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Examining the Effectiveness of a NIBIN Investigative Unit: A Time Series Analysis

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ABSTRACT

Gun crime continues to represent a substantial threat to public safety in the United States. Firearms are disproportionately involved in most crimes of violence, particularly murder, and firearm-related offending is more pronounced in the U.S. than any other industrialized nation. In response to these problems, there has been a sustained increase in the number of NIBIN investigative units within police departments across the U.S. through federal funding made available by the Crime Gun Intelligence Center (CGIC) program. The purpose of these centers is to facilitate improved information sharing between agencies, increased clearance rates in gun crime cases, identifying sources of crime guns, and overall reductions in the frequency of gun crimes. Despite the proliferation of CGIC sites, there has been little effort to examine their effectiveness. We directly address this gap in the literature through application of interrupted time series analysis to weekly performance metrics from 12/30/19 to 12/31/23 ($n = 209$) provided by a CGIC site in the Southeastern U.S.

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CGIC; crime guns; gun crime; NIBIN

Introduction

Gun crime continues to be a pervasive problem in the United States, with firearms disproportionately involved in nearly all forms of serious crime (i.e., murder, robbery, aggravated assault) (Collins et al., 2017; Cook & Pollack, 2017; Goldsmith et al., 2022; Johnson et al., 2021). For context, the U.S. maintains a firearm homicide rate that is nearly 25 times higher than its closest competitor among other developed nations (Grinshteyn & Hemenway, 2016; 2019; Rees et al., 2022; Wintemute, 2015). Excluding suicides, there were over 160,000 firearm-related deaths in the United States between 2014 and 2023 (Gun Violence Archive, 2024), and gun violence recently reached a 25-year high (Gramlich, 2022; Ssentongo et al., 2021). All in all, the combined costs associated with non-fatal firearm injuries and lifetime firearm-related fatalities total

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nearly $500 billion annually (Miller et al., 2024). These human and financial tolls also continue to be disproportionately incurred by marginalized communities that are simultaneously burdened by overlapping forms of structural deprivation (Cook & Ludwig, 2000; Dierenfeldt et al., 2017; Henry et al., 2024; Semenza et al., 2023).

These statistics have, in turn, prompted heated debate between politicians, researchers, and activist groups regarding solutions to firearm violence (Carlson, 2020; Cook, Harris, et al., 2015, Cook, Parker, et al., 2015; Goldsmith et al., 2022; Wachtel, 1998). Many of these efforts center around gun control and are built upon the reasoning that broad legislation will force potential offenders to "economize" their use of firearms "as guns become more scarce and valuable" (Braga, 2017, p. 77). There is, however, limited support for market-based approaches associated with restricting lawful access to firearms (Kleck et al., 2016; Wellford et al., 2005). The results of numerous studies report that gun ownership and gun control are unrelated to aggregate levels of violence (Kleck et al., 2016; Kovandzic et al., 2013; Kovandzic & Kleck, 2022). A comprehensive review by the RAND Corporation (2025), reveals that while 'stand your ground' and 'concealed carry' laws correspond with increased firearm offending, there is little evidence that bans of assault weapons, high-capacity magazines, or firearm registration requirements produce any changes in levels of violent crime. In fact, there is only moderate evidence that background checks and waiting periods lead to reductions in gun violence (RAND Corporation, 2025). In contrast, extensive research clearly illustrates the extent to which gun crime is influenced by the availability of illicit firearms, particularly within criminal networks like street gangs (Braga et al., 2012; 2021; Braga & Cook, 2016; Collins et al., 2017; Cook et al., 2007; Cook, Parker, et al., 2015; Dierenfeldt et al., 2017; Vittes et al., 2013). The involvement of these criminal groups not only exacerbates the problem of low clearance rates that are typical of gun crimes (Braga, 2021; King et al., 2017), but also increases the likelihood that the same illicit firearms will be used repeatedly across multiple gun offenses (Cook et al. 2007; Cook, Harris, et al., 2015; Cook, Parker, et al., 2015; Dierenfeldt et al., 2024; Hureau & Braga, 2018; Scott et al., 2023).

Accordingly, there has been a renewed effort to support widespread adoption of evidence-based law enforcement strategies and practices that maintain the potential for reducing gun violence. Firearm offenses are more likely to be solved if police consistently identify and gather physical evidence at the scenes of shootings (Braga, 2021; Cook et al., 2019)—an outcome that can be achieved through the appropriate use of forensic technology, interagency cooperation, and enhanced synergy between patrol officers and investigators (Huff et al., 2024). In this vein, the ATF's National Integrated Ballistics Information Network (NIBIN) and e-Trace program appear to be promising tools (Bottema & Barter, 2025; Braga, 2021; King et al., 2013, 2017). Each has been successfully used to disrupt the flow of illicit firearms, identify scofflaw dealers, and apprehend chronic gun offenders (Braga et al., 2021; Braga & Pierce, 2005; Kennedy et al., 1996). Yet, their adoption has been slow and inconsistent (Bottema & Barter, 2025; King et al., 2013; Novak & King, 2020).

