid. In addition, there were two small geographic areas in the study area in which the relative GDT sensitivity was lower than expected.

Conclusions: GDT systems identify the frequency and locational accuracy of gunshot incidents, particularly at nighttime. This technology has the potential to improve data collection on gun use and violence and produce more accurate representations if the temporal and distance limitations of the technology are understood. GDT may improve gun detection and, thereby, improve police operations and public support for police.

1. Introduction

This study examines the relationship between Gunshot Detection Technology (GDT) and calls for service relating to firearms discharges. Researchers have long known that information in available statistical measures of crime reveal only a portion of total offenses, with another portion, sometimes referred to as “the dark figure of crime,” going unrepresented (Coleman & Moynihan, 1996; Penney, 2014). GDT offers the possibility of identifying some of that unrepresented crime related to firearms use. However, few studies have assessed the accuracy of GDT and its relationship to other measures of violence.

1.1. Under-reporting of gun violence

Reporting bias, either due to individuals' reluctance to disclose information or failure to recall past crime incidents poses a particularly significant threat to research on gun violence. Public reports (Calls for Service) have been the primary means by which police become aware of gunshots (Mazerolle, Watkins, Rogan, & Frank, 1999). However, gun violence in communities tends to be concentrated within small geographic areas and affect a limited network of people (mostly young males), many of whom have been both victims and perpetrators of illegal gun activity (Braga, 2003; 2007) and who may be socially unconnected and disinclined to report incidents (Fox, 1996; Jones- Brown, 2007; Solis, Portillos, & Brunson, 2009). Lack of reporting may also occur where gunshots are commonplace and perceptions of police response and effectiveness are low (Kidd & Chayet, 1984; Langton, Berzofsky, Krebs, & McDonald, 2012; Mazerolle, Frank, Rogan, & Watkins, 1999) or when there are non-fatal firearm-related crimes such as gun

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discharges with no victim or gun assaults with minor wounds (Mazerolle, Frank et al., 1999).

To overcome reporting bias researchers generally focus on firearm-related homicides. However, most gunshot-related crime incidents do not result in a homicide (Alavarado & Massey, 2010; Archer & Gartner, 1984; La Free, 2005). These limitations of traditional data on gun violence underscore the need for additional information on gun-related crimes that can provide a more accurate identification.

1.2. Gunshot Detection Technology

Data from GDT offer a new source of information on firearm-related crimes. GDT uses a network of acoustic sensors to identify the sound of a gunshot and relay this information to emergency services personnel (Eng, 2004; Showen, 1997; Siuru, 2007). Beginning in the 1990s increasing numbers of law enforcement agencies began adopting GDT to facilitate improved response to gun violence and by 2014, a total of fifty cities and 267 square miles were covered by just one GDT vendor's system (SST Inc., 2014).

The technology uses the sensors to identify a gunshot sound and triangulate its position (see Fig. 1). Gunshots have a distinctive acoustic signature composed of the sound of the explosion, the muzzle blast, the sound of the firearm's projectiles and, to lesser degree, the mechanical sound of the firearm and vibration from any solid surfaces near the discharge of the weapon (Maher, 2007). A byproduct of the detection process is standardized data recording of the location and time of gunshot with considerable precision. The most recent versions of this technology have also been found to accurately record gunshots under most conditions (Goode, 2012).

1.3. Evaluation of the accuracy of GDT systems

Findings on the accuracy of GDT systems for detecting and triangulating gunshots are mixed but do suggest that it has improved over time. Early deployments detected approximately 81 percent of gunshots fired with the technology being able to triangulate the location of the gunshot in 84 percent of those cases (Mazerolle, Watkins et al., 1999; Watkins, Mazerolle, Rogan, & Frank, 2002). However, a two-city assessment yielded sharply divergent results with a 97 percent success rate identifying gunshot at one of the cities and a failure to identify shots of more than 70 percent at the other (Litch & Orrison, 2011). Another study found that the correlation between activations and reported calls for service differed substantially within Oakland, CA and Washington, DC (Carr & Doleac, 2015a, 2015b). That study found only 12% of the gunshots detected by the GDT system resulted in 911 calls to report gunshots.

