MICRO-HOT-SPOT POLICING IN BUFFALO

Prepared for the City of Buffalo Police Department

Abstract

The purpose of the project is to examine the effectiveness of a micro hot spot (MHS) crime reduction program developed by the Buffalo Police Department (BPD) and formally initiated in March of 2022. The MHS approach to dealing with violence and gun crime uses intelligence generated by the Erie Crime Analysis Center to identify violent crime with 500 x 500-foot segments of the city. Officers work in a "directed patrol" fashion. They are responsible for spending between 12 and 15 minutes within the micro hot spots to which they are assigned. The analytic methods used include Interrupted Time Series Analysis and an assessment of hot spot fidelity based on datafiles provided by the Erie Crime Analys is Center and Buffalo Police.

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Executive Summary

Like many other larger cities in the United States, Buffalo experienced an increase in violent crime, particularly gun related violence, for the past ten to fifteen years. Prior scholarship indicated that most violent crime is concentrated in small areas, commonly referred to as “micro hot spots” (MHS). The police administration in Buffalo implemented a MHS program to reduce violent crime. Specific areas within the city where violent gun crimes occurred most frequently were identified based on information provided by the Erie Crime Analysis Center. Patrol officers were to spend approximately 12-15 minutes in these areas at random times during their patrol shift.

Two analytic approaches were used to examine the effectiveness of the MHS program. First, an interrupted time series analysis was conducted, which essentially examines the levels of violent crime pre-intervention and again during the post-intervention period. This was also done with respect to calls-for-service. Second, “patrol fidelity” (patrol officers faithfully spending 12-15 minutes within the MHS) was assessed based on their reported “call out” times in those locations.

Analysis found that, overall, it is reasonable to assert that the MHS program in Buffalo strongly contributed to a decrease in gun violence after its implementation. The time series analysis found a there was an immediate percentage decrease of 51.179 in the level of gun homicides, which is statistically significant. There was a 22.586 percent decrease in the levels of nongang shootings immediately after implementation of the MHS intervention, which was also statistically significant. This was followed by a non-significant decline in the week-to-week trend. Also, the MHS program caused a decrease in both the level and slope of gang shootings, but its effects are not statistically significant.

Also, from mid-2022 through the present Buffalo experienced an increase, but a nonsignificant one, in calls-for-service (CFS) involving gun possession, while overall shootings and related CFSs demonstrated declining trajectories during the same time period. This may indicate that Buffalo residents have a positive view of the intervention and will increasingly call the police for service associated with gun possession, even before actual occurrences of shootings.

The "patrol fidelity" data indicates that directed patrol units spent almost 27 minutes, on average, per day, in a micro hot spot. This finding should be interpreted with caution. The data indicated that the shortest patrol within a hot spot was 14 minutes, and the longest was over 300 minutes. Many patrols were well over 25 minutes. Erie Crime Analysis Center employees and BPD supervisors suggested that some officers had forgotten to sign out when they left their directed patrol within a hot spot. Therefore, it is too early to suggest that directed patrol officers should spend less time within a micro hot spot.

Statement of the Problem

Violent crime has been increasing in many cities across the United States for almost a decade. Unfortunately, the impact of violence and gun crimes are not equally distributed across a city. Both violent crimes and gun crimes are often concentrated in smaller areas, such as street-segments or city blocks. The areas of a city that account for a high concentration of crime are commonly referred to as "hot spots." Further, within these hot spots there are often a small network of people who are considered "high risk" for committing crime.

For the last thirty years empirical studies have examined the police response to crime in hot spots. Commonly, officers work in a "directed patrol" fashion. These officers are responsible for spending between 12 and 15 minutes within the hot spots to which they are assigned. During their directed patrols the officers employed different tactics. For example, some police agencies simply assigned officers to park within a hot spot, under the assumption that their mere presence would deter offenders. Some agencies had police officers conduct vehicle and pedestrian stops, issue citations, and make arrests (Jang, Lee, & Hoover, 2012). Some agencies responded to hot spots by having officers dispersed loiterers and stop suspicious persons (Braga & Bond, 2008).

An important aspect of hot spot policing is the normal "dosage" of patrol officer time within a hot spot. The common expectation in most police agencies was approximately 12 - 15 minutes during non-specific times withing an 8-hour shift (Koper, 1995).

New research indicates that hot stop dimensions or "areas" might result in more efficient policing, and a greater reduction of crime, if these areas are treated as "micro hot spots." That is, rather than identify a high crime location within a few city blocks or a census tract, the police would be better served if a hot spot was concentrated within a few hundred feet (Weisburd, 2015).

The Buffalo Police Department's approach to dealing with violence and gun crime takes this approach. Information and intelligence generated by the Erie Crime Analysis Center was used to identify violent crime with 500 x 500-foot segments of the city. Further, as part of the department's hot spot tactics, Erie Crime Analysis Center produces "timed heat maps." These maps assess not only the location of shootings and other gun related crimes, but the timeframe for when these events most commonly occur. These timed heat maps are intended to focus on a 4-hour block of time when most shootings or gun crimes occurred in a MHS.

The overall goal of using MHSs is to provide a general deterrent effect on potential criminal activity. A further benefit of police officers engaging with the public is these informal interactions contributing to the goals of community policing. When the police interact with residents and businesspersons it improves the relationship between these groups. This leads to improved future interactions and a willingness of the public to work in other ways with the police to improve the quality of life in the neighborhood.

Understanding the Issue

Hot spot policing is a derivative from two sources. First, spatial variation analysis, which is a scientific tool that examines the distribution of social problems to identify the correlates of these issues and develop remedies. Sherman, Gartin and Buerger (1989) applied this analytic approach to the concentration of calls for service in Minneapolis. Sherman and his colleagues used the term "hot spot" to describe the few areas of the city receiving high numbers of calls for service. Over time the term hot spot has been adopted to describe an area having a higher-than-normal concentration of crime or victimization (Eck, 2005). Several scholars replicated this

Minneapolis research and demonstrated that crime is not randomly distributed across a city (Brantingham & Brantingham 1981; Ratcliffe, 2002); rather crime is concentrated in specific locations, although the size of those areas can vary (Weisburd, Maher, & Sherman, 1992; Weisburd, Bushway, Lum, & Sue-Ming, 2004).

Second, opportunity theories suggested that the characteristics of a location can create "routine activities" within that area (Cohen & Felson, 1979). Common behaviors within an area or neighborhood can result in a confluence of three factors: motivated offenders, suitable targets, and an absence of capable guardians. When these three factors exist, crime can occur. Different policing tactics, such as directed patrols, disrupting even one of these three factors, can lead to a reduction in crime.

While the term hot spot is conceptually clear, there is no specific definition with respect to the size or area of a hot spot (Eck, 2005). Researchers have operationalized hot spot locations based on higher levels of crime in census blocks (Bernasco & Block, 2010), or a concentration of crimes within clusters of addresses and street block faces (Braga & Weisburd, 2010). Others examined hot spots based on the crime levels associated with intersections (Braga, Hureau, & Papachristos, 2011; Weisburd & Green, 1995) and street segments (e.g., city blocks) (Andresen & Malleson, 2011; Weisburd, Morris, & Groff, 2009). Some scholars used mapping programs to identify higher crime sectors that comprised areas based on square miles (Taylor, Koper, & Woods, 2011) or using an intersection as a hot spot "epicenter" (Ratcliffe, et al., 2011).

Recent scholarship suggested that rather than identifying specific street segments or blocks, smaller areas should be used to define a hot spot. The Dallas police identified hot spots within 200 x 200 feet segments (Wheeler & Steenbeek, 2020). A study of hot spot policing in Jacksonville, Florida, examined 83 hot spots averaging 0.02 square miles in size (Taylor, et al., 2011). In St. Louis, researchers examined hot spots that averaged .01 square mile in size. This was roughly the size of four city blocks and suburban in nature (Kochel & Weisburd, 2019).

Locations targeted for increased surveillance or interdictions have been identified based on the level of "violent crime." For example, some used homicides, aggravated assaults, and robberies (Braga, Weisburd, Waring, Mazerolle, Spelman, & Gajewski, 1999; Braga, et al., 2011; Ratcliffe, et al., 2011). Braga et al. (2008) examined the association between locations and assault with a deadly weapon. Others used more general violent crime and property crime levels (Andersen & Malleson, 2011; Jang, et al., 2012; Taylor, et al., 2011). Sherman and his colleagues (1989) classified hot spots based on calls for service for "predatory" crimes (i.e., rape, robbery, auto theft). A few studies operationalized hot spot locations based on drug crimes (Lawton, Taylor, & Luongo, 2005; Sherman & Rogan, 1995). Weisburd, et al. (2009) used arrest records to determine hot spots associated with juvenile crime. Finally, Sherman and Rogan (1995) identified high-crime locations based on police and citizen lists of problem locations. Ultimately, there is no specific standard for the dimensions or size of a hot spot.