To further encourage the broad and uniform use of NIBIN and e-Trace, the ATF launched its Crime Gun Intelligence Center (CGIC) Initiative in 2016 (ATF, 2025b, Flippin et al., 2022; Huff et al., 2024). Since that time, funding from the Bureau of Justice

Assistance has been used to support the launch of more than two dozen fully operational CGICs across the U.S. There has been limited research on the effectiveness of these centers and most evaluations have been limited to cross-sectional analysis of a handful of outcome measures (Bottema & Barter, 2025). We directly address these concerns through application of interrupted time series analysis to 17 metrics collected by the Chattanooga Police Department's CGIC.

The Utility of NIBIN and e-Trace as Investigative Tools

Established in 1997, the NIBIN aids investigators through utilization of ballistics imaging to compare ballistic evidence from crime scenes and recovered firearms (ATF, 2025a). Combined with e-Trace, which is used to track the purchase and use history of guns used in violent crimes, NIBIN enhances inter-agency cooperation and allows police to link offenders, gun crimes, and unlawful firearm use across jurisdictions (ATF, 2025a; King et al., 2013). Once an agency enters ballistic information into NIBIN, which may range from spent cartridges and casings recovered from crime scenes to test fires from seized crime guns, technicians conduct a correlation review of digital images and identify potential associations between pieces of ballistic evidence known as "NIBIN Leads" (ATF, 2025; Bottema & Barter, 2025; Braga & Pierce, 2004). Physical examination of the ballistic by firearms examiners can confirm these leads as "hits," cementing the connection between two or more pieces of ballistic evidence and resulting in the production of intelligence reports that can be used by investigators and prosecutors (ATF, 2025a).

At the time of this writing, there are 6.5 million pieces of ballistic evidence stored in NIBIN, with more than 900,000 NIBIN leads generated by nearly 300 active NIBIN partner sites and agencies (ATF, 2025a; Bottema & Barter, 2025). Thus, NIBIN maintains the potential to serve as an important force multiplier in efforts to disrupt gun violence by providing agencies with actionable intelligence related to illicit firearm use (Braga, 2008; Braga & Pierce, 2011; King et al., 2017; Lopez et al., 2020). The effectiveness of NIBIN hinges, however, on close cooperation between agencies at the local, state, and federal level. In particular, it is dependent upon the willingness and ability of agencies to engage in timely, comprehensive collection and entry of ballistic evidence into NIBIN in order to maximize the value of leads and hits (ATF, 2025a).

Yet, early assessments by King et al. (2013) identified tremendous variation between NIBIN sites in terms of timeliness and comprehensiveness of evidence collection and entry, much of which was linked to disparities in funding, resources, and operations procedures between agencies. In turn, these shortcomings led to significant delays in producing actionable intelligence (King et al., 2013, 2017), limiting the value of NIBIN to criminal investigations (Braga & Pierce, 2011; Huff et al., 2024; Novak & King, 2020). These problems extended to early use of e-Trace, a web-based system through which police can use a crime gun's make, model, and serial number to identify its first retail purchaser (ATF, 2025). Despite its potential to inform policy related to illicit firearm networks and gun violence prevention, e-Trace remained underutilized for years (Bottema & Barter, 2025). As a consequence, the lack of widespread participation by law enforcement agencies inhibited its development as an investigative tool (Cook & Braga, 2001; Kopel & Blackman, 2000). In an effort to overcome these issues, the

ATF sought to encourage agencies to adopt standardized best practices and harness the utility of NIBIN and e-Trace through the launch of its CGIC Initiative in 2016 (ATF, 2025b; Flippin et al., 2022; Huff et al., 2024).

The Crime Gun Intelligence Center Initiative

CGICs are designed to serve as hubs for intelligence and coordination between local, state, and federal law enforcement agencies as they respond to a broad range of firearm offenses (ATF., 2025b; Bottema & Barter, 2025). In this vein, CGICs leverage the forensic utility of NIBIN and e-Trace and encourage interagency cooperation to support the investigation and prosecution of violent gun offenders (ATF, 2025b). As described by the National Policing Institute [NPI] (2025), CGIC sites are structured around five principles: 1) Consistently collect all ballistic evidence; 2) Utilize NIBIN and e-Trace in a timely manner; 3) Establish a dedicated investigative time that coordinates efforts; 4) Use forensic technology to drive investigations and prosecutions; and 5) Establish and maintain partnerships.

The primary goal of CGICs is to increase the timeliness with which violent gun offenders are identified, arrested, and charged (NPI, 2025). Simultaneously, these centers are used to support law enforcement agencies in their efforts to identify sources of crime guns, reduce the frequency of gun crime, and build trust and confidence within the community (NPI, 2025). At present, there are 25 fully operational CGICs located across the U.S. that support dozens of agencies and generate hundreds of thousands of investigative leads each year (ATF., 2025b). The federal government has committed hundreds of millions of dollars to the expansion of this program, and new CGICs are launched annually (Bottema & Barter, 2025).

