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Creating Solvability With Real-Time Crime Centers (RTCCs): Impacts on Homicide and Shooting Investigations

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Abstract

Amidst recent increases in homicides and shootings in the United States, clearances rates for homicides have declined and nonfatal shooting cases remain notoriously difficult to solve. Considerable research indicates that the outcomes of homicide and shooting investigations are likely influenced by a range of factors, including inherited case characteristics, investigative actions, forensic testing, and agency resources. Recent advancements in technologies available to law enforcement may help fill persistent gaps in solvability, but research remains limited on their effectiveness. RTCCs integrate a variety of technological innovations and software programs to rapidly receive and distribute information to support police operations, and they harness the strong potential to powerfully impact investigative outcomes and offer an additional pathway through which police agencies can increase case clearance. The current study explores the impact of strategic efforts in the Hartford Police Department (HPD) to increase investigative effectiveness through RTCC processes and technologies. Our findings indicate that RTCC activities significantly increase the likelihood that a case is solved, and this effect is primarily due to RTCC analysts' ability to locate and analyze video associated with the case. When associated video was

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located, cases were 442% more likely to be solved when controlling for other covariates. The HPD's RTCC operations, institutionalized technology, and organizational culture also play a crucial role, with a commitment to technology and information-sharing enhancing investigative capabilities. This study emphasizes the effectiveness of real-time crime centers in locating digital evidence, facilitating rapid information dissemination, and fostering agencywide collaboration, ultimately improving investigative outcomes.

Keywords
investigations, police technology, real-time crime centers

Introduction

Homicides and shootings increased precipitously across the United States following the onset of the COVID-19 pandemic. Multiple factors may have contributed to this trend, with surges in violence likely related to circumstances like social unrest, economic and employment changes, and increased criminal access to firearms during the pandemic years. Some communities also observed increases in interpersonal conflicts and sudden disputes that have contributed to rises in gun violence (see, for example, California Partnership for Safe Communities, 2022; City of Hartford, 2022). Importantly, the vast majority of these incidents continue to occur in fragile communities with high levels of poverty and disadvantage. In addition to threatening public safety and quality of life, exposure to violence in and of itself is associated with a range of life-altering consequences like psychological disorders and an increased risk of future criminal or violent behavior (Blum et al., 2019; Felitti et al., 1998; Kalmakis & Chandler, 2015; Metzler et al., 2017).

Alongside increases in violence and these community and individual level harms, recent statistics suggest that fewer violent offenders are being held accountable for their crimes. In many cities, homicide clearance rates have experienced both a long-term and steeper near-term decline (Cook & Mancik, 2024) and nonfatal shootings remain notoriously difficult to solve (Abadin & O'Brien, 2017; Cook et al., 2017; Kapustin et al., 2017). In nonfatal shooting cases in particular, gaining victim/witness cooperation can be a special challenge (Barao et al., 2021; Hipple et al., 2019). Victims and witnesses may be unlikely to cooperate with the police because they do not believe offenders will be apprehended, because of codes against snitching or feelings of distrust in the police (White et al., 2021), or they may prefer to respond with retaliatory violence rather than the seeking the aid of the criminal justice system (Brunson & Wade, 2019). Given that a relative minority of shooters in most cities are apprehended for their crimes, it can be difficult to overcome the legal cynicism and fear of retaliation that prevents many victims and witnesses from aiding investigations (Kirk & Matsuda, 2011; Sunshine & Tyler, 2003). Not only do unsolved shooting cases fail to provide

justice for victims and their loved ones, but they contribute to ongoing cycles of violence by undermining police efforts to deter gun violence and contributing to the willingness of individuals to seek retribution.

Substantial research demonstrates that the outcomes of homicide and shooting investigations are likely dependent upon a complex set of factors including inherited case characteristics, investigative actions, forensic testing, and agency resources. Whereas early investigations research suggested that the follow-up actions of detectives may do little to affect case clearance (Greenwood & Petersilia, 1975), more recent works support the notion that the investigative strategies and tactics used by investigators can have significant impacts on case outcomes (Braga & Dusseault, 2018; Braga et al., 2019; Wellford et al., 2019). Detectives may gather more evidence and build stronger rapport with victims and witnesses when they are given more time and resources to dedicate to their cases. This investigative effort alongside enhancements to training, personnel resources, and support staff may all help increase the likelihood that a case is cleared. Still, the pervasive lack of victim and/or witness cooperation in many homicide and shooting cases in spite of these efforts poses significant challenges to investigators, but recent advancements in technologies available to law enforcement may help fill these gaps in solvability.

The development of real-time crime centers (RTCCs) in U.S. law enforcement agencies has increased substantially over the past 10 years (Przeszlowski et al., 2023). RTCCs integrate a variety of technological innovations and software programs to rapidly receive and distribute information to support police operations. These centers vary widely in their capabilities and proficiencies (Przeszlowski et al., 2023), and resulting impacts are likely to differ as well. However, when RTCCs extensively deploy and utilize technologies, support skilled analysts, and embed efficient workflows for rapid information diffusion, they harness the strong potential to powerfully impact investigative outcomes and offer an additional pathway through which police agencies can increase case clearance.

The current study explores the strategic efforts of the Hartford Police Department (HPD) to increase investigative effectiveness through RTCC processes and technologies. We first review the existing literature regarding factors linked to the solving of homicides and nonfatal shootings. Next, we outline principal findings from the HPD's efforts to improve investigative responses to serious community violence using their RTCC and explore the effects of key RTCC activities on case clearance. Relying on observations of the Capital City Command Center (C4), the HPD's RTCC, and case studies, we provide insights into the approaches used by the HPD that likely contribute to their ability to generate improvements in solvability with comprehensive investigative assistance from their RTCC.

Literature Review

The ability of law enforcement to solve homicide and nonfatal shooting cases is crucial for several reasons. Clearing these cases first delivers justice and closure to victims and

their families. From a public safety perspective, apprehending offenders and holding them accountable removes dangerous individuals from communities and may prevent future violence (Braga, 2021). Throughout communities, demonstrating the efficacy of law enforcement agencies can foster improved trust and confidence in the police (Kruis et al., 2023). Especially in communities lacking in police legitimacy and police-community cooperation, these actions may publicly reinforce a dedication to the community that improves citizens' willingness to report criminal activity and provide information to the police (Kirk & Matsuda, 2011; Sunshine & Tyler, 2003; Tyler & Fagan, 2008). Clearing criminal cases, especially those involving serious violence, continues to be a fundamental external indicator of policing effectiveness. Acknowledging these impacts, a number of studies have explored the organizational factors and investigative actions that may be associated with higher solve rates, but the relationship between case characteristics, law enforcement actions, and case clearance remains complex, and there is limited research to assess the role of technology in these investigations.

Characteristics and Activities Associated with Clearance

Research demonstrates that several individual characteristics, event characteristics, and situational factors beyond investigators' control may contribute to the likelihood that cases will be solved. The police devaluation perspective assumes that cases involving socioeconomically disadvantaged individuals may be deprioritized by law enforcement and other criminal justice partners (Jarvis & Regoeczi, 2009). According to this perspective, cases involving Black victims and younger victims may be less likely to be solved (Black, 1976) but research findings regarding the impact of characteristics like race on case clearance are mixed (Prince et al., 2021). However, other individual characteristics have been associated with higher solve rates. For instance, cases involving female victims (Alderden & Lavery, 2007; Lee, 2005; Wellford et al., 2019), especially young or old victims (Lee, 2005; Litwin, 2004; Regoeczi et al., 2000; Wellford et al., 2019), or victims and offenders with a prior relationship (Lee, 2005; Roberts, 2007) are more likely to be solved.