Addressing the Problem of Gun Violence in Buffalo

Buffalo is like other mid-sized cities with respect to the level of violent crime. Cities with populations between 250,000 and 500,000 have experienced increases in serious crime. In 2021 Buffalo's violent crime rate ranked 12th worst among 79 mid-sized cities (Gambini, 2021). A review of crime control and crime reduction programs in Buffalo in the past decade provide some guidance on potentially successful policing tactics. For example, during a two-week period in the summer of 2012 the police used SWAT teams to conduct drug-raids. There was evidence of a slight short-term deterrent effect for Part 1 crimes (i.e., violent crimes) in the two weeks after the intervention. Still, calls for service and drug arrests increased in the treated areas compared with control neighborhoods (Phillips, Wheeler, & Kim, 2016). This hints at a reduction of legal cynicism and increase in police legitimacy in those areas (Desmond, Papachristos, & Kirk, 2016). Second, between 2010 and 2015, Buffalo demolished over 2,000 vacant residences to reduce crimes committed in or in association with those abandoned houses. An evaluation of this approach suggested that at the "micro-place level," similar to micro-hot-spots, housing demolitions lead to a sharp reduction in reported crime at the exact parcel. There were additional crime decreases in buffers locations of up to 1,000 feet away from the demolished house (Wheeler, Phillips, & Kim, 2018).

The more recent violent crime problems in Buffalo may be related to the COVID-19 pandemic. Between January 2017 through the first week of October 2020 there was a temporary increase in fatal shootings, and a long-term increase in all non-fatal shootings, non-fatal shootings with injury, non-fatal shootings without injury, as well as gang related shootings (Kim & Phillips, 2021). It has also been suggested that violent crime is not random with respect to the time it occurs and the location of the crimes. Rather violent crime tends to "stick" to specific areas (Abt, 2019; Weisburd, 2015). Research of Buffalo shooting data appears to support this assumption. The analysis of shooting offense in Buffalo found that during COVID-19 there was little evidence indicating shifts in the neighborhood distribution of shootings in the city. Those locations in the city that were already hot spots of shooting activity simply increased in intensity (Drake, Wheeler, Kim, Phillips, & Mendolera, 2022).

Hot Spot Policing in Buffalo: An Overview

The planned hot spot policing method in Buffalo has its origins in an unplanned approach used in 2021 when police officers were informally assigned to presumed hot spot areas based on maps showing shooting and shots fired locations. The officers were detailed to specific

Figure #1: Full Grids for City of Buffalo

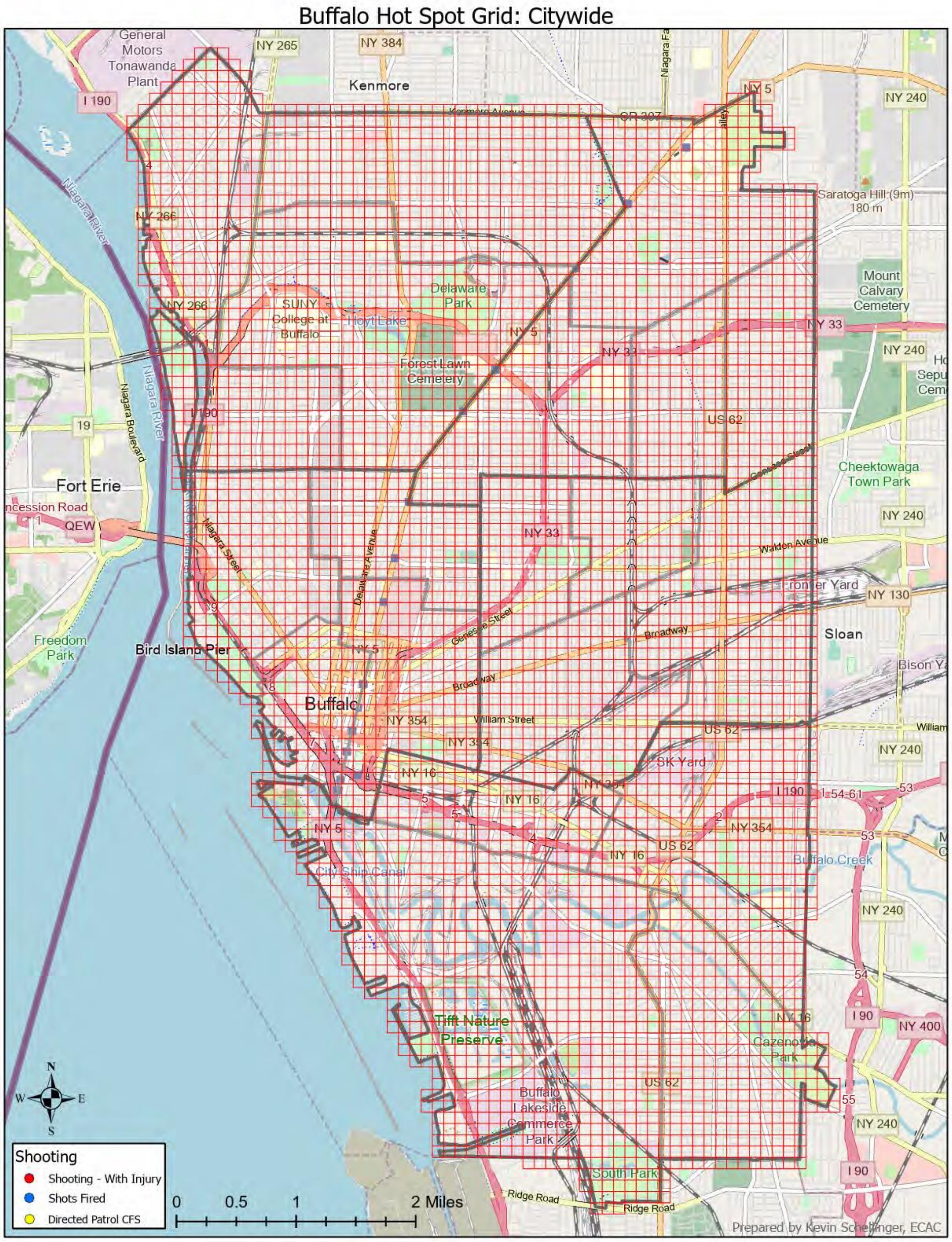
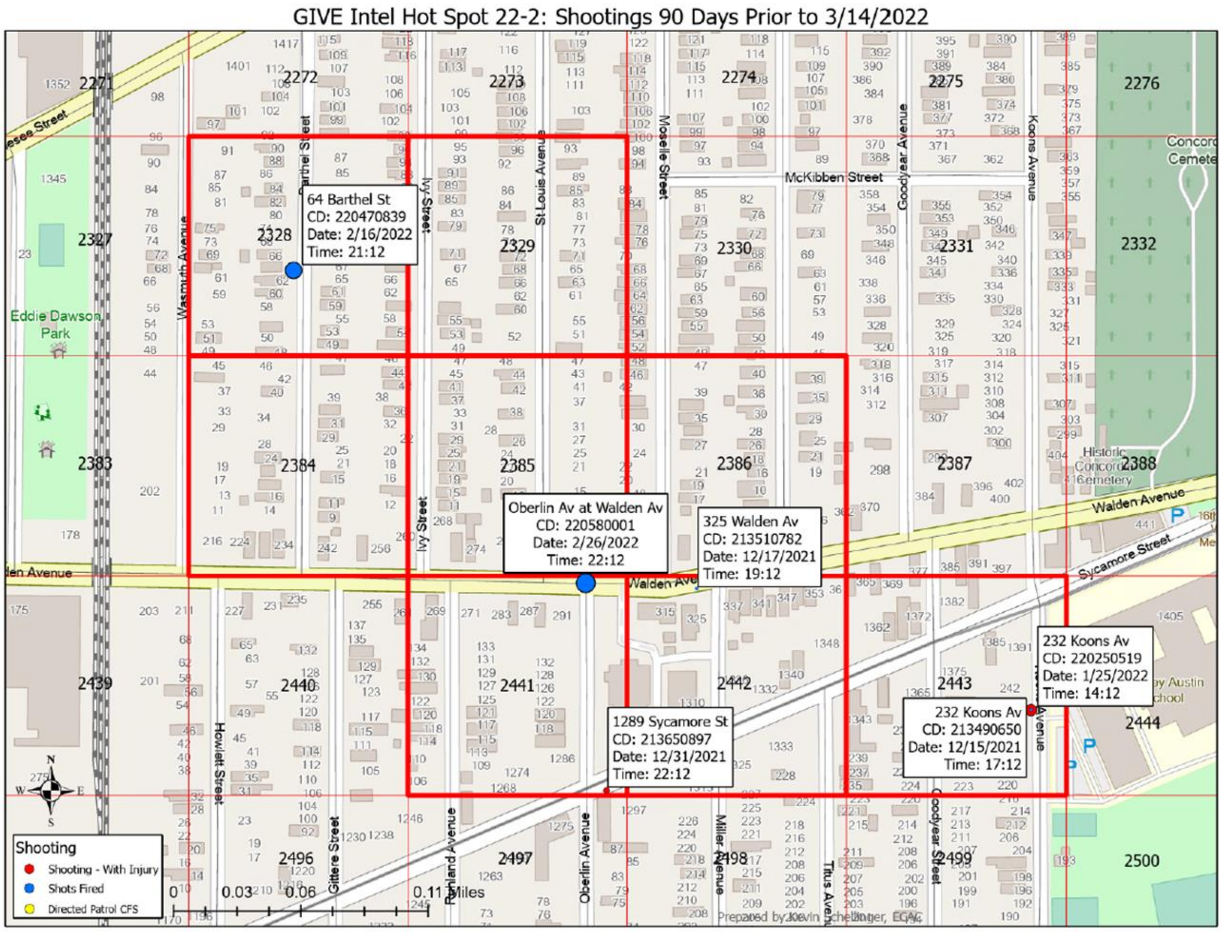


Figure #2: Sample Map with 500x500 Grids (closeup sample)



areas that were identified as hot spots, and they were given instructions to activate their patrol vehicle lights and engage citizens who might be in the area. The goal of this tactic was to serve as both a crime deterrent based on the officer's visible presence, as well as a community policing approach by informally interacting with local citizens.