Despite this significant investment, few evaluations of CGIC sites have been published and only a handful have benefited from peer review (Flippin et al., 2022; Huff et al., 2024). Some of these works suggest that implementation of CGIC may correspond with several desirable outcomes (Flippin et al., 2022; Huff et al., 2024; Katz et al., 2021), particularly when combined with focused deterrence (Barao et al., 2021; Cochran & Worden, 2022; Jiao, 2023). In their assessment of the Phoenix Police Department, for example, Flippin et al. (2022) reported that the launch of CGIC was associated with a greater number of crime guns seized, increases in NIBIN inputs and leads, more timely entry of ballistic evidence, and statistically significant increases in the odds of case clearance for serious gun crimes in the form of arrest.

The results of other studies are, to varying degrees, less promising. Although Koper et al. (2019) found statistically significant increases in clearance rates for non-fatal shootings following CGIC implementation in Milwaukee, these improvements did not extend to homicides or shots fired incidents. In their evaluation of the Metropolitan Police Department in Washington, D.C., Mei et al. (2019) reported no changes in violent crime, shots fired calls for service, or arrest rates following implementation of CGIC. Similarly, although Uchida et al. (2019) noted that the Los Angeles Police Department's collection of ballistic evidence and use of actionable intelligence each improved in response to the launch of CGIC, serious gun-related crimes decreased in only one of the four targeted divisions. Most recently, Bottema and Barter (2025) examination of CGIC implementation at the Manchester Police Department suggested that firearm recovery corresponded with increased odds of arrest across a general measure of gun crimes and specific measures of shots fired and non-fatal shootings. However, neither the use of NIBIN nor e-Trace was correlated with changes in odds of arrest for either of the specific measures of gun crime. More perplexing, the use of NIBIN was associated with a *decrease* in the odds of arrest for the general measure of gun crime. These mixed findings prompted Bottema and Barter (2025) to suggest expanded evaluative research on CGIC across a greater number of metrics.

The Current Study

We attempt to answer the call of Bottema and Barter (2025) through application of interrupted time series analysis to 17 outcome measures associated with the implementation of CGIC at the Chattanooga Police Department (CPD). Across all of its divisions, CPD employs approximately 500 sworn personnel who serve a community of approximately 190,000 citizens. In October 2020, CPD was notified that it was being named as a recipient of a grant from the Bureau of Justice Assistance (BJA) to establish a CGIC.

Prior to the award, Chattanooga experienced a steady uptick in violence, including a homicide rate that climbed from 13.12 to 19.94 between 2015 and 2019. Similarly, the city maintained a rate of nearly 50 aggravated assaults involving firearms per 100,000 and the CPD responded to an average of 3 shots-fired calls each day. Having created a "Gun Team" in 2018 with a dedicated focus on gun crimes and intelligence gathered from lead produced by NIBIN, the establishment of a CGIC was a logical next step. Efforts were further bolstered by the CPD's Real Time Intelligence Center (RTIC) and Crime Analysis Unit (CAU), each of which launched in 2017. At the request of the Gun Team supervisor, RTIC and CAU developed and implemented a dashboard to track all reported gun crimes across Chattanooga. This real-time database allowed the Gun Team supervisor to actively monitor gun crime and assign cases to investigators for follow-up and re-canvassing. The dashboard was complemented by an internally maintained NIBIN Lead Log.

The department also purchased and deployed a Brasstrax, secured placement in the National NIBIN Correlation and Training Center (NNCTC), and established internal NIBIN Standard Operating Procedures (SOP) that mirrored the ATF's "Minimum Required Operating Standards" (MROS) into CPD's own internal NIBIN procedures.[1] Maintaining its own local database allowed the department to receive leads within 7 working

[1]ATF MROS include the following standard practices: 1) Enter all fired or test fired cartridge cases from serviced law enforcement agencies and/or departments through a NIBIN acquisition machine within two business days of receipt; 2) Enter accurately all required information during the acquisition process on the NIBIN acquisition machine; 3) Correlate and conduct a secondary review of any potential NIBIN leads through an approved NIBIN correlation machine within two business days; 4) Disseminate NIBIN leads within 24 hours; 5) Designate and maintain a NIBIN Program Administrator; 6) Have no policies that inhibit or restrict NIBIN submissions by serviced law enforcement agencies and/or departments; and 7) Operate with only Qualified NIBIN Users.

days.[2] Once a NIBIN lead was produced, the Gun Team supervisor developed a related link chart to visually represent connections. These charts were then disseminated to all stakeholders—including the patrol officers who had initially responded. This approach not only reinforced the importance of accurate reporting and evidence processing, but also eliminated information silos and increased buy-in.

CPD's CGIC launched on July 16, 2021, in accordance with site recommendations offered by subject matter experts assigned by the National Policing Institute. Among them was the dissolution of the department's Gang Unit and merger of its personnel, which included four investigators and one sergeant, with the Gun Team. The department also implemented a policy requiring the documentation and collection of all shell cases observed at crime scenes. In alignment with the work of Huff et al. (2024), the same policy required responding patrol officers to use their body cameras to document and log the location of each shell casing using GPS coordinates. Each recovered shell casing was permanently preserved regardless of whether it produced a subsequent NIBIN lead. Similarly, the department implemented a standardized "gun form" and required its use by patrol officers in every instance in which a crime gun was seized. The form listed Miranda rights on one side and a list of detailed investigative questions on the other, which enhanced the ability of investigators to establish possession of firearms connected to NIBIN leads. The unit was aware of the increased workload this would place on patrol officers. To encourage participation and recognize impactful efforts, the department created monthly awards that were presented to patrol officers at roll call. The unit also committed to same-day e-Trace of recovered crime guns and the triaging of NIBIN leads in order to devote more resources to the identification and seizure of the most active crime guns (see Dierenfeldt et al., 2024; Scott et al., 2023).