Alternatively, the solvability perspective posits that victim characteristics have little influence on investigative actions, and event and scene characteristics instead more strongly influence whether or not a case can be solved (Litwin, 2004; Roberts, 2007). Existing research has lent support to this perspective as well. For example, incidents occurring indoors (Braga & Dusseault, 2018; Braga et al., 2019; McEwen & Regoeczi, 2015) and non-gun homicides (Alderden & Lavery, 2007; Braga & Dusseault, 2018; Braga et al., 2019; Puckett & Lundman, 2003; Roberts, 2007; Wellford et al., 2019) have a greater likelihood of clearance. Conversely, drug and/or gang related homicides and nonfatal shootings are less likely to be solved (Alderden & Lavery, 2007; Barao et al., 2021; Braga & Dusseault, 2018; Braga et al., 2019; Wellford et al., 2019).

Despite the impacts of these inherited case characteristics, more recent research emphasizes that the activities of investigators can still make significant contributions to

the likelihood of case clearance. This growing body of literature suggests that enhancements to police resources and investigative effort can result in higher solve rates (Barao et al., 2021; Cook et al., 2019). Efforts like enhancing training for detectives and investigative units (Barao et al., 2021; Braga & Dusseault, 2018; Braga et al., 2019; Keel et al., 2009), managing detective caseloads (Keel et al., 2009, LoFoso, 2020), building collaborative relationships and intelligence sharing processes (Carter & Carter, 2016; Richardson & Kosa, 2001), and/or enhancing the availability of forensic support staff (Wellford & Cronin, 1999) can improve the likelihood that both homicide and nonfatal shooting cases are cleared. Importantly, these benefits are generated across both homicide and nonfatal shooting cases as well as in more difficult-to-solve cases like gang- and drug-related incidents (Barao et al., 2021).

During active investigations, ensuring the availability of time and resources to collect more evidence and generate cooperative witnesses (Braga et al., 2019; Regoeczi & Jarvis, 2013; Wellford & Cronin, 1999) may improve clearance rates. In particular, Cook and colleagues (2019) emphasize that differences in sustained investigative effort may account for the gap in clearance rates for homicides versus nonfatal shootings. In a comparative analysis of fatal and nonfatal shootings in Boston from 2010–2014, about 11% of both fatal and nonfatal shootings were solved within the first 48 hours. Beyond the first two days, an additional 33% of gun homicides were solved but only an additional 8% of nonfatal shootings were solved. Some of this difference in fatal versus nonfatal shooting solve rates may be attributable to a "cooperation gap" in which witnesses are more likely to cooperate when a victim dies (Cook et al., 2017, 2019), but the greater availability of time and resources in homicide units, allowing for more persistent investigative effort, is likely an important determinant of case outcomes.

Additional benefits to fatal and nonfatal shooting investigations specifically may be produced through forensic firearm examination and ballistics. The National Integrated Ballistic Information Network (NIBIN), established by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF), employs systems to acquire, store, and compare images of bullets and fired cartridge casings. Ballistic evidence is entered into NIBIN when casings are collected from crime scenes or when seized or recovered firearms are test fired by law enforcement personnel. Storage and comparison of ballistic images makes it possible to link recovered evidence to other crimes, groups, or individuals. In 2016, the ATF also launched efforts to establish Crime Gun Intelligence Centers (CGICs) in law enforcement agencies across the United States. CGICs use tools like NIBIN to collect and distribute cross-jurisdictional information about shootings, crime guns, and criminal networks to generate links to support arrests and prosecutions (National Policing Institute, 2022).

Whether or not NIBIN leads increase investigative effectiveness remains unclear. Initial evaluations failed to find significant effects, primarily because of shortcomings in entry frequency, workflows, and processing times (King et al., 2013, 2017). However, others have found the collection of ballistic evidence to be associated with increased case clearance (Barao et al., 2021; Braga & Pierce, 2011), though few studies have assessed the explicit use and effectiveness of NIBIN in these cases. Emerging

research suggests that the generation of NIBIN leads may increase the likelihood of clearing a case, but its utility is likely dependent upon the depth of resources and intelligence-gathering activities centered around these leads (DeBiasi, 2024).

Beyond the comparison of casings, recovered guns also serve as powerful pieces of evidence in that they likely carry other critical physical evidence like DNA or fingerprints as well. If the firearm was recovered in a subject's possession, test firing the weapon and comparing casings to those recovered at the scene can positively link the possessor to the crime. Supporting these potential benefits, research demonstrates that cases are more likely to be solved when firearms are recovered (Wellford et al., 2019). Other physical evidence and forensic testing may also increase the likelihood of clearance, though existing research points to a complex relationship between forensic evidence and case outcomes. For example, some have found that DNA evidence is associated with increases in suspect identifications (McEwen & Regoeczi, 2015) while others have found null (Abrahams et al., 2011) or negative effects (Schroeder & White, 2009). Overall, it appears that forensic evidence has little impact on clearance (McEwen & Regoeczi, 2015; Schroeder & White, 2009), but its benefits may be more apparent among prosecution and sentencing outcomes and recent improvements in rapid test processing might enhance the efficacy for homicide and shooting investigations.

Real-Time Crime Center Technologies

The use of technological tools and specialized intelligence-gathering techniques constitutes one type of enhancement to police resources and effort that may help generate more successful investigations. Real-time crime centers integrate an array of technologies and analytic capabilities, and there has been a rapid and continuous expansion of technologies and software programs aiming to enhance police effectiveness and efficiency. To date, there is a limited body of evidence that explores whether criminal investigations can be improved by these technological advancements. Existing research suggests that some law enforcement technologies may produce investigative benefits, (see, for example, Ashby, 2017; Coupe & Kaur, 2005; Koper & Lum, 2019; Lum et al., 2019), though findings overall are mixed.

RTCCs most commonly deploy gunshot detection technology, license plate readers, and CCTV as key foundational tools for real-time and investigative support functions. Acoustic gunshot detection technology (GDT) typically uses a network of microphones or acoustic sensors that monitor for gunshots and analyze these sounds to determine the location and type of gunfire. GDT may alert police to gunfire more often and more rapidly than citizens themselves. In areas plagued by social disorganization, distrust of the police, or where gunfire is a frequent occurrence, gunfire incidents may be severely underreported (Mazeika & Uriarte, 2019). Given the severity of these offenses, GDT can play a critical role in helping the police respond to gun violence by reducing response times and enhancing spatial precision (Piza, Hatten, Carter, et al., 2023). However, aside from increasing police awareness and response to shootings, little

evidence exists to support the impact of GDT on case outcomes (Choi et al., 2014; Ratcliffe et al., 2019). Recent research does suggest that GDT may increase the likelihood and amount of ballistic evidence collected on scene (Piza, Hatten, Mohler, et al., 2023) and may be associated with increases in citywide gun recoveries (Connealy et al., 2024). Beyond these findings, some argue that the technology, whether through increased police presence after gunfire or through citizen awareness alone, could make communities feel safer (see Fallon Research, 2022; Runevitch, 2022).