In early 2022 the Buffalo Police administration engaged in a formal coordinated approach to focus on hot spots. Working with the Erie Crime Analysis Center (ECAC), the city was divided into micro-grids that measured 500 x 500 feet (0.009 square miles) (see Figure #1 for a citywide view and Figure #2 for a closeup example). This approach is in line with the hot spot dimensions used in recent scholarship (Kochel & Weisburd, 2019; Taylor, Koper, & Woods, 2011; Wheeler & Reuter, 2021). Using 500 foot-square grids resulted in a full 4798 grids across the city, with roughly 4,700 usable locations. That is, some areas of the city include industrial structures, water-front sections, or large park-areas. These locations would not likely contain any serious or violent crime and would not be identified as areas to receive additional police treatment.

Hot Spot Tactics in Buffalo: Some Specifics

The Buffalo Police created a computer aided dispatch (CAD) call labeled "directed patrol" (DP) for officers who are assigned to a MHS. The patrol officers will "call out" on the CAD system when they begin their activities in their assigned areas, and the system will record the time the officers are working in the hot spot. The agency can then overlay the DPs onto the grids to see where officers are and ensure that they are in the areas during the assigned timeframes. The grid maps can be used to overlay any call type / crime that occur in the city. This will help the police department when evaluating the effectiveness of the hot spot program in relation to the officer's activities ensuring they are in the control areas.

While police officers are working within a MHS they are engaging in a directed patrol. The directed patrol tactic is used as a general deterrent method to disrupt criminal activity. The officer's mere presence, as well as their engaging with the community members, for set periods of time in these areas is intended to prevent offenders from active criminal behavior. This is a focused approach to crime prevention rather than a "grab everyone in sight" philosophy. Connecting with members of the community is intended to build bridges through good community engagement.

Directed patrol can include a variety of different police officer behaviors. For example, the officers will park in a specific identified grid for approximately 15 minutes. The officers will activate the patrol car's flashing lights for high visibility as a deterrent. In addition, officers will document their time and location on the CAD system. This will ensure the officers are maintaining "fidelity" (Groff, Ratcliffe, Haberman, Sorg, Joyce, & Taylor, 2015) to the goals of their assignments. Further, existing crime data will be examined by the Erie Crime Analysis Center (ECAC) to identify individuals who live in hot spot areas who are shown to be active in a violent criminal lifestyle. Officer assigned to those MHS will be informed about those individuals and if they are members of groups who are involved in violent behavior. Thus, police officers in those MHS can pay particular attention to the individuals identified by the ECAC.

Each week there was a "patrol intelligence" meeting held on a rotating basis in each of the five police districts at different shift times. Included in this meeting was the district detail car patrol officers and other law enforcement partners including county, state, and federal partners. The goal was to take the meetings directly to the officers in their district substations rather than the central police headquarters. Thus, all detail shift officers are engaged at some point, ensuring all officers are exposed to the program. It is believed that by bringing the meetings and intelligence information to the patrol officers in their district stations that they will feel more comfortable when sharing the intelligence in a more open fashion.

During these intelligence meetings, patrol officers and district detectives exchanged intelligence information in real time with the special investigation's lieutenant. Occasionally, the patrol officers provided more accurate information to the detectives, as the detective's intelligence may be stale. Also, during these meetings, patrol officers were also provided with the updated Micro Hot Spot grids, 'be-on-the-lookout' (BOLOs) announcements, reports of gun arrests, as well as parole and probation reports regarding offenders living in the micro hot spot area. Real time information exchange fosters more buy in from street-level officers, promoting the idea that they are a part of the process. These officers act on that information while sharing it with other officers in the districts where they work.

Based on intelligence information provided by the ECAC, search warrants will be acquired for identified violent group members who are known gun traffickers / trigger pullers and are known to carry guns illegally. After a search warrant is executed by SWAT, within a reasonable amount of time, ideally the same day, the Buffalo Police Department's Neighborhood Engagement Team will walk within the neighborhood where the search warrant was executed to engage community members. This allows officers to explain why the raid was conducted and answer questions that residents may have because of the conspicuous police action that took place. Officers will also distribute materials that explain some of the resources and abilities of the police department. The police department is also developing a door hanger that will include a link to an anonymous survey allowing residents to provide feedback on the police department as well as any crime info they may provide.

The officers will also engage in community policing activities, such as foot patrol, in an effort to interact and network with the residents of the neighborhood within that MHS. Most residents within a MHS are good people living in a bad location (Abt, 2019). Interacting with these citizens can contribute to their feeling of procedural justice from the officers. Procedural justice occurs when the police give citizens a voice and the opportunity to express their opinion to an officer. Procedural justice is attained when police officers treat citizens with dignity and respect (Skogan, Van Craen, & Hennessy, 2015).

The police department has also purchased a web-based app that can be downloaded to an officer's smartphone. The app allows police officers to easily access the weekly intelligence meeting reports as well as any BOLO's that have been issued. The app can also be used to disseminate training bulletins to officers.

A Gun Involved Violence Elimination (GIVE) grant provided by the New York State Division of Criminal Justice Services allows the police department to dedicate specific police officers to the MHS. These officers are also available to provide "custom notifications" between the time spent in the hot spots. A custom notification occurs when personnel from several law-enforcement agencies work together with civilian nonprofit organizations to confront a person known to be affiliated in some way with gun violence. This is intended to have a preemptive deterrent impact on potential offenders and connect these citizens with social services as a long-term solution to violent behavior. Custom notifications are akin to the "pulling levers" approached used in other police agencies (Braga, Pierce, McDevitt, Bond, & Cronin, 2008). Shift officers who respond to calls are also being held responsible for their "non committed" time (when not on calls) to actively be in these areas while patrolling. We need to best utilize our officers time when it is not a call heavy time.

Current Study

As indicated above, the Buffalo Police administration engaged in a formal coordinated approach to focus on hot spots in March 2022. The planned hot spot policing approach in Buffalo has its origins in an unplanned approach used by the department because of a spike in shootings in the first half of 2021. It began an informal response to the shooting hot spots in July of 2021. At that time police officers were informally assigned to presumed hot spot areas based on maps showing shooting and shots fired locations. The officers were detailed to specific areas that were identified as hot spots, and they were given instructions to activate their patrol vehicle lights and engage citizens who might be in the area. The goal of this tactic was to serve as both a crime deterrent based on the officer's visible presence, as well as a community policing approach by informally interacting with local citizens. Therefore, this analysis used July of 2021 as the intervention date.

ANALYTIC METHOD

Interrupted Time-Series Analysis

The goal of the micro hot spot (MHS) crime reduction program is to reduce gun violence in Buffalo. Using data provided by the Erie Crime Analysis Center that dated from January 2018 to May 2023, the study seeks to examine the extent to which the MHS program caused declines in gun violence and corresponding calls for service. This portion of the evaluation used interrupted time-series analysis to examine the impact of the MHS program on gun violence. The level and trend of incidents that occurred after the implementation of the MHS program in July 2021 are compared to those that occurred before that start date, while other covariates are held constant.

Data

Dependent Variables

There are a total of seven dependent variables: gun vs. nongun homicides, gang vs. nongang shootings, and calls for service (CFSs, hereafter) involving gun possession, shootings with injuries, and shootings without injuries, respectively. The study differentiates homicide data by gun use to examine whether the effect of the intervention differs depending on the use of a firearm. Given that the program intends to address gun violence, it would have a greater effect on gun homicides, as opposed to nongun homicides. In addition, it disaggregates gun shooting into gang- vs. nongang-related incidents to obtain a more nuanced understanding of the impact of the intervention. Further, the study examines whether the intervention had an impact on various types of gun-related CFSs. The unit of analysis is weekly incidents at the city level.

Independent Variable

The independent variable of interest is the MHS program. The weeks from July 2021 through May 2023 are the intervention period, while those from January 2018 through June 2021 are the pre-intervention period. There are two possible impact patterns: level and slope changes (Linden, 2015). To measure a level change in the mean of incidents immediately following the program, the study uses a dummy variable that takes the value of zero for the pre-intervention weeks, and one afterwards. In addition, the study creates a continuous variable that measures subsequential numbers of weeks in time after the program. This variable estimates a slope or trend change in the mean of incidents that occurred with each week after the program was introduced, compared to a before-intervention trend.