The addition of personnel brought total staffing to 8 investigators, 2 sergeants, and 1 crime analyst. The department also purchased a new bullet trap and mobile cameras that could be (re)deployed across the city in response to spatial-temporal changes in gun violence across the city. The Hamilton County District Attorney's Office agreed to embed an assistant district attorney within the CGIC, which allowed for bi-weekly meetings centered on gun crime case review and discussions of how best to proceed with prosecution. The ATF assigned three Special Agents to the unit, and five CGIC investigators received ATF Task Force Office (TFO) deputization in order to expand their jurisdictional authority. The CGIC was housed within the same facility as the Crime Scene Unit in order to facilitate enhanced communication and more timely processing of evidence from gun-related crimes. Finally, though not required by the grant, CPD secured research partners through the local university who met with unit supervisors on a bi-weekly basis and worked to assess the impact of CGIC implementation and practices.

[2]This change was particularly critical in terms of obtaining data in a timely and more robust manner. Prior to this implementation, the department was entirely dependent on the Tennessee Bureau of Investigation for this service, and only in cases of serious firearm violence. If a lead was developed, it typically took 10-16 months for CPD to receive it.

Data, Measures, and Methods

Data

All data used in this study were obtained directly from the CPD's CGIC. Specifically, we examine data for 17 performance metrics tracked by the CPD CGIC from December 30, 2019, to December 31, 2023[3]. These measures were tracked by the CGIC supervisor *via* the CPD's gun crime dashboard and NIBIN Lead Logs, and aggregated into weekly counts that were made available to the research partners each week. This approach not only facilitated more timely input from researchers in the form of technical reports, but also allowed the department to be highly responsive to changes in the nature and frequency of gun crime across the city.

Dependent Variables

Each of the 17 performance metrics was operationalized as a weekly count. As displayed in Table 1, CPD received an average of approximately 29 shots-fired calls each week during the observation period, with an average of 2.29 people being wounded and 0.51 killed by gunfire each week. Ballistics (e.g., spent shell casings) and crime guns were routinely seized, evidenced by the fact that the department recovered an average of 9.43 ballistics and more than 20 crime guns each week. Descriptive statistics also indicate that the department actively utilized both NIBIN and e-Trace. An average of approximately 23 test fires from crime guns and more than 15 ballistics were entered into NIBIN each week. This consistency was important, as it clearly illustrated the extent to which crime guns were being used in multiple crimes. Similarly, the department e-Traced approximately 24 crime guns each week and received hits on nearly half. An average of 37.26 cases were referred to Gun Team/CGIC investigators each week, while approximately 30 were cleared. On average, more than 11 suspects were identified, 9.27 were arrested, 3.80 were charged, and 1.66 were prosecuted.

Although the descriptive statistics in Table 1 provide a complete picture of the 17 performance metrics over the observation period, a more nuanced breakdown may yield insights into how these metrics changed across time. We therefore offer a summary of means and standard deviations for each of the 17 performance metrics by year. As can be seen in Table 2, the weekly average number of ballistics and crime guns recovered remained relatively stable between 2020 and 2021, but the average weekly number of ballistics recovered dropped by almost half by 2023 despite an increase in crime gun seizures. There was limited year-to-year variation in average weekly number of ballistics entered into NIBIN and crime gun ballistic test fires entered

[3]This project was supported by Grant No. 2020-DG-BX-0008 awarded by the Bureau of Justice Assistance. The Bureau of Justice Assistance is a component of the Department of Justice's Office of Justice Programs, which also includes the Bureau of Justice Statistics, the National Institute of Justice, the Office of Juvenile Justice and Delinquency Prevention, the Office for Victims of Crime, and the SMART Office. Points of view or opinions in this document are those of the author and do not necessarily represent the official position or policies of the U.S. Department of Justice.

Table 1. Weekly descriptive statistics from 12/30/19 to 12/31/23 ($n = 209$).

	Mean	SD	Minimum	Maximum_
911 Shots Fired Calls for Service	28.65	9.15	8.00	68.00
Confirmed Non-Fatal Shootings	2.29	2.14	0.00	15.00
Confirmed Fatal Shootings	0.51	0.82	0.00	5.00
Ballistics Recovered	9.43	4.62	0.00	26.00
Crime Guns Recovered	20.25	8.43	0.00	48.00
Ballistics Entered into NIBIN	15.28	8.80	0.00	53.00
Crime Gun Ballistic Test Fires Entered into NIBIN	23.29	8.84	0.00	51.00
Ballistics Linked to Other Crimes	13.54	8.97	0.00	44.00
Crime Guns Linked to Other Crimes	3.64	2.16	0.00	12.00
Crime Guns E-Traced	23.95	34.42	0.00	162.00
E-Trace Hits	11.77	15.21	0.00	80.00
Cases Referred to CGIC Investigators	37.26	14.80	12.00	101.00
Cases Cleared by CGIC Investigators	29.92	12.16	9.00	89.00
Suspects Identified in CGIC Cases	11.33	4.86	2.00	23.00
Suspects Arrested in CGIC Cases	9.27	3.99	2.00	22.00
Suspects Prosecuted in CGIC Cases	3.80	3.55	0.00	16.00
Suspects Convicted in CGIC Cases	1.66	1.83	0.00	10.00

Table 2. Weekly descriptive statistics from 12/30/19 to 12/31/23 by year ($n = 209$).