2. Methodology

Our study focuses on concentrations of detected gunshots and Calls for Service in Washington, DC. In 2010, the city had 17.3 square miles of GDT coverage which represented about 25% of the total area of the city. The GDT installations were placed in areas with high amounts of citizen-reported gunshots and gun-related crimes. The city also has ample crime data of sufficient quality, collected by the Washington DC Metropolitan Police Department (MPD).

In 2010, Washington, DC had approximately 1241 violent crimes per 100,000 persons, putting its violent crime rate (819 violent crimes per 100,000 persons) substantially above the national average for cities with populations between 500,000 and 999,999. According to official records, in 2010 in the city, 76 percent of homicides, 19 percent of aggravated assaults, and 40 percent of robberies were committed with firearms (FBI, 2011).

2.1. Data sources

The biggest methodological problem in evaluating GDT is that there is not a complete database of gunshot events. Based on the data we have, actual gun-related crimes appear to be fewer than 10% of all gunshot events. Consequently, it was necessary to approximate the number of gunshot events by comparing the GDT detection with Calls for Service for gun-related events.

Three different sources of data were used for this study: 1) Activations of the Metropolitan Police Department (MPD)'s GDT system; 2) Gun-related calls for police service reported to the MPD in 2010 (hereinafter referred to as Calls for Service), and 3) Gun-related crimes reported to the MPD in 2010. These data sources were only collected for the GDT coverage areas. The GDT data was obtained from ShotSpotter, the largest GDT manufacturer (SST, 2016), which divided its coverage within the city into four zones. To ensure better accuracy, a buffer zone of 0.25 miles beyond the boundaries was added for the identification of gunshot incidents.

The data were obtained by accessing a data file made publically available online by the MPD in response to a Freedom of Information request. The data provide the geographic coordinates of the detected gunshot event (within 25 m), the date and time, file of the gunshot, and an indicator of whether the incident involved single or multiple shots. These data provided an initial total of 5745 detected incidents in 2010. Eliminating GDT counts outside the coverage area (the coverage area plus a quarter mile buffer zone beyond) reduced the number to 5437. Calls for Service data were obtained from the MPD. In 2010, there were 6855 Calls for Service related to gunshot incidents within Washington DC. Of these, 6072 (or 89%) occurred within the study area. However, for many gunshot events, there were multiple calls received.

To identify unique calls, that is unique gun events for which one or more calls were received, we selected three time windows of 10 (N = 4251), 20 (N = 3592), and 30 min (N = 1708) and only identified the first call within each window. The aim was to identify a unique set of gunshot events based on one or more persons calling the police for a gunshot sound. When we made comparisons by month, day of year, day of week, hour of day, and spatial variability, the three sub-sets correlated highly with each other.

We chose the 20 min window (N = 3592) as representing a reliable estimate of the number of unique gun events identified by the public.[1] We chose the 20 min window for three reasons. First, considering the number of unique events in 10, 20, and 30 min windows, we decided that a 20 min window was a good break point. The number of GDT events identified was 5,437, which is more frequent than the calls received in any of those windows. The longer the time window, the greater the ratio since the number of unique events identified decreases. Clearly, without having an independent dataset of actual gun shots, we cannot easily test which window is the most accurate.

Second, we did not want to bias the results by either overestimating or underestimating. Having a higher overall ratio makes GDT appear more accurate than it is; the converse would be true for a 10 min window where the ratio was lower (i.e., we would get more hours where the ratio fell below 1.0).

Third, there is a potential 'false negative' problem in taking a longer window. If two separate gun events came within 30 min of each other, then the 30 min window would categorize them as a single event, rather than two. On the other hand, using a 10 min window might create 'false positive', identifying two 'events' which actually was only one. Thus, the 20 min window is a good balance

[1] All three subsets produced virtually identical results on all temporal and spatial tests.