Control Variables

To adjust for possible confounding, the study includes several covariates. First, the study includes a dummy variable to measure a level change in the dependent variables during the pandemic. It takes the value of one for the weeks of March 23, 2020, and afterwards, and zero for all pre-pandemic data points. The study uses the "stay-at-home order" (SAHO), issued on March 20, 2020, as the starting point of the pandemic. To estimate any post-SAHO trend, it also creates a continuous variable measuring subsequential numbers of weeks in time, which begins immediately following the SAHO and runs until the last observation. Given that gun violence and CFSs had begun decreasing even prior to the program implementation (see Figure #3 and #4), it would be plausible that gun violence simply regressed to the pre-pandemic levels as the nation was coming out of the effects of the pandemic. It is thus important to adjust for a post-SAHO trend to decide whether study outcomes are attributable to the MHS program and/or regression to the mean. Figure #5 zooms in on the trend components of all time series in Figures #3 and #4 to enhance an understanding of trend changes before and after the intervention.

Figure #3. Gun Violence in Buffalo

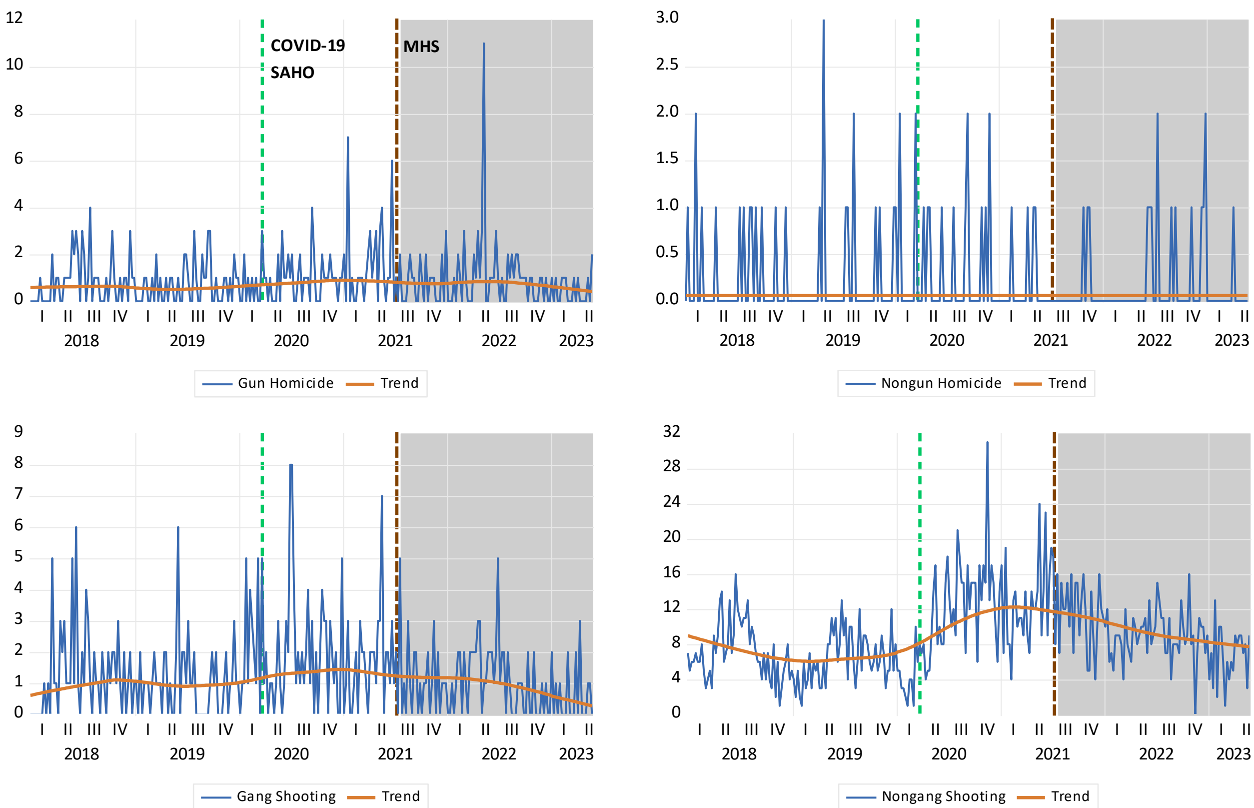


Figure #4. Gun-Related Calls for Service in Buffalo

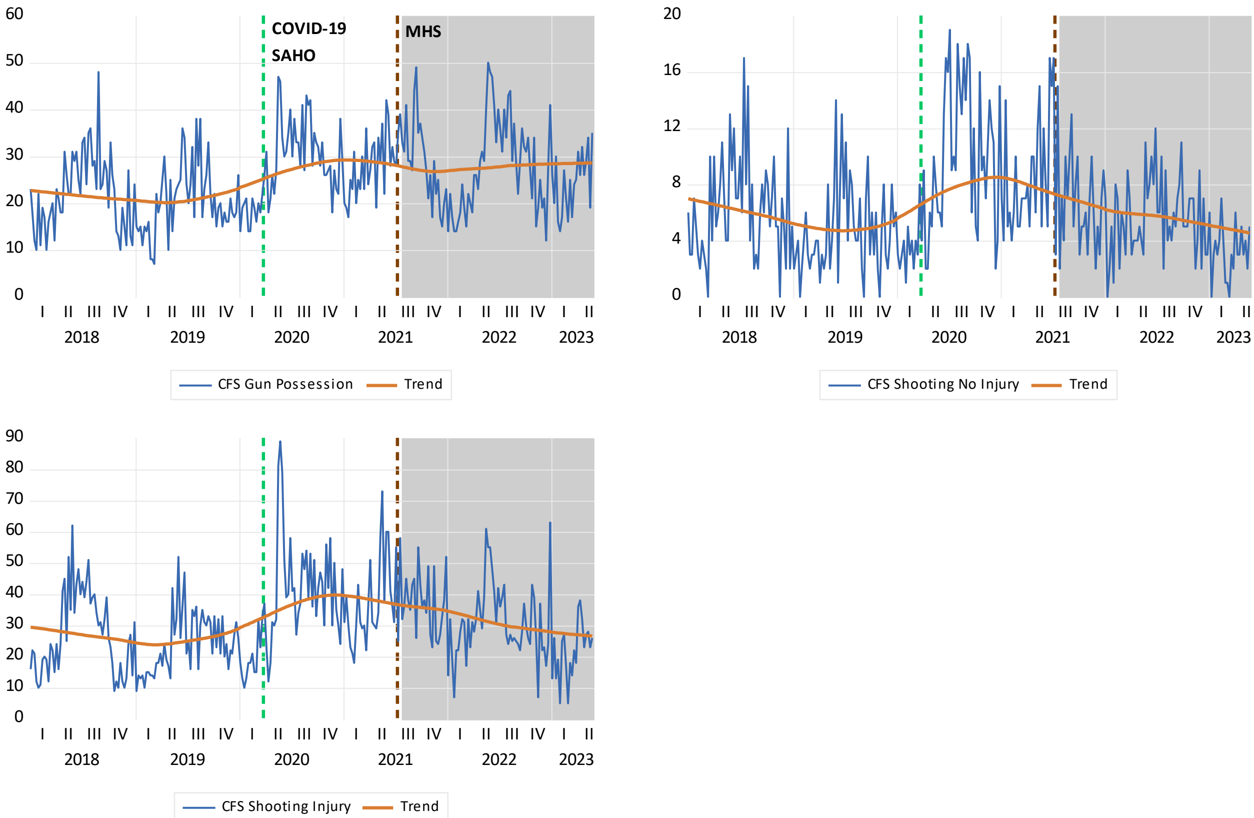
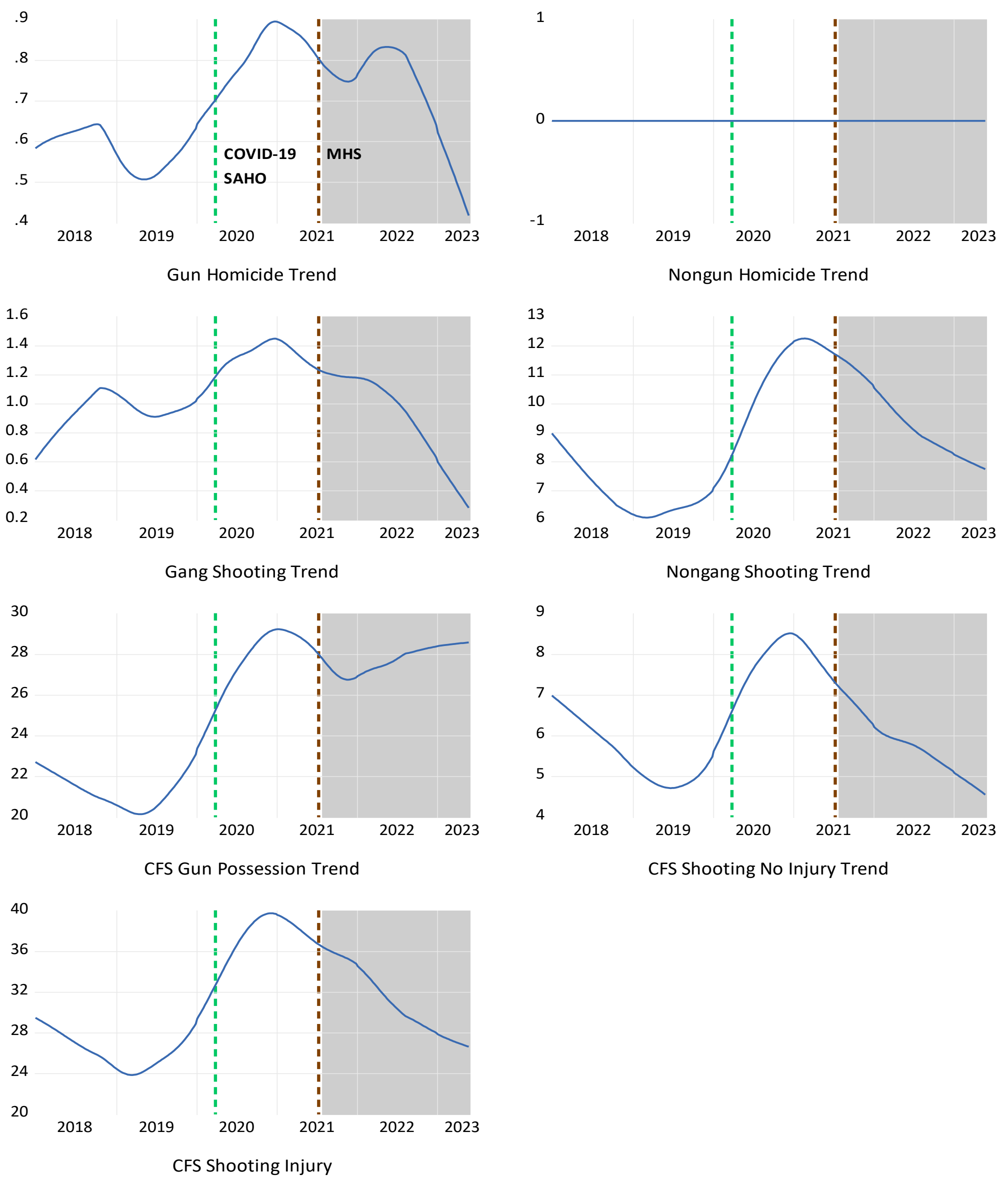