Similarly limited evidence has been found to support the investigative impacts of automatic license plate readers (LPRs). The acquisition of automatic license plate readers has proliferated across police agencies in the United States over the past 15 years (Lum et al., 2019). LPRs scan and read license plates on vehicles via fixed or mobile installations. Scanned plates can then be compared to selected databases and alerts can be generated when these match persons and/or vehicles of interest. Assessments of license plate readers suggest that they may aid investigations of some types of serious crime like auto theft and robbery (Koper & Lum, 2019), but agencies may not have historically relied upon LPRs to assist investigations (Lum et al., 2019). One examination of agency use of LPRs indicated that achieving investigative impacts may depend upon factors like accessibility, coverage, and organizational culture surrounding technology usage (Willis et al., 2018).

Though most reviews of CCTV have focused on prevention and deterrence effects, CCTV may also produce a number of benefits for investigators including depicting entire incidents, providing contextual information, capturing escape routes, or corroborating or refuting statements (Ashby, 2017; Brookman & Jones, 2022). Some studies have found that CCTV increases detections of criminal activity and associated suspects (Coupe & Kaur, 2005) and that the availability of CCTV footage is associated with increased case solve rates (Ashby, 2017; Morgan & Dowling, 2019). Still, others have found that the introduction of CCTV produces only very limited improvements in solvability (Robin et al., 2021). Notably, the locations and deployment types of CCTV video have grown substantially in recent years, and sources like street light cameras or private video sharing services can increase the availability of video to assist criminal investigations.

Though this evidence implies relatively limited effectiveness of these tools separately, several researchers argue that greater effect sizes can likely be achieved through the implementation of multiple technologies and interventions (Piza et al., 2019; Ratcliffe et al., 2019), especially when strategically integrated within a RTCC. Importantly, the use and fusion of these technologies not only assists law enforcement in collecting more information and evidence, but it allows them to do so rapidly. Rapid information gathering and diffusion can be especially critical for increasing solvability in nonfatal shootings given that the likelihood of clearance decreases quickly following the first 48 hours (Cook et al., 2019).

In their summary of relevant research, Prince et al. (2021) argue that although technology may generate positive investigative benefits, these potential benefits are likely dependent upon deployment, coverage, reliance, and whether and how

departments have considered how to align and optimize technology for investigative use (also see Taylor et al., 2012). For instance, Guerette and Przeszlowski (2023) worked together with the Miami Police Department to examine the impact of RTCC assistance across a sample of violent crime types and found that RTCC-assisted cases had a 66% greater odds of being cleared when compared to cases receiving no RTCC assistance. The authors assessed the impacts of RTCC assistance on case outcomes for 648 violent crimes receiving support from the Miami PD RTCC when compared to a stratified random control sample drawn from more than 23,000 other violent crimes occurring during the same period. Guerette and Przeszlowski (2023) control for several case characteristics and investigative actions to assess overall impact of RTCC support, but this study was not structured to determine the potential impacts of various RTCC activities. In addition, Miami PD's RTCC assisted only 3% of all violent crime cases occurring during the sample period. The authors acknowledge that selection bias may influence detected outcomes, but the controlling for confounding variables and conducted sensitivity analyses suggest their findings to be robust. Still, given that RTCCs encompass a range of different structures and technologies (Przeszlowski et al., 2023), our understanding of what resources and processes might generate these observed effects remains vague.

Additionally, rapid expansions and improvements to RTCC technologies may not be captured in previous limited work assessing the impacts of tools like CCTV, LPRs, and GDT. For example, several vendors now offer edge video analytics, artificial intelligence, and/or facial recognition technology to improve the utility of these technologies. Video management software (VMS) programs offer agencies the ability to ingest and integrate data from all three foundational technologies discussed in addition to other sources of citywide data, including GPS locations of city vehicles, CAD data, and live video from body-worn cameras or dash cameras. Several vendors also offer the ability for private citizens and business owners to connect their own cameras to law enforcement registries with or without livestream capabilities. Such technology enhancements bolster the investigative power of RTCCs in ways that would not have been captured by previous research.

Also important to consider, though less often discussed, is that the organizational processes and people operating these technologies are likely to be critical determinants of RTCC effectiveness. Organizational support can improve technology usage in police agencies through the provision of resources and training and by supporting integration and ongoing innovation. With this support, the building of efficient workflows can also be critical for maximizing the effectiveness of technology by enhancing communication and collaboration and facilitating informed decision-making. Without skilled analysts, efficient workflows, and supportive organizational environments, law enforcement technologies may not achieve their full capabilities. As Gagliardi (2010) emphasizes, "People can become more efficient and effective in solving and preventing crime through the use of innovative processes and applied technology. … However, technology is useless without people who can use it in an efficient manner" (p. 25).

The Current Study

The HPD established its Capital City Command Center (C4) in 2016 and has continued to develop its technological skills and capacities over the past eight years. C4 detectives and analysts assist patrol officers and detectives in their immediate response and follow-up activities for investigations of incidents ranging from motor vehicle accidents to homicides. The HPD has placed a strong emphasis on solving gun violence cases and the C4 adopts an all-hands-on-deck approach to all shooting and homicide investigations.

The HPD currently deploys an extensive network of CCTV cameras throughout the city and centralizes those video streams within the C4. This CCTV network allows C4 analysts and detectives to aid real-time response and lead in-depth investigative follow-up efforts. The utility of citywide cameras has been bolstered by the integration of citywide LPRs. The C4's LPR system allows analysts and detectives to track vehicles not only by license plate, but also by vehicle make, model, color, and/or body style. The HPD has also deployed GDT coverage in 66% of the city, and GDT covers every residence in Hartford. GDT detects about two thousand gunfire incidents in Hartford annually, many of which generate no citizen calls for assistance.[1] Outside of these primary tools, the C4 incorporates multiple pieces of forensic investigative software for tasks like information gathering, intelligence dissemination, video analysis, and cell phone extraction and analysis.

In addition to its tools and programs, the C4 has worked to develop an efficient and effective workflow process to aid officers and investigators in real time and in follow-up investigations. C4 personnel monitor city patrol radios and react to any call that may have associated digital evidence in real time. This response can be self-initiated and proactive, executed at the request of an officer, or initiated due to a technology prompt such as a GDT alert. Once an analyst or detective's "virtual response or patrol" is conducted, C4 personnel will gather relevant information such as video, images, address or suspect analysis, and LPR alerts/query responses, and distribute them to officers in the field via police radios and a digital communication platform. The platform used by the HPD is accessible via mobile device application, web browser, and computer application. In practice, most officers in the HPD receive disseminated video, images, and intelligence directly on their mobile devices in the field. This timely information becomes vital for responding investigators to assist in suspect apprehension/detentions, shell casing recovery, vehicle seizures, and collection of other pieces of physical evidence. It can also lead to the subsequent canvassing and gathering of other forms of digital evidence such as citizen CCTV video. C4 personnel respond to crime scenes and conduct forensic collection of digital evidence.

C4 personnel also engage in extensive video analysis post incident to support a wide variety of investigative processes for detectives. Ongoing video analysis can include locating and extracting video pre- and post-incident, and tracking vehicles, suspects, and their last known direction of travel. When property is seized or additional cameras are located, analysts conduct forensic mobile extraction and analysis, call detail record

mapping, hard drive extractions, forensic video enhancements, and vehicle infotainment extractions. C4 analysts and detectives also conduct open source/web information gathering, social media analysis, suspect identifications, phone number subscriber identifications, and intelligence dissemination.