	2020	2021	2022	2023
911 Shots Fired Calls for Service	32.75(8.96)	32.48(7.00)	26.06(9.95)	23.35(6.58)
Confirmed Non-Fatal Shootings	2.63(2.11)	2.81(1.99)	1.91(2.76)	1.83(1.34)
Confirmed Fatal Shootings	0.58(0.87)	0.58(1.04)	0.38(0.66)	0.50(0.67)
Ballistics Recovered	10.65(5.07)	11.63(4.10)	8.83(4.35)	6.63(3.25)
Crime Guns Recovered	17.56(7.20)	19.37(9.43)	23.40(8.83)	20.62(7.14)
Ballistics Entered into NIBIN	16.85(11.63)	18.06(7.96)	12.70(6.92)	13.56(6.94)
Crime Gun Ballistic Test Fires Entered into NIBIN	22.08(8.99)	23.44(8.72)	24.74(9.72)	22.88(7.84)
Ballistics Linked to Other Crimes	12.08(8.28)	12.38(9.03)	15.26(9.58)	14.40(8.79)
Crime Guns Linked to Other Crimes	3.08(2.08)	3.48(1.79)	3.91(2.25)	4.08(2.42)
Crime Guns E-Traced	21.13(17.41)	24.60(30.50)	28.34(48.39)	21.65(34.32)
E-Trace Hits	18.06(13.51)	18.02(21.17)	4.77(8.54)	6.35(8.78)
Cases Referred to CGIC Investigators	45.06(15.10)	44.08(11.24)	30.75(12.70)	29.29(12.52)
Cases Cleared by CGIC Investigators	35.58(11.45)	28.17(11.86)	28.21(11.31)	27.75(12.55)
Suspects Identified in CGIC Cases	7.33(3.15)	13.50(4.28)	12.70(5.24)	11.79(4.11)
Suspects Arrested in CGIC Cases	7.33(3.15)	10.21(3.54)	10.02(4.68)	9.52(3.84)
Suspects Prosecuted in CGIC Cases	1.19(1.30)	2.79(2.46)	4.36(1.64)	6.85(4.21)
Suspects Convicted in CGIC Cases	0.67(0.96)	1.42(1.71)	1.64(1.72)	2.88(2.06)

Standard deviation in parentheses.

into NIBIN, but a discernable increase in the average weekly number of ballistics linked to other crimes, crime guns linked to other crimes, and crime guns e-Traced between 2021 and 2022. In contrast, the average weekly number of e-Trace hits dropped sharply from 18.02 in 2021 to 4.77 in 2022—indicating that a substantially smaller proportion of e-Traces were successful in providing investigators with information regarding history of firearms seized.

In terms of potential impact, the average number of 911 shots fired calls remained relatively steady between 2020 and 2021 at approximately 32, but then dropped to 26 in 2022 and less than 24 in 2023. Similarly, there was an average of approximately 3 non-fatal shootings each week during 2020 and 2021, but this figure dropped to an average of less than 2 during 2022 and 2023. The average number of cases referred to CGIC investigators, which remained in the mid-40s during 2020 and 2021 was reduced to approximately 30 in 2022 and 2023. The average number of case clearances, however, remained stable, which means that investigators were solving a larger number of cases referred to CGIC. It is also noteworthy that the average weekly number of suspects identified, arrested, prosecuted, and convicted each increased rather dramatically after 2020. The most notable increase was in terms of the number of suspects prosecuted and convicted. The average weekly number of suspects prosecuted increased from 1.19 to 6.85, which represented an increase of 476%. Similarly, the average weekly number of convictions in CGIC cases rose from 0.67 to 2.88, an increase of 330%.

Independent Variable

This study uses a single intervention component associated with the date at which the CPD CGIC became fully operational (7/16/21). This included the transfer of personnel and deployment of new equipment (e.g., bullet trap, mobile cameras). All related policies and procedures described above were also effective by this date. The intervention component was treated as a dichotomous measure (0 = pre-intervention, 1 = post-intervention) in accordance with the assumptions of interrupted time series analyses described below.