Figure #5. Zoomed Trends in the Dependent Variables



Second, the study includes a continuous variable to measure average temperatures per week to account for seasonality in the dependent variables. Prior research found a significant association between hot temperatures and rising violent crimes (McDowall & Curtis, 2015; McDowall, Loftin, & Pate, 2012). Third, this analysis controls for an overall trend prior to the pandemic and MHS program, as measured by consecutive values in weeks that follow one after another in a counting order for the entire data period. This variable can estimate what the temporal pattern of incidents would have been like if the COVID-19 pandemic and MHS program had not occurred. Finally, as shown in Figure #3, there was a sudden spike in gun homicides in the week of May 9, 2022. On May 14, 2022, a 19-year-old white man, motivated by hate, shot and killed 10 African Americans in a supermarket, while livestreaming the mass shooting. To adjust for this outlier in gun homicides, the study creates a dummy variable that has a value of one in that week and zero in other weeks. It is important to model this type of non-random variation in the time series for accurate model specification.

Analytic Strategies

There is a three-step procedure. First, the study provides descriptive statistics and conducts the t-tests to compare pre- and post-MHS intervention means. It also performs a visual inspection of the time series. Second, it performs the Augmented Dickey Fuller (ADF), Phillips-Perron (PP), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and Jarque-Bera tests to check for stationarity and normality. Third, it executes multiple interrupted time series analyses using poisson or negative binomial regression to model count data with a non-normal distribution. To facilitate interpretation, the study exponentiates and communicates the coefficients in percentage terms.

As suggested in Cameron & Trivedi (1990; 2013), the study performed a regression-based test to check for mean-variance equality. Specifically, it builds a poisson model for each dependent variable, estimates its fitted and residual values, and conducts an auxiliary OLS regression of $\varepsilon^2 - y$ on $\bar{y}^2$. The variance parameter presents underdispersion for gun homicides (α = -.082; p = .000), equidispersion for nongun homicides (α = .611; p = .126) and nongang shootings (α = .016; p = .209), and overdispersion for gang shootings (α = .277; p = .000), and CFSs involving gun possession (α = .010; p = .009), CFSs involving shootings without injuries (α = .066; p = .000), and CFSs involving shootings with injuries (α = .074; p = .000).

All said results considered, the study re-estimates the models that adjust for mean-variance inequality. Specifically, it fits a poisson generalized linear model for gun homicides to allow for underdispersion in the time series. It also fits poisson models for nongun homicides and nongang shootings where the assumption of mean-variance equality was not violated. Using the fixed variance estimates, it builds quasi-maximum likelihood negative binomial (QMLNB, hereafter) models to correct for overdispersion in the time series for gang shootings and all types of CFSs. Finally, the study conducts diagnostic tests of the residuals to examine model adequacy in terms of serial correlation, heteroskedasticity, and normal distribution.

To address the problem of autocorrelation in the residuals of the models for gang shootings, nongang shootings, and CFSs involving shootings with injuries, the study includes one or two legs of the logged dependent variable (Ln Y_{t-i}*) as independent variables in each model (Cameron & Trivedi, 2013; Zeger & Qaqish, 1988). It is noted that the study took the log transformation of the time series to reduce the explosive problem of exponentiated lagged dependent variables. Given the presence of zero counts for gang shootings, nongang shootings, and CFSs involving shootings with injuries, the study adds a constant value (.5) to only the zero values, in which case Y_{t-i}* = Max (Y_{t-i}, c), before conducting the log transformation (Cameron & Trivedi, 2013; Zeger & Qaqish, 1988).

Results

Descriptive Statistics and T-Tests

Figures 3 - 5 present temporal changes in the dependent variables from January 2018 through May 2023. The vertical maroon line presents the beginning of the MHS program in July 2021, while the green line indicates the beginning of the COVID-19 SAHO and pandemic. A visual examination of the time series suggests substantial increases in gun homicides, gang shootings, nongang shootings, and all types of CFSs, subsequently following the SAHO. After the MHS program was introduced, these time series, but calls for service related to gun possession, present an overall decreasing trajectory. On the other hand, there is no particular temporal pattern in nongun homicides.

As seen in Table 1, the t-tests compare the numbers of incidents that occurred before and after the implementation of the MHS program. The post-intervention means are significantly lower than the pre-intervention means for gang shootings and CFSs involving shootings without injuries. Following the intervention, in contrast, there was a significant increase in CFSs involving gun possession. No significant mean difference is reported for other dependent variables. Overall, the levels of gun violence and related CFSs after the intervention are lower than those during the pandemic but still higher than those prior to the pandemic, as reported in Table 2. It is noted that the visual evidence and t-tests did not take into account any systematic patterns in the time series, which warrants further analyses in consideration of seasonal and trend components.

Table 1. Descriptive Statistics and T-Tests, Total Weeks = 282

Variable	Sum Total	Mean (SD)	Pre-MHS Mean (SD)	Post-MHS Mean (SD)	Difference in Mean (t)
Homicide					
Gun	258	.915 (1.21)	.934 (1.142)	.879 (1.335)	- .055 (.368)
Non-gun	61	.216 (.498)	.246 (.534)	.162 (.422)	- .084 (.176)
Gun Shooting					
Gang	373	1.322 (1.431)	1.497 (1.558)	1.000 (1.097)	- .497 (2.819)*
Non-gang	2504	8.879 (4.479)	8.732 (4.897)	9.152 (3.590)	+ 420 (.454)
Calls for Service					
Gun Possession	7169	25.422 (8.792)	24.208 (8.429)	27.667 (9.049)	+3.459 (-3.205)**
Shooting No Injury	1784	6.326 (4.032)	6.770 (4.362)	5.505 (3.199)	-1.265 (2.540)*
Shooting Injury	8653	30.684 (13.901)	30.579 (14.765)	30.879 (12.212)	-.300 (-.172)
Temperature	-	49.471 (17.345)	49.117 (17.691)	50.127 (16.754)	+ 1.010 (-.466)

Notes.
Pre-intervention period: 1/1/2018 - 6/28/2021 (183 weeks); post-intervention period: 7/5/2021-5/22/2023 (99 weeks)
† Significant at $\alpha = .10$; * Significant at $\alpha = .05$; ** Significant at $\alpha = .01$.