Existing literature supports the idea that investigative activities and effort are important determinants of homicide and nonfatal shooting case outcomes. However, a lack of victim cooperation, especially in nonfatal shooting cases, remains a significant obstacle for investigators to overcome. Moreover, recent law enforcement staffing challenges (Mourtgos et al., 2022) diminish the ability of agencies to manage detective caseloads, ensure adequate resources, and support sustained investigative effort, especially amidst post-pandemic increases in gun violence (Ssentongo et al., 2021). In light of these challenges, real-time crime centers may be an especially worthwhile investment. Some research suggests that RTCCs may contribute to higher solvability rates by providing investigators with timely information and critical images and videos that can help identify suspects or generate leads (Brookman & Jones, 2022; Guerette & Przeszlowski, 2023; Morgan & Dowling, 2019). Still, other research regarding various law enforcement technologies finds either null or modest impacts (Prince et al., 2021) and studies examining the effects of these technologies in the context of a strategically integrated RTCC are limited.

Previous research has noted that the investigative impacts of various police technologies are likely dependent upon agency-specific characteristics of deployment, coverage, and usage, and benefits might be maximized through the integration of multiple tools and programs (Prince et al., 2021). Since the C4 strategically adapts its technologies and programs to increase investigative effectiveness and focuses its resources most intensely on serious violence, the HPD is an ideal setting to explore how and whether RTCC activities can improve outcomes in shooting and homicide investigations.

Data and Methods

For this study, the HPD provided data on all criminal gun homicides and nonfatal injury shootings occurring between January 1, 2022 – December 31, 2023 (N = 243).[2] In addition to providing initial action reports and case documentation for review, Major Crimes Division detectives participated in case review meetings for every homicide and shooting, and detectives were asked to update suspect and arrest information in incident databases approximately every six months. The HPD also provided access to its C4 activity tracker in which C4 detectives and analysts log all activities related to criminal investigations. Activities logged include technologies and programs used, associated case information, and descriptions of analyst actions and the information queried or collected.

We first conduct quantitative analyses of case outcomes. We explore the relationship between case characteristics, investigative activities, and technology usage for homicides and shootings using independent samples t-tests. Then, we compare case

characteristics, investigative activities, and technology usage in solved cases versus unsolved cases using independent samples *t*-tests. Finally, we use logistic regression to explore the relationship between technology usage and the likelihood of solving homicide and shooting cases.

Second, we provide qualitative process insights from interviews and observations of C4 personnel regarding the investigative activities for shooting and homicide investigations within their RTCC. We also summarize case studies provided by the HPD which highlight the workflows and processes that likely produce these positive investigative impacts.

Quantitative Measures

The dependent variable in our quantitative analyses was whether or not a case was solved. Solved cases were either cleared by arrest or by other exceptional means. In line with the FBI's Uniform Crime Reporting Program definitions, a case was labeled as solved absent an arrest if detectives collected enough evidence and information from victims and witnesses to support an arrest or charge, though circumstances beyond law enforcement control prevented it. The majority of HPD cases, particularly nonfatal shootings, suffered from a lack of victim/witness cooperation or involved impeachable witnesses that prevented acceptance for prosecution. Other instances of prosecutorial discretion also affected whether an arrest could be made. Still, future research should seek to explore the degree to which investigative activities may increase rates of acceptance for prosecution or conviction as these are important measures of offender accountability.

All characteristics and activities included in this study were coded dichotomously, with the exception of month. Case characteristic variables refer to inherited characteristics of the homicide or nonfatal shooting case and include whether the incident: was a homicide, occurred during daylight hours, occurred indoors, involved multiple victims, involved a drug-related dispute or robbery, or involved group-associated victims and/or suspects. Since group-associated individuals often perpetrate a notable share of drug-related disputes and/or robberies, these circumstance-related categories are not mutually exclusive. To generate a daylight variable, we used the average monthly sunrise and sunset times, with averages adjusted for months in which daylight savings time began or ended. Group associations for victims and suspects were collected through case reports as well as interviews with Intelligence Division detectives regarding group-involved individuals. Lastly, since cases occurring more recently may have been less likely to be solved, we also included a time variable that ranged from month 1 (January 2022) to month 24 (December 2023). The inclusion of this variable helps to account for impact of the time detectives have had to investigate and solve the case, with incidents occurring at the beginning of the sample time period benefitting from more investigative time and resources than incidents occurring at the end of the sample time period.

The investigative activities category refers to actions typically undertaken by the lead detective(s) assigned to the case from the Major Crimes Division along with Crime Scene Division personnel. These activities included: whether the victim and/or witnesses provided information that aided the identification of a suspect (e.g., names, aliases, social media, residence); collection of DNA; gunshot residue (GSR) testing; latent print collection; recovery of the firearm used in the shooting; collection of casings; and the receipt of a NIBIN lead. Each of these variables was coded from detective case reports, RMS supplementary reports and evidence inventories, and interviews with lead detectives.

Lastly, we included key RTCC activities used most often in homicide and nonfatal shooting investigations, including whether video of the incidents or suspects was captured, a GDT alert was received, LPR searches were conducted, or mobile device forensics (e.g., extraction, CDR mapping) were performed. Video was coded as captured only when one or more videos explicitly captured the incident or other related information like potential suspect images or suspect vehicles. The nature of the video collected was determined by detective case reports, detective interviews, and the C4's internal activity tracker. It is important to note that only C4 personnel can access and analyze video for criminal investigations. LPR searches were noted to have occurred when analysts and C4 detectives had full or partial plates or vehicle descriptions that were queried through C4 systems. This only includes LPR searches conducted by C4 personnel as noted in the C4 internal activity tracker. Finally, whether mobile device forensics were performed was coded based on the C4's internal activity tracker. This captures any call detail record mapping performed by C4 analysts as well as mobile device extractions. C4 personnel are the only department personnel trained and authorized to extract and analyze data from mobile devices. A correlation matrix for this sample is reported in Appendix A.

Quantitative Results

Table 1 presents selected characteristics of homicide and shooting cases occurring in Hartford between January 1, 2022 – December 31, 2023. About 24% of the included cases were homicides and about 43% of all cases were solved. The vast majority of incidents (92.2%) were reported and/or confirmed to have occurred outdoors and nearly 60% occurred at night.

Victims and witnesses only provided identifying information in about 12% of cases. Detectives noted that victims and/or witnesses were explicitly uncooperative in 43% of the included incidents, with individuals providing conflicting statements or unable to provide any helpful details in other cases. DNA was collected in 47% of cases and GSR testing was conducted in 24% of cases. Latent print collection was less common, occurring in only 8% of investigations, and recovery of firearms used in the shooting events occurred in only 9% of included cases. Shell casings were collected in the majority (76.1%) of cases, and NIBIN leads were generated in 39% of investigations.

Table 1. Characteristics of Homicides and Shootings, January 1, 2022 – December 31, 2023 (*N* = 243).