Analytic Strategy

We adopted a quasi-experimental, longitudinal design using interrupted time series analyses to assess the impact of the introduction of CGIC on 17 performance metrics across an observation period of 209 wk from December 30, 2019 to December 31, 2023. Time series designs are often used in longitudinal analysis of crime-related outcomes ranging from terrorism (Carson, 2014; Fortunato et al., 2022) to sex offending (Dierenfeldt & Carson, 2017; Vásquez et al., 2008). Interrupted time series analysis is a particularly effective method of determining the impact of a discrete intervention on a social process through comparison of observations that precede and the follow introduction of a new law, policy, or practice (Dugan, 2010; McDowall et al., 1980). This analytical approach is capable of modeling and controlling for serial dependence between observations that is often observed in social science research (Dugan, 2010, McDowall et al., 1980). The use of Autoregressive Integrated Moving Average (ARIMA) modeling, in particular, further allows researchers to control for three sources of noise that might otherwise obscure the effect(s) of an intervention: trend, seasonality, and random error (Dugan, 2010; McDowall et al., 1980).

Inspection of the data revealed a high degree of skewness and kurtosis, necessitating either square root or logarithmic transformation for several series (see Table 3). The Augmented Dickey-Fuller test was then applied to each series to determine the presence of a unit root and, in turn, the potential need for differencing. The critical values for each series were smaller in absolute magnitude than the test statistic, and the associated MacKinnon approximate *p*-values were .0000, indicating that each series was stationary and did not require differencing. Further examination of the autocorrelation function (ACF), partial autocorrelation function (PACF), and Q statistic revealed statistically significant spikes in various lags for nearly every series, indicating the presence of autoregressive and/or moving average processes. Model

Table 3. Model specification.

Outcome Measure	Noise Model
911 Shots Fired Calls for Service[a]	ARIMA (2,0,0)
Confirmed Non-Fatal Shootings[a]	ARIMA (1,0,0)
Confirmed Fatal Shootings[a]	ARIMA (0,0,0)
Ballistics Recovered	ARIMA (1,0,1)
Crime Guns Recovered	ARIMA (1,0,1)
Ballistics Entered into NIBIN[a]	ARIMA (2,0,0)
Crime Gun Ballistic Test Fires Entered into NIBIN	ARIMA (1,0,0)
Ballistics Linked to Another Incident[a]	ARIMA (2,0,0)
Crime Guns Linked to Another Incident	ARIMA (1,0,0)
Crime Guns E-Traced[b]	ARIMA (0,0,1)
E-Trace Hits[b]	ARIMA (1,0,1)
Cases Referred to CGIC Investigators[b]	ARIMA (2,0,0)
Cases Cleared by CGIC Investigators[b]	ARIMA (2,0,0)
Suspects Identified in CGIC Cases	ARIMA (2,0,0)
Suspects Arrested in CGIC Cases	ARIMA (1,0,0)
Suspects Prosecuted in CGIC Cases[b]	ARIMA (2,0,0)
Suspects Convicted in CGIC Cases[b]	ARIMA (0,0,0)

'a' Indicates square root transformation; 'b' indicates log transformation.

parameters were estimated to control for each of these processes, and subsequent analysis confirmed that the ACF and PACF residuals were not statistically different from white noise. Each of the specified noise models is displayed in Table 3.

Once parameters for each of the ARIMA models were estimated and tested, the intervention component was added to each series. Given that the CGIC was launched on a Friday, modeling of effects were lagged 1 week in order to avoid simultaneity bias. Dugan (2010) and McDowall et al. (1980) note that, when assessing the impact of an intervention, one of three distinct patterns are typically observed: abrupt and temporary, gradual and permanent, or abrupt and permanent. Dugan (2010) and McDowall et al. (1980) further recommend that abrupt, temporary effects first be modeled because the statistical significance and magnitude of the slope are often indictive of permanent effects. Specifically, effects are more likely to be permanent if the slope is near one and statistically significant. In such instances, gradual and permanent effects should then be modeled. This requires replacing the pulse function (ωPt) associated with modeling of temporary effects with a step function (ωIt). In terms of permanent effects, those that are gradual are most often observed in the social sciences. If the resulting slope is statistically non-significant, this may suggest that the effect is abrupt and permanent, which can be tested by simply removing the slope component of the equation for gradual, permanent effects.

Results

Descriptive Analysis

Prior to application of ARIMA, preliminary descriptive analysis was performed through examination of percent changes across dependent variables following implementation of CGIC (see Table 4). Accordingly, the weekly average of the pre-intervention series ($n = 81$) and post-intervention series ($n = 128$) for each variable was calculated. In terms of process-related outcomes, the average weekly number of ballistics recovered decreased 28.16% from 11.40 to 8.19, while the average number of crime guns

Table 4. Weekly pre- versus post-CGIC means from 12/30/19 to 12/31/23 ($n = 209$).

	Pre	Post	Percent Change
911 Shots Fired Calls for Service	33.17	25.73	−40.61
Confirmed Non-Fatal Shootings	2.93	1.91	−34.81
Confirmed Fatal Shootings	0.54	0.48	−11.11
Ballistics Recovered	11.40	8.19	−28.16
Crime Guns Recovered	18.39	21.36	16.15
Ballistics Entered into NIBIN	17.90	13.61	−23.97
Crime Gun Ballistic Test Fires Entered into NIBIN	22.20	24.02	8.20
Ballistics Linked to Other Crimes	13.21	13.77	4.24
Crime Guns Linked to Other Crimes	3.09	3.98	28.80
Crime Guns E-Traced	21.88	25.10	14.72
E-Trace Hits	18.39	7.44	−59.44
Cases Referred to CGIC Investigators	46.18	31.57	−31.64
Cases Cleared by CGIC Investigators	31.32	28.94	−7.60
Suspects Identified in CGIC Cases	9.77	12.34	26.31
Suspects Arrested in CGIC Cases	8.48	9.76	15.09
Suspects Prosecuted in CGIC Cases	1.35	5.38	298.52
Suspects Convicted in CGIC Cases	0.79	2.21	179.75