Table 2. Total Incidents Per Year, Total Weeks = 282

Year	Week N.	Homicide		Shooting		Calls for Service		
		Gun	Nongun	Gang	Nongang	Gun Possession	Shooting No Injury	Shooting Injury
2018	53	46	13	69	380	1178	332	1446
2019	52	37	11	53	335	1072	244	1262
2020	52	47	17	108	556	1461	448	1933
2021	52	62	7	74	629	1483	397	1946
2022	52	56	12	56	465	1465	294	1611
2023	21	10	1	13	139	510	69	455
Total Sum		258	61	373	2504	7169	1784	8653

Tests for Stationarity and Normality

The study conducts the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests to determine differencing orders for stationarity, as seen in Table 3. The results indicate that no unit root is present in the time series for gun homicides, nongun homicides, gang homicides, and all types of CFSs. They are stationary and thus analyzed in levels. However, there is contradictory evidence about the stationary property of nongang shootings. The ADF and PP tests suggest that nongang shootings are stationary, whereas the KPSS test indicates otherwise. For comparison purposes, the study analyzes nongang shootings in both levels and differences. Finally, the Jarque-Bera test suggests the presence of non-normality in the time series for all dependent variables.

Table 3. Tests for Stationarity and Normality

	Augmented Dickey-Fuller	Phillips-Perron	KPSS	Jarque-Bera
Homicide				
Gun	-16.178**	-16.274**	.189	4632.190**
Non-gun	-16.761**	-16.761**	.146	718.821**
Gun Shooting				
Gang	-9.044**	-15.893**	.278	317.202**
Non-gang	-3.757*	-13.361**	.239**	75.968**
Calls for Service				
Gun Possession	-4.410**	-10.655**	.071	9.197*
Shooting No Injury	-5.264**	-14.116**	.197	46.855**
Shooting Injury	-5.633**	-9.919**	.281	56.068**

Notes.
† Significant at $\alpha = .10$; * Significant at $\alpha = .05$; ** Significant at $\alpha = .01$.
Figures for unit root tests represent a t-statistic in a model with constant and/or trend.
The null hypothesis of the Aug. Dickey-Fuller and Phillips-Perron tests is that the variable is nonstationary, while the null hypothesis of the KPSS test is that the variable is nonstationary.

The Models for Gun versus Nongun Homicide

Table 4 reports the results of the poisson (generalized linear) models for gun and nongun homicides. In percentage terms, gun homicides increased by 1.207, or 100 x ($e^{.012}$-1), percent per week following the SAHO (b = .012 [1.207%], $p < .05$). After the implementation of the MHS intervention, there was an immediate percentage decrease of 51.179 in the level of gun homicides (b = -.717 [-51.179%], $p < .01$). The MHS intervention led to an additional 1.390 percent deduction in the week-to-week trend (b = -.014 [-1.390%], $p < .01$).

There was a 1.409 percent increase in gun homicides in response to every one unit increase in temperature (b = .014 [1.409%], $p < .01$). The mass shooting at the Tops supermarket led to a 1,027 percent increase in gun homicides (b = 2.423 [1027.965%], $p < .01$). Finally, the MHS program did not influence nongun homicides. No significant results are reported in the models for nongun homicides.

The Models for Gang vs. Nongang Shootings

Table 4 presents the results of the QMLNB and poisson models for gang and nongang shootings, respectively. The effect of the pandemic differs by gang involvement. The pandemic caused an increase of 60.801 percent in nongang shootings immediately after the SAHO (b = .475 [60.801%], $p < .01$). In contrast, no significant increase in gang shootings was observed during the pandemic.

Table 4. The Models for Homicide and Gun Shooting, Total Week *N* =282

	Homicide		Gun Shooting		
	Gun	Non-Gun	Gang	Non-Gang	Non-Gang
Model	GLM Poisson	Poisson	QMLNB (V = .277)	Poisson	ARIMA (9, 1, 9)
Intercept	-.938 (.328)**	-1.724 (.548)**	-.364 (.303)	.807 (.210)**	-.005 (.019)
Overall Trend	-0.001 (.004)	.003 (.006)	.002 (.003)	.000 (.002)	-
COVID-19					
Level	.050 (.259)	.014 (.592)	.216 (.303)	.475 (.114)**	4.283 (1.653)*
Slope	.012 (.005)*	-.012 (.014)	-.002 (.006)	.002 (.003)	-
MHS					
Level	-.717 (.226)**	-.554 (.785)	-.250 (.280)	-.256 (.092)**	-2.648 (1.465)†
Slope	-.014 (.005)**	.017 (.016)	-.006 (.007)	-.004 (.003)	-
Temperature	.014 (.004)**	.003 (.008)	.010 (.004)**	.010 (.001)**	
Mass Killing	2.423 (.121)**	-	-	-	-
Ln $Y^*(-2)$	-	-	.171 (.080)*	-	-
Ln $Y^*(-7)$	-	-	-	.147 (.044)**	-
Ln $Y^*(-26)$	-	-	-	.122 (.047)**	-
Adj. R^2	-	-.011	.102	.469	.482
Ljung-Box Q_{36} - Residuals	30.644	37.068	27.735	44.028	27.907
Ljung-Box Q_{36} - Residuals^2	15.579	20.554	16.859	27.430	46.065
Jarque-Bera	314.140**	596.728**	93.888**	27.149**	111.435**

Notes: † Significant at $\alpha = .10$; * Significant at $\alpha = .05$; ** Significant at $\alpha = .01$

There was a 22.586 percent decrease in the levels of nongang shootings immediately as a result of the MHS intervention (b = -.256 [-22.586%], $p < .01$), followed by a non-significant decline in the week-to-week trend. Given some evidence of non-stationarity in the time series for nongang shootings, the study fitted an additional analysis to the differenced data. All trend variables are removed from the model because the differencing procedure renders them to be a constant. The ARIMA (9, 1, 9) model presents a significant drop in nongang shootings following the MHS program, and its significance is at the .1 level. On the other hand, the MHS program caused a decrease in both the level and slope of gang shootings, but its effects are not statistically significant. Finally, temperature is significantly associated with both gang (b = .010 [1.005%], $p < .01$) and nongang shootings (b = .010 [1.005%], $p < .01$).

The Models for Calls for Service (CFSs)

Table 5 reports the results of the QMLNB models for CFSs related to gun possession, shootings without injuries, and shootings with injuries. All types of CFSs appeared to increase immediately following the SAHO at the .05 significance level. In the post-MHS intervention period, there was an immediate percentage decrease of 29.883 in calls for service related to shootings without injuries (b = -.355 [-29.883%], $p < .05$), followed by a -.697 percent decrease in the weekly trend (b = -.007 [-0.697%], $p < .05$), relative to the pre-intervention trend. In addition, the intervention led to an immediate decrease in calls for service associated with gun possession (b = -.108 [-10.237%], $p < .1$), but its significance is at the .1 level. On the other hand, there was no significant decrease in both the level and trend of calls for service associated with shooting injuries during the post-intervention period. Finally, temperature is positively related to all types of CFSs at the .01 significance level.

Table 5. The Models for Calls for Service, Total Week *N* =282

Model	Gun Possession	Shooting - No Injury	Shooting - Injury
	QMLNB (V =.010)	QMLNB (V =.066)	QMLNB (V =.074)
Intercept	2.427 (.070)**	1.149 (.135)**	1.923 (.188)**
Overall Trend	-.000 (.001)	-.004 (.001)**	-.001 (.001)
COVID-19			
Level	.284 (.065)**	.684 (.146)**	.340 (.106)**
Slope	.001 (.001)	.006 (.003)*	.001 (.002)
MHS			
Level	-.108 (.065)†	-.355 (.144)*	-.083 (.101)
Slope	.000 (.001)	-.007 (.003)*	-.003 (.003)
Temperature	.013 (.001)**	.015 (.002)**	.011 (.002)**
Ln Y*(-1)	-	-	.131 (.060)*
Ln Y*(-2)	-	-	.114 (.051)*
Adj. R^2	.563	.374	.463
Ljung-Box Q_{36} - Residuals	38.745	24.281	36.023
Ljung-Box Q_{36} - Residuals^2	36.778	45.399	32.138
Jarque-Bera	10.726**	10.881**	120.721**

Notes.
† Significant at $\alpha = .10$; * Significant at $\alpha = .05$; ** Significant at $\alpha = .01$.

Discussion of Time Series Analysis Results

The goal of the study is to examine city-wide changes in gun violence and CFSs following the implementation of the MHS program in Buffalo. It uses disaggregated data by situational context. The comparison of multiple time series allows us to examine whether the program has a differing effect across crime and call types, ultimately providing a more nuanced understanding of intervention effects and useful policy implications.

There are four main results. First, the effect of the intervention differs by gun use. Gun homicides are more amenable than nongun homicides to the impact of the MHS program. While the program did not influence nongun homicides, there was a significant decrease in both the level and trend of gun homicides. Second, significant declines are observed in the level of nongang shootings, but not in their week-to-week trend, immediately after the MHS program was implemented. Despite the apparent decreasing trend in the post-intervention time series for gang shootings (see Figure #3 and #5), on the other hand, the multivariate model failed to find a significant impact of the MHS program after all seasonal and trend patterns are taken into account. Third, while gun violence decreased in the post-intervention period, there was a significant decrease in both the level and trend of CFSs involving no shooting injury. In addition, there was some evidence of a post-intervention decrease in the level of CFSs involving gun possession, but its impact was abrupt and temporary. Subsequently, the time series demonstrates an overall increasing trajectory and returns to the pre-intervention level. Further, the program did not significantly reduce the number of CFSs involving shooting injuries. Finally, temperature is a significant predictor of gun violence. Temperature is positively associated with gun violence and CFSs. Specifically, there is a seasonal pattern in which gun violence and CFSs increase in warm weather and decrease in cold weather.