Characteristic	*N*	Mean	SD
Case characteristics			
Solved	105	0.432	0.496
Homicide	57	0.235	0.425
Daylight	99	0.407	0.492
Indoor	19	0.078	0.269
Multiple victims	43	0.177	0.382
Drug-related dispute/robbery	43	0.177	0.382
Gang-related dispute	49	0.202	0.402
Investigative activities			
Victim/Witness information	29	0.119	0.324
DNA collection	113	0.465	0.500
GSR collection	58	0.239	0.427
Latent print collection	19	0.078	0.269
Gun recovered	22	0.091	0.288
Casings collected	185	0.761	0.427
NIBIN Lead	95	0.391	0.489
RTCC activities			
C4 analyst activities	209	0.860	0.348
Video captured	125	0.514	0.501
ShotSpotter alert	134	0.551	0.498
LPR search	78	0.321	0.468
Phone ext/Mapping	30	0.124	0.330

Hartford PD's C4 provided investigative support for 86% of the included investigations. Relevant video was located in about 51% of cases, accounting for video of both the incident itself and/or suspects or suspect vehicles. GDT alerts were generated for about 55% of incidents. Though most of the incidents included in this sample were gunfire incidents, GDT alerts are not generated for indoor shootings, and they may not be generated for shootings from vehicles or small caliber firearms. Additionally, Hartford includes two Level 1 trauma centers within the city's 17 square miles. As a result, a substantial number of gunshot victims self-transport. When those victims are uncooperative, investigators may not always be able to confirm a scene within or outside of the city. LPR searches were conducted for potential suspect vehicles in about 32% of investigations. Finally, mobile device forensics were conducted in about 12% of all homicide and shooting cases.

Table 2 presents results of independent samples *t*-tests comparing investigative activities and technology usage for nonfatal shootings and homicides. Relative to nonfatal shootings, homicides were much more likely to be solved ($t = 3.881$, $p = .000$). About 65% of homicides in the sample were solved relative to 37% of nonfatal

Table 2. Comparison of Characteristics for Nonfatal Shootings Relative to Homicides.

	Nonfatal shooting (*N* = 186)		Homicide (*N* = 57)			
Characteristic	Mean	SE	Mean	SE	T	*p*
Case characteristics						
Solved	0.366	0.035	0.649	0.064	3.881	0.000**
Daylight	0.414	0.036	0.386	0.065	−0.375	0.708
Indoor	0.054	0.017	0.158	0.049	2.587	0.010*
Multiple victims	0.097	0.022	0.439	0.066	6.368	0.000**
Drug-related dispute/robbery	0.167	0.027	0.211	0.054	0.757	0.450
Gang-related dispute	0.161	0.027	0.333	0.063	2.868	0.005**
Month (1–24)	11.645	0.466	11.544	0.888	−0.104	0.917
Investigative activities						
Victim/Witness information	0.124	0.024	0.105	0.041	−0.373	0.709
DNA collection	0.360	0.035	0.807	0.053	6.369	0.000**
GSR collection	0.210	0.030	0.333	0.063	1.923	0.056
Latent print collection	0.005	0.005	0.316	0.062	0.469	0.000**
Gun recovered	0.048	0.016	0.228	0.056	4.272	0.000**
Casings collected	0.704	0.034	0.947	0.030	3.865	0.000**
NIBIN Lead	0.360	0.035	0.491	0.067	1.778	0.077
RTCC activities						
C4 analyst activities	0.817	0.028	1.000	0.000	3.556	0.001**
Video captured	0.425	0.036	0.807	0.053	5.319	0.000**
ShotSpotter alert	0.532	0.037	0.614	0.065	1.084	0.279
LPR search	0.274	0.033	0.474	0.067	2.858	0.005**
Phone ext/Mapping	0.048	0.016	0.368	0.064	7.024	0.000**

*$p < .05$, **$p < .01$.

shootings. Homicides were more likely to occur indoors ($t = 2.587$, $p = .010$) and they were more likely to involve multiple fatally or nonfatally injured victims ($t = 6.368$, $p = .000$). When compared to nonfatal shootings, homicides were also more likely to involve gang members as victims, suspects, or both ($t = 2.868$, $p = .005$).

Homicides also received more investigative attention and resources from the Major Crimes Division, Crime Scene Division, and C4 personnel. Homicide investigations were characterized by more frequent DNA collection ($t = 6.369$, $p = .000$), latent print collection ($t = 8.725$, $p = .000$), and weapon recoveries ($t = 4.272$, $p = .000$). Homicide investigations were also more likely to receive C4 investigative support ($t = 3.556$, $p = .001$), and the C4 was more likely to locate associated video ($t = 5.319$, $p = .000$), run LPR searches for potential suspects ($t = 2.858$, $p = .005$), and conduct mobile device forensics ($t = 7.024$, $p = .000$). In the case of mobile device forensics, this was more frequently undertaken for homicide investigations

because victim cell phones were often located and collected from associated crime scenes.

Table 3 presents results of independent samples *t*-tests comparing investigative activities and technology usage for unsolved versus solved cases. Relative to unsolved cases, solved cases were more likely to be gang member involved ($t = 3.226$, $p = .001$). This runs counter to previous research indicating that gang-related homicides and shootings are often more difficult to solve (Barao et al., 2021). However, Hartford is a relatively small city with less than ten known gangs actively involved in violence. The HPD's Intelligence Division, Violent Crimes Unit, Vice & Narcotics Unit, and Major Crimes Division all work in tandem to actively share intelligence and proactively intervene with violent gang-associated gun offenders. These information collection, intelligence dissemination, and proactive intervention efforts could make these individuals and conflicts easier to identify.

Table 3. Comparison of Characteristics of Unsolved Cases Relative to Solved Cases.

	Unsolved (*N* = 138)		Solved (*N* = 105)			
Characteristic	Mean	SE	Mean	SE	T	*p*
Case characteristic						
Homicide	0.145	0.030	0.352	0.047	3.881	0.000**
Daylight	0.355	0.041	0.476	0.049	1.910	0.057
Indoor	0.051	0.019	0.114	0.031	1.833	0.068
Multiple victims	0.152	0.031	0.210	0.040	1.159	0.248
Drug-related dispute/robbery	0.159	0.031	0.200	0.039	0.819	0.414
Gang member involved	0.130	0.029	0.295	0.045	3.226	0.001**
Month (1–24)	12.370	0.518	10.638	0.659	−2.094	0.037*
Investigative activities						
Victim/Witness information	0.051	0.019	0.210	0.040	3.883	0.000**
DNA collection	0.362	0.041	0.600	0.048	3.771	0.000**
GSR collection	0.196	0.034	0.295	0.045	1.809	0.072
Latent print collection	0.022	0.012	0.152	0.035	3.856	0.000**
Weapon recovered	0.022	0.012	0.181	0.038	4.438	0.000**
Casings collected	0.696	0.039	0.848	0.035	2.785	0.006**
NIBIN Lead	0.391	0.042	0.390	0.048	−0.013	0.990
RTCC activities						
C4 analyst activities	0.812	0.033	0.924	0.026	2.520	0.012*
Video captured	0.377	0.041	0.695	0.045	5.164	0.000**
GDT alert	0.551	0.042	0.552	0.049	0.026	0.980
LPR search	0.297	0.039	0.352	0.047	0.912	0.363
Mobile device forensics	0.072	0.022	0.190	0.039	2.803	0.006**

*$p < .05$, **$p < .01$.

When compared to unsolved cases, solved cases were more likely to benefit from a range of investigative activities. Cases were more likely to be solved when victims and/or witnesses provided helpful or identifying information to detectives ($t = 3.883$, $p = .000$). Solved cases were more likely to involve DNA collection ($t = 3.771$, $p = .000$), latent print collection ($t = 3.856$ $p = .000$), weapon recoveries ($t = 4.438$, $p = .000$), and the collection of casings ($t = 2.785$, $p = .006$). Solved cases were also more likely to involve C4 analyst support ($t = 2.520$, $p = .012$), captured video ($t = 5.164$, $p = .000$), and mobile device forensics ($t = 2.803$, $p = .006$).