recovered increased 16.15% from 18.39 to 21.36. Accordingly, the average number of ballistics entered into NIBIN decreased 23.97% from 17.90 to 13.61, while the number of crime gun ballistic test fires entered into NIBIN increased slightly (8.20%) from 22.20 to 24.02. The pre and post means for each series remained relatively stable, while the average number of crime guns linked to other crimes increased 28.8% from 3.09 to 3.88. Similarly, the average weekly number of crime guns e-Traced increased 14.72% from 21.88 to 25.10, while the average number of e-Trace hits fell from 18.39 to 7.44, a change of 59.44%.

Several desirable changes were also observed across outcomes related to impact. Confirmed non-fatal shootings dropped by 34.81% while 911 shots fired calls fell by 40.61%. There was also a substantial decrease in caseload, with the average weekly number of cases referred to investigators falling from 46.18 to 31.57, a decrease of more than 31%.[4] Yet, the average weekly number of cases cleared remained much more stable, indicating that investigators successfully cleared a larger proportion of cases following implementation of CGIC. Arguably, the most important changes were those related to case outcomes. Following implementation of CIGC, the average weekly number of suspects identified (26.31%), arrested (15.09%), prosecuted (298.52%), and convicted (179.75%) each increased rather substantially. Taken together, these findings suggested that the introduction of CGIC corresponded with a greater number of crime guns being removed from the streets, more gun offenders being taken out of circulation, and decreases in gun violence across the city of Chattanooga. The extent to which these changes could be directly attributed to CGIC implementation were then tested using interrupted time-series analysis.

[4]Pre-intervention means for the series related to CGIC investigators and CGIC cases are the product of the Gun Team, which was responsible for operation of CGIC once it was live.

Table 5. Intervention effects.

Outcome Measure	Effect Type	ω	SE	z
911 Shots Fired Calls for Service	Gradual, Permanent	−0.296*	.124	−2.39
Confirmed Non-Fatal Shootings	Abrupt, Permanent	−0.369**	.132	−2.81
Confirmed Fatal Shootings	Abrupt, Permanent	−0.016	.082	−0.02
Ballistics Recovered	Abrupt, Permanent	−1.968	1.598	−1.23
Crime Guns Recovered	Gradual, Permanent	2.183†	1.120	1.95
Ballistics Entered into NIBIN	Abrupt, Permanent	−0.473*	.240	−1.97
Crime Gun Ballistic Test Fires Entered into NIBIN	Gradual, Permanent	1.875	1.381	1.36
Ballistics Linked to Another Incident	Abrupt, Permanent	.016	.313	0.05
Crime Guns Linked to Another Incident	Gradual, Permanent	.586*	.266	2.20
Crime Guns E-Traced	Abrupt, Permanent	−0.665***	.201	−3.30
E-Trace Hits	Abrupt, Permanent	−1.113***	.126	−8.80
Cases Referred to CGIC Investigators	Gradual, Permanent	−0.127**	.045	−2.83
Cases Cleared by CGIC Investigators	Abrupt, Permanent	−0.045	.103	−0.44
Suspects Identified in CGIC Cases	Abrupt, Permanent	2.567**	1.082	2.37
Suspects Arrested in CGIC Cases	Abrupt, Permanent	1.251†	.675	1.85
Suspects Prosecuted in CGIC Cases	Gradual, Permanent	1.170***	.303	3.87
Suspects Convicted in CGIC Cases	Abrupt, Permanent	.466***	.143	3.27

†$p \leq .10$.
*$p \leq .05$.
**$p \leq .01$.
***$p \leq .001$.

Time Series Analysis

In accordance with the recommendations of Dugan (2010) and McDowall et al. (1980), abrupt and temporary effects were the first to be modeled for each series, followed by modeling of gradual, permanent effects and, if necessary, abrupt and permanent effects. The significance threshold for all ARIMA models was set at .10 based on our inclusion of a variety of previously untested outcomes and the fact that the CGIC literature is not yet well-established. As can be seen in Table 5, the introduction of CGIC corresponded with statistically significant and permanent changes in 12 of the 17 series we examined. Specifically, the implementation of CGIC was associated with statistically significant decreases in the weekly number of 911 shots-fired calls, confirmed non-fatal shootings, ballistics recovered, ballistics entered into NIBIN, crime guns e-Traced, e-Trace hits, and cases referred to CGIC investigators. In contrast, introduction of CGIC corresponded with statistically significant increases in the number of crime guns recovered, crime guns linked to prior incidents, suspects identified, suspects arrested, suspects prosecuted, and suspects convicted. No statistically significant changes were observed in the weekly number of confirmed fatal shootings, ballistics recovered, crime gun ballistic test fires entered into NIBIN, ballistics linked to another incident, or cases cleared by CGIC investigators.