Several findings merit further discussion. In 2020, Buffalo experienced increases in gun violence and gun-related CFSs that may be attributed to the ramifications of the pandemic and death of George Floyd in Minnesota. Gun violence and CFSs reached their highest peak in mid- or late 2020 and afterwards have decreased until the end of the study. Given that the declining trends had begun even before the program implementation, it is difficult to determine what might have occurred in the absence of the program. In other words, gun violence and CFSs might have decreased as a function of the intervention and/or simply have regressed to the pre-pandemic levels as the nation was transitioning out of the pandemic and Floyd era.

Since the comparison of level and trend changes before and after the MHS program is of direct substantive interest, the study adjusted for any pre-intervention level and trend to decide how much of the post-intervention declines resulted from the MHS program or regression to the mean, or both. As reported in Table 4 and 5, the MHS program led to an immediate decrease of 51.179% and 29.883%, respectively, in the level of gun homicides and CFSs involving shootings without injuries. In addition, the decreasing trends became steeper in the post-MHS program period. As opposed to the post-SAHO trend as a counterfactual, there was a percentage decrease of 1.390 and .697 in the week-to-week trend of gun homicides and CFSs involving shootings with no injury, respectively. All said results considered, the program might not only have caused an immediate decrease in gun homicides and CFSs involving no shooting injury but also have accelerated their existing declining trajectory, which had already begun prior to the MHS program. In addition, there was a significant decrease in the level of nongang shootings immediately following the MHS program. Given that there was no significant decline in the week-to-week trend, as opposed to the pre-intervention trend, whether the immediate declines were due to the intervention alone should be interpreted with caution. It is plausible that the post-intervention declines might result in part from the pre-intervention behavior of the time series in nongang shootings, as well as the deterrent effect of the MHS program.

There was a decrease in CFSs involving gun possession immediately after the MHS program. Since mid-2022 through the present, however, Buffalo experienced an increase, but a nonsignificant one, in CFSs involving gun possession, while overall shootings and related CFSs demonstrated declining trajectories during the same time period. One possible explanation is that after the MHS program began and overall gun violence decreased, the police department has been viewed as legitimate, responsive, and well-equipped to address the problem of gun violence. While police legitimacy increased, residents have a positive view of the intervention and have increasingly called the police for service associated with gun possession, even before actual occurrences of shootings.

In sum, the MHS program has been successful in reducing gun violence and CFSs, especially gun homicides and CFSs involving no shooting injury. Given that the current levels of gun violence and CFSs are still above the pre-pandemic levels, further research is warranted to examine whether gun violence and associated CFSs would continue to decrease over time and eventually return to the pre-pandemic level and afterwards below it.

ANALYTIC METHOD

Micro-Hot Spot Fidelity

Police officers commonly apply discretion to their decisions and are used to working independently. Prior research exploring the effectiveness of hot-spot policing indicated that police officers should spend 15 minutes at a specific location within a hot spot to achieve optimal results. This portion of the evaluation will examine "officer fidelity." That is, it will explore the amount of time a directed patrol will spend in a MHS.

Data

The data was provided by the Erie Crime Analysis Center. It was, unfortunately, not available in a datafile, but rather as part of their weekly reports provided to the Buffalo Police Department. This made it somewhat cumbersome to work with for analysis. These reports were dated starting on August 1, 2022, and were available through June 20, 2023 (43 weeks). These reports included information on the number of hot spots per district, the number of minutes of directed patrol for the week, the number of directed patrols for the week, and the average number of minutes on directed patrol for each hot spot.

Analysis

We first examined the number of MHS each week for each district. As can be seen in Table 6, most districts had a relatively large number of hot spot locations. There were a few weeks when there were no locations in Districts A and D. On the other hand, most weeks found District E with multiple hot spot locations.

Table 6: Number of Micro Hot Spots (August 2022 – June 2023)

Number of MHS	District A	District B	District C	District D	District E
1	36	43	43	37	42
2	6	24	31	24	37
3	0	3	6	3	27
4	0	0	0	0	10
5	0	0	0	0	3

When looking at the average amount of time that a directed patrol unit spent within a hot spot, it is expected that these units would spend approximately 12 – 15 minutes within the hot spot. Often referred to as "the Koper curve," this timeframe suggests "a curve of increased deterrence after police leave in relation to increasing length of each visit" (Williams & Coupe, 2017, p. 7). Simply stated, if a directed patrol unit spends roughly 15 minutes in a hot spot, this will provide the optimum level of deterrence after the unit leaves the area.

The data indicates that directed patrol units spent almost 27 minutes, on average, per day, in a micro hot spot. This finding should be interpreted with caution. The data provided by ECAC indicated that the shortest patrol within a hot spot was 14 minutes, and the longest was over 300 minutes. Many patrols were well over 25 minutes. A conversation with ECAC analysts and BPD supervisors suggested that some officers had forgotten to sign out when they left their directed patrol within a hot spot. Therefore, it is too early to suggest that directed patrol officers should spend *less* time within a micro hot spot.

Discussion of Fidelity Analysis

The expectation that patrol officers who are assigned to MHS locations will dedicate 12-15 minutes of time to these locations is a very important component of any MHS program. The officers in Buffalo spent considerably more time in these areas than required. It is important to recall that officers may have forgotten to clear themselves from the location when they returned to routine patrol. Still, if there were a few "outliers" in the data, that is, only a few officers who forgot to call back into service when their time in the hot spot ended, this suggests that officers overextended their time in the hot spot locations. Strictly speaking, this might be considered time wasted.

Further, the datafile contained no information describing what officers did while spending time in the MHS. The Buffalo MHS program expected officers to park within the boundaries of a hot spot and activate their patrol vehicle lights, perhaps engaging with citizens who might be in the area. It is possible that the directed patrol officers in Buffalo did more than these specified tasks. It is important for the agency to document the actions of an officer who is assigned to the MHS. The various actions an officer can engage in when in a MHS may impact the results of their assignment. For example, prior research indicated that in some MHS programs the officers simply sat in their patrol vehicles. Officers in Dallas conducted vehicle and pedestrian stops, citations issued, and made arrests (Jang, et al., 2012). Documenting the behaviors of hot spot officers may uncover a few behavioral themes that may allow for a deeper analysis of the MHS program. Thus, while the interrupted time series analysis suggests the MHS program reduced gun violence, it is too soon to determine if any specific type of police officer behavior contributed better to this reduction.

Conclusions

This study attempted to assess if the MHS program in Buffalo reduced violent crime while control for the impact of COVID-19 and the stay-at-home order. Overall, despite some non-statistical outcomes, it is reasonable to assert that the MHS program in Buffalo strongly contributed to a decrease in gun violence after its implementation. The MHS program in Buffalo was implemented with the goal of decreasing gun violence. The time series analysis found a there was an immediate percentage decrease of 51.179 in the level of gun homicides, which is statistically significant. There was a 22.586 percent decrease in the levels of *nongang* shootings immediately because of the MHS intervention, which was also statistically significant. This was followed by a non-significant decline in the week-to-week trend. Also, the MHS program caused a decrease in both the level and slope of *gang* shootings, but its effects are not statistically significant.

With respect to the increase in calls-for-service, one possible explanation is that after the MHS program began and overall gun violence decreased, the police department has been viewed as legitimate, responsive, and well-equipped to address the problem of gun violence (Desmond, et al., 2016). When police legitimacy increases, residents have a positive view of the intervention and will increasingly call the police for service associated with gun possession, even before actual occurrences of shootings.

An important overall finding of this evaluation relates to the difference between an informal and formal start to Buffalo's MHS program. An informal MHS program started roughly seven months before a formal program was implemented in 2022. This evaluation selected the informal start date of July 2021 for analytic purposes and the results were positive.[1] This is an encouraging outcome. Other police agencies with plans to institute a MHS program can start with a simple approach to identifying hot spot locations, and they can assign officers to these locations for short periods of time (i.e., 12-15 minutes). This will allow both police officers and citizens in the hot spot locations to become familiar with the plan while the more formal program is developed.

Recommendations

Based on the findings of this evaluation, the following recommendations are offered:

1) Continue using directed patrols in MHS locations and reexamine the data on a yearly basis. This is necessary to determine if the decline in gun violence continued well after COVID-19. It will also determine if the lower "plateau" has been reached in the programs ability to deter shootings.

2) It is very likely any decline in gun violence will level off. When this point in time is identified the Buffalo Police Department should maintain the MHS program, identify locations where a new hot spot emerges, or a warm location becomes hot again. Directed patrols should be returned to those locations.