Results from a logistic regression predicting that a case is solved are presented in Table 4. When controlling for all other covariates, the odds ratio (OR) indicates that gang member involvement increased the odds of clearing a case by 174% (OR = 2.742, $p = .025$). Older cases were also significantly more likely to be solved (OR = 0.949, $p = .047$).

Table 4. Logistic Regression of Case Closure on Case Characteristics and Investigative/RTCC Activities.

Characteristic	OR	RSE	z	*p*
Case characteristic				
Homicide	0.976	0.514	−0.05	0.964
Daylight	1.449	0.488	1.10	0.271
Indoor	1.654	0.973	0.86	0.392
Multiple victims	0.539	0.239	−1.39	0.164
Drug-related dispute/robbery	0.936	0.420	−0.15	0.883
Gang member involved	2.742	1.231	2.25	0.025*
Month (1–24)	0.949	0.025	−1.98	0.047*
Investigative activities				
Victim/Witness information	5.215	2.525	3.41	0.001**
DNA collection	1.392	0.530	0.87	0.385
GSR collection	1.147	0.455	0.34	0.731
Latent print collection	4.237	4.166	1.47	0.142
Weapon recovered	10.120	7.567	3.10	0.002**
Casings collected	1.391	0.633	0.72	0.469
NIBIN Lead	0.736	0.284	−0.79	0.427
RTCC activities				
Video captured	5.416	2.394	3.82	0.000**
GDT alert	0.593	0.222	−1.40	0.163
LPR search	0.716	0.305	−0.79	0.432
Mobile device forensics	1.909	1.081	1.14	0.253
Constant	0.271	0.132	−2.68	0.007**

$N = 243$.
Pseudo R2 = 0.2680.
*$p < .05$, **$p < .01$.

Among investigative and RTCC activities, only three variables had significant effects on the likelihood that a case was solved. Holding other variables constant, when victims and/or witnesses provided helpful or identifying information, the odds of clearing the case were 422% higher (OR = 5.215, $p = .001$). Weapons were also more likely to be recovered (OR = 10.120, $p = .002$) in solved versus unsolved cases. Among RTCC activities, locating video associated with the case is associated with a 442% increase in the odds that a case is solved (OR = 5.416, $p = .000$) when controlling for all other covariates.

In addition to measuring whether video was captured or not captured, analyst and detective documentation provided information regarding the detailed nature of the video captured in all cases. Table 5 presents results from a logistic regression predicting that a case is solved and accounting for whether captured video showed the incident

Table 5. Logistic Regression of Case Closure on Case Characteristics, Investigative/RTCC Activities, and Type of Video Captured.

Logistic regression predicting solved Characteristic	OR	RSE	z	*p*
Case characteristic				
Homicide	0.871	0.462	−0.26	0.794
Daylight	1.489	0.503	1.18	0.238
Indoor	1.623	0.938	0.84	0.402
Multiple victims	0.536	0.239	−1.40	0.162
Drug-related dispute/robbery	0.915	0.414	−0.20	0.844
Gang member involved	2.792	1.252	2.29	0.022*
Month (1–24)	0.953	0.025	−1.82	0.069
Investigative activities				
Victim/Witness information	5.297	2.541	3.47	0.001**
DNA collection	1.467	0.570	0.99	0.324
GSR collection	1.079	0.433	0.19	0.849
Latent print collection	4.293	4.087	1.53	0.126
Weapon recovered	9.429	6.957	3.03	0.002**
Casings collected	1.585	0.716	1.02	0.307
NIBIN Lead	0.753	0.293	−0.73	0.466
RTCC activities				
Video: Incident	7.177	3.810	3.71	0.000**
Video: Context	4.446	2.064	3.21	0.001**
GDT alert	0.583	0.219	−1.44	0.151
LPR search	0.705	0.306	−0.80	0.422
Mobile device forensics	2.025	1.119	1.28	0.202
Constant	0.241	0.118	−2.91	0.004**

$N = 243$.
Pseudo R2 = 0.2670.
*$p < .05$, **$p < .01$.

itself or only relevant context (e.g., fleeing suspects, suspect vehicles). Similar to the previous model, cases are significantly more likely to be solved when victims and/or witnesses provide helpful or identifying information (OR = 5.297, $p = .001$) and when weapons are recovered (OR = 9.429, $p = .002$), net all other variables.

Amongst RTCC activities, video is still the only statistically significant variable, and its impact remains significant regardless of whether the incident or only context is captured. When controlling for other covariates, locating video that captured the incident itself was associated with a 618% increase in the likelihood that a case was solved (OR = 7.177, $p = .000$). Still, even when video captured only contextual information about the scene, victims, and/or suspects, that video was associated with 345% increase in the likelihood of solving the case (OR = 4.446, $p = .001$) when holding other variables constant.

The C4 Process

Regression models illustrate the statistically significant impact of video on increasing the likelihood that a case is solved. Observations of C4 operations and case studies shed light on why the effects of video may be so powerful within the HPD and other well-structured RTCCs. In particular, the C4 has strategically developed processes that capitalize on the skills and talents of analysts and emphasize rapid information distribution. When a homicide or nonfatal shooting occurs, personnel within the C4 are mobilized to assist immediately. C4 personnel are responsible for all video analysis for criminal investigations, and they are the only personnel with access to video capabilities like playback and export. This creates a single-entry point and ensures that all video evidence is handled in a forensically sound manner. City-owned video can be accessed and searched from the RTCC, and analysts also query several in-house systems to gather information about GDT alerts, conduct LPR searches, and gather information on potential victims, witnesses, and suspects. After this immediate response, C4 personnel work in close collaboration with Major Crimes Division detectives in ongoing investigatory follow-up actions. While city-owned video can be accessed from the RTCC, C4 personnel also are trained in third party video extraction and deploy to the field at the request of investigators to pull video. Shooting investigations often rely on a combination of videos pulled from city-owned video and third party sources.

The C4 provided multiple examples of the sequence of events that typically occurs immediately following a gunfire incident in Hartford. In one sample case occurring in 2023, the HPD received and dispatched a GDT alert for 19 rounds. No citizen caller reported the shots fired. As officers were responding to the shots fired location, C4 personnel also immediately responded virtually via the city camera system. C4 personnel observed the incident occur and saw the suspected shooter run behind a residential building further down the street. C4 personnel immediately relayed this information and the associated address to the responding units over the radio and

distributed a picture of the shooter via their digital communication platform. Responding units quickly proceeded to the rear of the provided address and found the shooter. He was still armed with a 9 mm "ghost gun" equipped with an auto-sear that allows for fully automatic firing. On scene, officers recovered 19 shell casings and the suspect ultimately confessed to the shooting. While video facilitated this arrest, it required a GDT alert, an expansive CCTV network, an efficient analyst, and effective information distribution structures to achieve this result.

In addition to this immediate response, C4 personnel also provide comprehensive ongoing assistance to investigators in the days and weeks following a homicide or shooting event. In another 2023 case, HPD dispatch received a call for a male party suffering from multiple gunshot wounds inside of a store. C4 personnel immediately started reviewing surrounding cameras. Three individuals were seen exiting the store and running out of camera view. Images of potential suspects were disseminated to all HPD officers via a digital communications platform. After further review of nearby cameras, analysts observed one vehicle driving by the store multiple times during the incident. Analysts tracked the vehicle through available cameras and observed the vehicle dropping the suspects off one block away from the store. The suspects then walked to the store while the vehicle relocated down the street to wait and pick up the suspects after the shooting. In addition to capturing higher quality images of the suspects through this camera review, C4 personnel were also able to capture a partial plate from the associated vehicle. Partial plates were run through LPR systems until a complete plate was confirmed.