Discussion and Conclusions

The CGIC Initiative empowers law enforcement agencies to leverage the forensic utility of NIBIN and e-Trace, while establishing intelligence hubs, and encouraging inter-agency cooperation at multiple levels of government (ATF, 2025b; Bottema & Barter, 2025). Thus, it maintains the potential to act as an important force-multiplier in efforts to curb gun violence, identify sources of crime guns, and successfully prosecute gun offenders (ATF, 2025b). Prior studies on CGIC-related outcomes have, however, produced mixed findings (e.g., Flippin et al., 2022; Koper et al., 2019). As noted by Bottema and Barter (2025), these incongruities may be attributed, at least in part, to methodological limitations of measurement and analysis. The current study therefore represents a substantive contribution to the small but growing body of literature on CGIC, NIBIN, and e-Trace.

Overall, our findings indicate that the introduction of the CPD CGIC was associated with several desirable outcomes. The results of our descriptive analysis revealed that the average weekly number of shots-fired calls, non-fatal shootings, and fatal shootings each decreased following implementation of CGIC, while the average number of suspects identified, arrested, prosecuted, and convicted increased. These results should be fully expected given the enhanced evidentiary value provided by NIBIN and e-Trace. Similarly, the average number of crime guns seized increased—meaning that a larger number of crime guns were being removed from circulation despite fewer reported shootings. Taken together, these findings suggest that implementation of CGIC corresponded with increased efficiency and effectiveness in the handling of gun crimes.

Moreover, our findings suggest the likely impact of CGIC on the sources of crime guns and their use in the Chattanooga, while also indicating that CGIC investigators were adaptive and responsive to those changes. Although the number of crime guns being e-Traced increased by nearly 15% following the introduction of CGIC, the average number of e-Trace hits decreased by more than 59%. For context, an average of 18 out of 22 (84%) crime guns being e-Traced pre-CGIC resulted in a hit. In the post-CGIC series, this proportion dropped to 7 out of 25 (30%). It seems unlikely that this sudden decline would be the result of an influx of inaccurate or incomplete submissions. Instead, we believe this change to be the result of increased use of older crime guns with longer time-to-crime, which suggests greater reliance on secondary and illicit gun markets. An additional, though not necessarily competing, explanation is an increase in the use of firearms lacking serial numbers (i.e., ghost guns). Despite these changes, CPD seized a larger number of crime guns and saw a substantial increase in offenders prosecuted and convicted following implementation of CGIC—all while gun crime in Chattanooga decreased.

Importantly, the results of interrupted time series analysis demonstrate that changes in 12 of the 17 outcome measures were statistically significant and could be directly attributed to implementation of CGIC. Specifically, the introduction of CGIC predicted decreases in shots fired calls and non-fatal shootings, coupled with increases in the number of crime guns seized, and gun offenders identified, arrested, prosecuted, and convicted. It should also be noted that these changes were not temporary but rather they persisted over time. Given the lack of empirical support for popular approaches to addressing gun crime that are centered around gun control, the value of these findings in relation to policy and practice should not be understated. Considering the annual price tag of firearm victimization and the costs associated with legislating and enforcing new gun control laws, CGIC appears to be a much more effective and cost-efficient approach to reducing gun crime.

We must, however, acknowledge that these conclusions come with caveats related to limitations in our study. First, the use of city-wide analysis is potentially problematic. Prior works illustrate the degree to which gun violence is concentrated around a small number of places and among a small number of people (Braga et al., 2010; Drawve et al., 2016; Papachristos et al., 2015). Similarly, research has suggested fundamental differences between gun offenses that are gang-involved and those that are not (e.g., Huebner et al., 2016; Stripling et al., 2024). The degree of aggregation in the present study may have obscured disparate effects that might be observed through the use of smaller units of analysis (e.g., census tracts and block groups) and through differentiation of gang-involved versus non-gang-involved gun crimes. We encourage future researchers to explore these possibilities, as the findings would likely provide a more complete understanding of those circumstances in which CGIC offers the greatest value and those in which there is opportunity for improvement. Second, while the use of interrupted time series analysis in the form of ARIMA represents a significant advancement within this body of literature, we strongly encourage future studies to utilize additional analysis in the form of series hazard modeling or Cox proportional hazard modeling. Although ARIMA provides researchers with information concerning changes in frequency across time, hazard models and survival analysis are capable of yielding additional insights, such as change in the number of hours, days, or weeks between shooting events.

Finally, we acknowledge that Chattanooga is a somewhat unique study site in comparison to others explored within the CGIC literature. In this respect, generalizability is potentially problematic. We posit, however, that Chattanooga is much more representative of the average U.S. city than Los Angeles, Milwaukee, or Washington, D.C. As a consequence, the CPD CGIC likely represents a more relatable and useful model for implementation.

Author contributions

CRediT: **Rick Dierenfeldt**: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing; **Laura K. Whitsett**: Writing – original draft, Writing – review & editing; **Joshua T. Shadwick**: Writing – original draft, Writing – review & editing; **Xinting Wang**: Writing – original draft, Writing – review & editing; **Grant Drawve**: Writing – original draft, Writing – review & editing.

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