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[1] A separate evaluation used the official start date of March 2022 for analysis. The results were roughly the same as those presented here.

3) Impress upon directed patrol officers the 12-15-minute limit to be spent in the hot spots. Supervisors should emphasize the importance of officers keeping track of time within the hot spot. If there are extenuating circumstances that necessitate staying longer (e.g., engaged in a lengthy conversation with citizens), there should be a mechanism for documenting these events.

4) Clearly document the timeframe that directed patrol officers are "called out" in hot spots. That is, the time of day the call out occurs, not simply the amount of called out in a hot spot. For accurate record keeping and follow-up analysis, each call out should be an individual "case" in a datafile.

5) Identify the behavior of the directed patrol officers while "called out." Are they interacting with citizens? If so, who? Are the officers interacting with "suspicious" persons or potentially wanted suspects? Was an arrest / citation necessary?

References

Abt, T. (2019). *Bleeding Out: The devastating consequences of urban violence – and a bold new plan for peace in the streets*. Basic Books, New York.

Andresen, M.A., & Malleson, N. (2011). Testing the stability of crime patterns: Implications for theory and policy. J*ournal of Research in Crime and Delinquency, 48*(1), 58-82.

Bernasco, W., & Block, R. (2011). Robberies in Chicago: A block-level analysis of the influence of crime generators, crime attractors, and offender anchor points. *Journal of Research in Crime and Delinquency, 48*(1), 33-57.

Braga, A.A., & Bond, B.J. (2008). Policing crime and disorder hot spots: A randomized controlled trial. *Criminology, 46*(3), 577-607.

Braga, A.A., Pierce, G.L., McDevitt, J., Bond, B.J., & Cronin, S. (2008). The strategic prevention of gun violence among gang-involved offenders. *Justice Quarterly, 25*(1), 132-162.

Braga, A.A., Papachristos, A.V., & Hureau, D.M. (2010). The concentration and stability of gun violence at micro places in Boston, 1980-2008. *Journal of Quantitative Criminology, 26*(1), 33-53.

Braga, A.A., & Weisburd, D. (2010). *Policing problem places: Crime hot spots and effective prevention*. New York: Oxford University Press.

Braga, A.A., Hureau, D.M., & Papachristos, A.V. (2011). An ex-post-facto evaluation framework for place based police interventions. *Evaluation Review, 35*, 592-562.

Braga, A.A., Weisburd, D.L., Waring, E.J., Mazerolle, L.G., Spelman, W., & Gajewski, F. (1999). Problem-oriented policing in violent crime places: A randomized controlled experiment. *Criminology, 37*(3), 541-580.

Brantingham, P.L. and Brantingham, P.J. (1981). *Notes on the geometry of crime.* In P.J. Brantingham and P.L. Brantingham (eds.) Environmental Criminology, Beverly Hills, CA: Sage Publications.

Cameron, A.C., & Trivedi, P.K. (1990). Regression-based tests for overdispersion in the poisson model. *Journal of Econometrics, 46*, 347-364.

Cameron, A.C., & Trivedi, P.K. (2013). *Regression analysis of count data*. New York, NY: Cambridge University Press.

Cohen, L.E., & Felson, M. (1979). Social change and crime rate trends: A routine activity approach. *American Sociological Review, 44*:588-608.

Desmond, M., Papachristos, A.V., & Kirk, D.S. (2016). Police violence and citizen crime reporting in the black community. *American Sociological Review, 81*(5), 857-876.

Drake, G., Wheeler, A.P., Kim, D.Y., Phillips, S.W., & Mendolera, K. (2022). The impact of COVID-19 on the spatial distribution of shooting violence in Buffalo, NY. *Journal of Experimental Criminology*, 1-18.

Eck, J.E. (2005). *Crime hot spots: What they are, why we have them, and how to map them*. In J. E. Eck, S. Chainey, J. G. Cameron, M. Leitner, & R. E. Wilson (Eds.), Mapping crime: Understanding hot spots (pp. 1-14). Washington: National Institute of Justice, U.S. Department of Justice.

Gambini, P. (2021). *Violent crime in Buffalo is declining, but still high*. Investigative Post, October 21, 2021. Available at https://www.investigativepost.org/2021/10/20/violent-crime-declining-but-still-high/

Groff, E.R., Ratcliffe, J.H., Haberman, C.P., Sorg, E.T., Joyce, N.M., & Taylor, R.B. (2015). Does what police do at hot spots matter? The Philadelphia policing tactics experiment. *Criminology*, *53*(1), 23-53.

Jang, H., Lee, C.B., & Hoover, L.T. (2012). Dallas' disruption unit: efficacy of hot spots deployment. *Policing: An International Journal of Police Strategies & Management*, *35*(3), 593-614.

Kim, D. Y., & Phillips, S. W. (2021). When COVID-19 and guns meet: A rise in shootings. *Journal of Criminal Justice*, *73*, 101783.

Kochel, T.R., & Weisburd, D. (2019). The impact of hot spots policing on collective efficacy: Findings from a randomized field trial. *Justice Quarterly, 36*(5), 900-928.

Koper, C. (1995). Just enough police presence: Reducing crime and disorderly behavior by optimizing patrol time in crime hot spots. *Justice Quarterly, 12*(4), 649-672.

Lawton, B.A., Taylor, R.B., & Luongo, A.J. (2005). Police officers on drug corners in Philadelphia, drug crime, and violent crime: Intended, diffusion, and displacement impacts. *Justice Quarterly, 22*(4), 427-451.

Linden, A. (2015). Conducting interrupted time-series analysis for single- and multiple-group comparisons. *The Stata Journal, 15*(2), 480-500.

McDowall, D., & Curtis, K. (2015). Seasonal variation in homicide and assault across large U.S. cities. *Homicide Studies, 19*(4), 303-325. https://doi.org/10.1177/1088767914536985.

McDowall, D., Loftin, C., & Pate, M. (2012). Seasonal cycles in crime, and their variability. *Journal of Quantitative Criminology, 28*(3), 389-410. https://doi.org/10.1007/s10940-011-9145-7.

Phillips, S.W., Wheeler, A., & Kim, D.Y. (2016). The effect of police paramilitary unit raids on crime at micro-places in Buffalo, New York. *International Journal of Police Science & Management*, *18*(3), 206-219.

Ratcliffe, J. H. (2002). Aoristic signatures and the spatio-temporal analysis of high volume crime patterns. *Journal of Quantitative Criminology, 18*(1), 23-43.

Ratcliffe, J.H., Taniguchi, T., Groff, E.R., & Wood, J.D. (2011). The Philadelphia foot patrol experiment: A randomized controlled trial of police patrol effectiveness in violent crime hotspots. *Criminology, 49*(3), 795-831.

Sherman, L.W., Gartin, P.R., & Buerger, M.E. (1989). Hot spots of predatory crime: Routine activities and the criminology of place. *Criminology*, *27*(1), 27-56.

Sherman, L., & Rogan, D. (1995). Effects of gun seizures on gun violence: 'Hot spots' patrol in Kansas City. *Justice Quarterly, 12*, 673-694.

Skogan, W.G., Van Craen, M., & Hennessy, C. (2015). Training police for procedural justice. *Journal of Experimental Criminology*, *11*, 319-334.

Taylor, B., Koper, C.S., & Woods, D.J. (2011). A randomized controlled trial of different policing strategies at hot spots of violent crime. *Journal of Experimental Criminology, 7*(2), 149-181.

Weisburd, D. (2015). The law of crime concentration and the criminology of place. *Criminology 53*:133-57.

Weisburd, D., Maher, L., & Sherman, L. (1992). *Contrasting crime general and crime specific theory: The case of hot spots of crime*. Advances in Criminological Theory. New Brunswick, NJ: Transaction Press. pp. 45-69.

Weisburd, D., & Green, L. (1995). Policing drug hot spots: the Jersey City drug market analysis experiment. *Justice Quarterly, 12*, 711-735.

Weisburd, D., Bushway, S., Lum, C., & Yang, S.M. (2004). Trajectories of crime at places: a longitudinal study of street segments in the city of Seattle. *Criminology, 42*, 283-321.

Weisburd, D., Morris, N., & Groff, E. R. (2009). Hot spots of juvenile crime: a longitudinal study of arrest incidents at street segments in Seattle, Washington. *Journal of Quantitative Criminology*, 25, 443-467.

Wheeler, A.P., Kim, D.Y., & Phillips, S.W. (2018). The effect of housing demolitions on crime in Buffalo, New York. *Journal of Research in Crime and Delinquency*, *55*(3), 390-424.

Wheeler, A.P., & Steenbeek, W. (2021). Mapping the risk terrain for crime using machine learning. *Journal of Quantitative Criminology, 37*(2), 445-480.

Williams, S. & Coupe, T. (2017). Frequency vs. length of hot spots patrols: a randomised controlled trial. *Cambridge Journal of Evidence-Based Policing, 1*(1), 5-21.

Zeger, S.L., & Qaqish, B. (1988). Markov regression models for time series: A quasi-likelihood approach. *Biometrics, 44*, 1019-1031.