An NCIC check of the vehicle plate revealed that it was a rental vehicle. Upon receipt of the renter's name from the rental car company, C4 analysts requested and received a DMV photo of the renter from a regional state fusion center. Analysts worked to continue to track the vehicle through citywide cameras and LPRs. The vehicle was observed to have stopped at a local gas station and video was pulled from the business. This video provided C4 personnel with unmasked photos of the vehicle occupants. Two individuals were matched to the suspect photos captured near and at the scene. A third individual was matched to the DMV photo received of the vehicle renter. Finally, a fourth occupant was identified by Department of Corrections intelligence personnel from another state. Major Crimes Division detectives obtained cell phone records for the driver by search warrant. C4 analysts then worked to map the driver's call detail records (CDRs) and matched these to LPR hits over the same time period. The resulting data showed the suspect in the area of the shooting and traveling across multiple states both before and after the incident. In this case, C4 personnel responded immediately and disseminated timely and actionable intelligence to the field. After this initial response, analysts continued to work this case by searching numerous cameras, analyzing video, tracking vehicles, and searching LPR databases. When their searches led to an eventual suspect identification, C4 personnel sought information from regional collaborating agencies and used their intelligence sharing forums to identify others involved.

Once a mobile device search warrant was secured, C4 personnel mapped call detail records and queried regional LPR systems to comprehensively depict suspect travels and event sequences before and after the event.

These cases underscore that the impacts of HPD's RTCC are not simply the result of an opportunely placed camera that happens to capture the entirety of a homicide or shooting in its viewshed. Often, cameras throughout the city are used to capture suspect movements and activities before and after the incident. Even when incidents are captured fully on camera, that video alone is rarely enough to help detectives make suspect identifications. Instead, video can serve as a springboard that sets a multifaceted RTCC and investigative response in motion.

Discussion & Conclusion

This study presents findings comparing investigative activities and technology usage for nonfatal shootings and homicides. Homicides in this sample were much more likely to be solved when compared to nonfatal shootings, with 65% of homicides being solved compared to 37% of nonfatal shootings. Reflecting findings from a growing body of research, homicide investigations appeared to receive more attention and resources, including more frequent DNA and latent print collection, weapon recoveries, and investigative support from the C4. Solved cases benefitted from cooperating victims and/or witnesses who provided information helpful to identifying suspects. Investigators received helpful information from victims or witnesses in only 5% of unsolved cases but 21% of solved cases. More forensic evidence was collected in these cases, including DNA, latent fingerprints, weapons, and shell casings. Solved cases were more likely to receive RTCC assistance, and they were substantially more likely to have associated video. About 39% of unsolved cases had captured video associated with the case while 70% of solved cases had associated video.

Regression analysis demonstrated that when victims or witnesses provide helpful information, the odds of clearing a case increased by 422%, controlling for other covariates. The recovery of weapons increased the odds of clearance by 912%. Weapon recovery occurred in only 9% of cases, but these cases were much more likely to be solved. Rather than reflecting inherent forensic value, this finding may be reflective of the nature of the incident itself, with weapons being recovered more often from the scenes of close personal disputes and domestic disputes. There were no significant effects associated with other physical evidence collected like DNA, latent prints, GSR, or shell casings. This evidence likely proves less fruitful in the absence of actionable leads generated through information gathered from victims, witnesses, or video. Though, it may still prove critical for more successful prosecutions in these cases.

Other than victim/witness information and weapon recovery, the only additional investigative variable with significant effects was the location of associated video. Locating video associated with the case increased the odds of solving a case

by 442%, net other variables. Furthermore, these significant effects persisted regardless of whether the video directly captured the incident or only captured helpful contextual information (e.g., fleeing suspect vehicles). Cases with video depicting the incident were 618% more likely to be solved while cases with video depicting other helpful context were 345% more likely to be solved when controlling for other covariates.

In contrast to previous research, video was only coded as present for an investigation in this study if C4 analysts or detectives noted that cameras had captured the incident itself, suspects, suspect vehicles, and/or other information specifically helpful to the case. This coding approach allows us to have increased confidence in the ability of this analysis to more accurately capture the effect of video on investigative outcomes. Video may of course aid in case closure when it captures the entirety or partial scenes of a homicide or shooting. However, analysts and investigators still benefit even when the incident does not occur in direct view of a camera. Video tended to most often capture suspect vehicles either immediately on scene or travelling through nearby cameras. Citywide CCTV and private video often allowed analysts to track suspects and associated vehicles in their travels across the city both before and after an incident, shedding light on events, activities, addresses, and individuals associated with suspected shooters. As a whole, the video located by C4 analysts and detectives helped investigators better understand the homicide or shooting events, corroborate or refute accounts of the incident, and generate critical leads to collect additional evidence and identify suspects.

Moreover, our process findings highlight the operational practices of the C4 and show how the immediate response and ongoing assistance of C4 personnel contribute to case clearance. Among investigative RTCC variables, associated video was the only statistically significant factor impacting case solvability. Though video is a powerful contributor on its own, our findings suggest that the effects of video are likely to be amplified by the C4's operational processes and the HPD's institutionalization of the value of technology in enhancing investigative responses. The location of video, either of the incident or associated context, initiates rapid internal and regional information-sharing and sets off a series of subsequent investigative activities. For instance, when analysts locate video or images of suspects or suspect vehicles, those images are immediately disseminated to law enforcement personnel in the field via a digital communications platform. Analysts also continue to track suspects and vehicles through other citywide cameras, conduct LPR searches, query intelligence databases, and seek information from partnering agencies. The C4 has citywide GDT coverage and access to an extensive network of CCTV cameras and LPRs. They have acquired a host of programs aimed to bolster their investigative capabilities for forensic analysis of digital evidence like video, mobile devices, and vehicle infotainment systems. CCTV works in tandem with a vast network of strategic technologies, and the purposeful acquisition and deployment of a comprehensive suite of tools and technologies in the HPD has likely maximized the evidentiary value of video evidence.

The efficiency and effectiveness of the C4 is also supported by a strong organizational culture that values the ability of technology to enhance law enforcement operations and public safety. Willis et al. (2018) recognized that organizations play an important role in motivating the innovative use of technology in investigations. Commitment from command staff and the institutionalization of RTCCs and their technologies enhances the capabilities of these initiatives. The C4 organizes and facilitates weekly intelligence meetings involving HPD personnel and partners from regional police departments and collaborating criminal justice agencies. The C4 and command staff also use these weekly intelligence meetings, CompStat, and community meetings as forums to showcase successful investigations. The C4 has long recognized the value of real-time communication and rapid information-sharing, and HPD personnel have worked to build processes that facilitate these activities and generate agencywide and regional buy-in. Within the HPD, all officers are added to the digital communications platform, and both officers and supervisors use this application to routinely talk within and across units about a variety of different topics and crime types. These communications are timely, purposeful, and contain actionable information and images. Officers are able to communicate in real-time using and messages are organized and easily accessible. By keeping engagement on this platform active and adaptable to various uses, officers have embraced this method of direct communication, and it is entrenched in the operational culture of the HPD and surrounding agencies. All of these factors lead officers to prioritize and devote more attention to the messages they receive and send through the digital platform over communications through other systems or via email, and this makes the C4's efforts to quickly disseminate and seek intelligence more effective.

A growing body of literature supports the notion that law enforcement agencies can improve homicide and shooting clearance rates by investing in investigative personnel and resources, supporting enhanced training opportunities, and improving investigative processes to facilitate additional canvassing, evidence collection, and forensic analysis. Recent research extends these ideas to RTCCs, suggesting that the technologies integrated within these centers may lead to improvements in solvability. Guerette and Przeszlowski's (2023) assessment of the investigative impacts of real-time crime centers found that RTCC assistance was associated with marked improvements in clearance for violent crime cases. In their research, CCTV was the most frequently used technology and was accessed in 87% of cases. The current study builds upon these findings by exploring how specific RTCC activities influence investigative outcomes. Indeed, locating video associated with fatal and nonfatal shooting cases provides the greatest investigative benefit, but the strength of this effect is likely dependent upon the technology integrations, operational processes, and information-sharing systems of each RTCC.

Though, our findings suggest that agencies should be mindful of the operational processes within their RTCCs and the organizational culture surrounding their centers. To optimize effectiveness and maximize return on investment, implementation plans should work to strategically align technologies, bolster officer

buy-in, and develop efficient workflows. The HPD's RTCC appears to produce especially powerful impacts because the investigative capabilities of its technologies are supported by operational processes that facilitate the timely collection, distribution, and utilization of a range of actionable digital evidence and intelligence. Notably, agencies that have already established RTCCs can continuously purchase and realign technologies. They can also adjust workflows and enhance communication processes to improve investigative responses and outcomes. Whereas some programs may quickly fall into disrepair if not initially implemented correctly, RTCC programs offer the opportunity for continued improvement, growth, and reinvention. Agencies seeking to implement or improve RTCCs would benefit from peer learning opportunities and consultation with departments that have developed especially well-functioning programs.

Still, we do acknowledge several limitations to this study. First, this research only assessed outcomes in a single city. The population and context of violence in Hartford may not mirror the dynamics of other cities, and it may influence the degree to which investigators are able to solve cases. Hartford is also a relatively small city of only about 17 square miles, and it is unclear whether RTCCs covering larger areas would be able to produce similar effects. Second, and relatedly, since RTCCs vary widely in structure, technology coverage, and operations, these factors likely impact the effects that each center is able to produce. Third, we only assessed the impact of investigative activities and RTCC technologies on homicides and nonfatal shootings. Impacts on other violent crimes, property crimes, and disorder crimes were not assessed, and potential effects on investigations of these offense types remain unknown. Further, this study does not assess the impact of these investigative and RTCC activities on prosecutorial outcomes, and this is an important area for additional research.

In spite of these limitations, this research has important implications for how law enforcement technologies and RTCCs can be leveraged to aid investigations. Despite their suggested benefits, a 2020 survey found that less than 1% of agencies nationwide operated RTCCs (Przeszlowski et al., 2023). The current study complements recent findings that suggest RTCCs can have meaningful benefits to police agencies, and the expanded deployment of RTCCs in more agencies could greatly enhance investigative efficiency and increase homicide and shooting clearance rates. When agencies harness the capabilities of several well-aligned technologies and focus on supporting effective people and processes within their RTCC, these centers are tremendously valuable to police operations and investigations. These effects tend to stem from the value of video evidence, but the ability to locate and utilize this evidence effectively hinges on the personnel, processes, and complementary tools operating and centralized within an RTCC. These findings underscore the importance of strategic technology deployment, integration, and institutionalization alongside the implementation of comprehensive investigative approaches supported by real-time crime centers to enhance solvability rates.

Appendix

Appendix A. Bivariate Correlation Matrix.

	Solved	Homicide	Daylight	Indoor	Mult. Victims	Drug-related	Group-related	Time	Vic./Wit. Info	DNA
Solved	1.0000									
Homicide	0.2425	1.0000								
Daylight	0.1221	−0.0242	1.0000							
Indoor	0.1173	0.1644	0.0393	1.0000						
Mult. Victims	0.0744	0.3795	−0.0333	0.1060	1.0000					
Drug-related	0.0527	0.0487	0.0764	0.0658	−0.0172	1.0000				
Group-related	0.2035	0.1817	0.0216	−0.1082	0.1164	0.0088	1.0000			
Time	−0.1337	−0.0067	0.0280	−0.0449	0.0139	−0.1962	−0.2149	1.0000		
Vic./Wit. Info	0.2426	−0.0240	−0.0211	0.1292	−0.0709	−0.0709	0.0365	−0.0831	1.0000	
DNA	0.2361	0.3796	−0.0006	0.0665	0.2811	0.0001	0.0661	0.1129	0.0131	1.0000
GSR	0.1157	0.1229	0.0466	0.0886	0.1198	−0.0826	−0.0649	0.0707	0.0321	0.2135
Prints	0.2411	0.4899	0.0705	0.0294	0.1863	0.0658	0.1211	−0.1214	−0.1072	0.3124
Gun recovered	0.2749	0.2653	0.0303	0.1218	0.1919	0.0040	0.0559	0.0298	0.0608	0.3097
Casings	0.1766	0.2416	−0.0073	0.0552	0.1837	0.0826	0.1611	−0.0511	0.0572	0.3091
NIBIN	−0.0008	0.1138	−0.0464	−0.0449	0.2031	−0.1063	0.1438	0.0381	−0.0088	0.1661
Video captured	0.3156	0.3241	0.2023	−0.0237	0.2348	0.0406	0.0984	0.1095	0.0021	0.3115
GDT alert	0.0016	0.0697	0.0237	−0.2613	0.0279	−0.1022	0.2264	−0.0158	−0.0253	0.1441
LPR search	0.0587	0.1811	0.1654	−0.1017	0.0970	0.0277	−0.0160	0.2013	−0.0628	0.2426
Mobile device for	0.1777	0.4122	−0.0820	0.1237	0.1866	0.0882	−0.0015	0.0533	−0.0224	0.1517

	GSR	Prints	Gun recovered	Casings	NIBIN	Video captured	GDT alert	LPR search	Mobile device for
GSR	1.0000								
Prints	0.1965	1.0000							
Gun recovered	0.1934	0.2286	1.0000						

(continued)

Appendix A. Bivariate Correlation Matrix. (continued)

	GSR	Prints	Gun recovered	Casings	NIBIN	Video captured	GDT alert	LPR search	Mobile device for
Casings	0.0191	0.1631	0.1430	1.0000					
NIBIN	−0.0134	0.0494	0.0705	0.4090	1.0000				
Video captured	0.0804	0.1910	−0.0091	0.2479	0.0697	1.0000			
GDT alert	−0.0385	0.0469	−0.0615	0.2908	0.1800	0.2495	1.0000		
LPR search	−0.0541	0.0624	−0.0633	0.0955	0.0633	0.5093	0.2479	1.0000	
Mobile device for	0.0833	0.2635	0.0996	0.0927	0.1095	0.2145	−0.0640	0.0903	1.0000

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Notes

1. An internal analysis of injury shootings occurring 2019-2020 showed that 56% of these incidents had no associated citizen call for service.
2. We conducted sensitivity analysis of parameters and examined the data with and without the inclusion of ten additional non-gun homicides during the study period. Our analyses showed no overall impact on results. However, given our focus on shooting investigations and the inclusion of firearm evidence parameters, non-gun homicides were dropped from our sample.

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