Police Can Improve Arrest Rates for Shootings: A Quasi-Experimental Evaluation of the Denver FAST Unit

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Abstract

Arrest rates for nonfatal shootings (NFS) are disturbingly low in many U.S. cities, with recent estimates suggesting that only one-third of these events are cleared by arrest. In 2020 the Denver Police Department (DPD) created the Firearm Assault Shoot Team (FAST) and assigned most of the NFS cases to this special unit. (Previously most NFS investigations had been handled by district detectives who were also responsible for a large volume of other violent and property crime cases.) The goal was for FAST to investigate NFS cases with the same urgency as homicide cases. This evaluation estimates the impact of DPD's FAST unit on the frequency with which nonfatal shootings are cleared by arrest during an evaluation period spanning 2017-2023. For these 7 years, we compare the trajectory of arrest rates for NFS to similar trajectories for gun crimes without injuries, gun homicides, and burglaries investigated by other DPD detectives. We estimate that the FAST Unit increased the arrest rate for nonfatal shootings by approximately 19 percentage points – from 26% to 45%. The findings are robust to alternative identification strategies and are supported by a series of placebo outcome tests. Among the mechanisms that appear to explain increases in arrest is that FAST detectives have a light enough caseload that they can spend time developing witnesses and convincing victims to cooperate with investigators.

Significance Statement

This study is the first to provide causal evidence that better resourced investigations can improve arrest rates for nonfatal shootings. DPD's FAST unit expanded investigative capacity by dedicating specialized detectives to NFS cases, providing additional training and resources, prioritizing access to investigative technology, and strengthening coordination with prosecutors and federal law enforcement. Beyond the impact of the FAST unit on case clearances, our findings highlight the potential for improving victim cooperation in NFS investigations. Victim cooperation is a virtual necessity for building a robust case against an assailant. The findings suggest that with sufficient time, detectives can "convert" reluctant victims, opening the door to arrest and prosecution.

Main Text

Introduction

There were roughly 15,000 fatal and 60,000 nonfatal shooting (NFS) victimizations in the U.S. in 2024. The clearance rate – the percentage of cases resulting in arrest or closed through exceptional circumstances such as the death of the suspect – for gun homicides and NFS cases were about 52% and 34%, respectively, in that year (1). The national figure masks considerable variation across jurisdictions. Some of the largest and most prominent cities in the U.S. have arrest rates for NFS cases of 10% or lower (2). For instance, in Chicago between 2010 and 2016, annual clearance rates for gun murders ranged from 26% to 46% and from 5% to 11% for NFS cases (3).

The clearance rate gap between these two serious violent crimes is noteworthy for several reasons. First, the difference between a fatal and a nonfatal shooting is often a matter of chance, including what area of the victim happens to be struck and how quickly help arrives. Gun homicides and NFS cases are generally similar with respect to the circumstances and the characteristics of victims and offenders (4, 5). Reflecting how arbitrary the differences can be, in Los Angeles, investigators often refer to NFS cases as "almocides" (i.e., almost homicides) (6). Second, in principle, the NFS cases should be easier to investigate given there is a living victim who might be able to describe their assailant to investigators or otherwise cooperate in bringing their attacker to justice. In practice, victims often refuse to cooperate for various reasons including

mistrust and dislike of the police, the “no snitching” norm, and fear of retaliation (7). Without the victim’s cooperation it is nearly impossible to obtain a conviction even if there is an arrest (7). An additional explanation for the gap in clearance rates between fatal and nonfatal shootings is that police departments assign higher priority to shooting cases in which the victim dies. Homicide detectives typically have lower caseloads and more resources than detectives who are assigned to NFS cases (8).

Policymakers are increasingly interested in addressing the problem of low arrest rates for serious violent crimes. The effects of low NFS clearance rates are thought to be multifaceted and profound—violent offenders are not held accountable, justice is not delivered to victims, communities lose confidence in their government and justice system, and future gun attacks are not prevented. Underlying all these concerns is the empirical regularity that lethal violence is disproportionately concentrated among a small number of individuals and social networks, thus raising the stakes of failing to incapacitate future offenders (9,10).

Descriptive studies, as well as the consensus of police professionals, suggest that police can improve clearance rates by strengthening the capacity and accountability of investigative work, devoting targeted resources towards investigations, increasing efforts to develop cooperative witnesses, and enhancing crime scene responses (11). Descriptive studies provide suggestive evidence, but they were not designed to identify whether the observed statistical associations are a result of investigative resources, or some other process. For example, investigators may tend to devote more effort to promising cases, in which case the positive association between effort and success would be partly the result of selection bias.

In 2012, the Boston Police Department launched several reforms affecting homicide investigations, including the assignment of additional detectives to the homicide unit, the standardization of investigative procedures and forensic reviews, improved training for investigative personnel, and peer review of open investigations (12). Several measures of investigative activity in homicide cases increased, and the homicide clearance rate improved by ten percentage points. Other jurisdictions that served as plausible no-treatment control groups did not exhibit a comparable increase in clearance rates. The reforms were limited to homicide investigations, but a subsequent study compared investigations of gun homicide cases relative to NFS cases. The authors found that the large gap in arrest rates (43% for gun murders vs. 19% for NFS cases) was primarily a result of sustained investigative effort in homicide cases made after the first two days (8). Given the similarity of gun homicide and NFS cases, it is reasonable to infer that clearance rates for NFS cases could be increased if they were investigated with the same priority as fatal shootings.

This research tests whether additional investigative effort can increase the likelihood that NFS cases will be cleared by an arrest. The paper also attempts to uncover the mechanisms through which case clearances can be most effectively improved.

Improving NFS Investigations in Denver, Colorado

In 2019, the Denver Police Department (DPD), faced with increasing rates of gun violence, launched a reform designed to increase arrest rates for NFS cases. At that time, investigations of most NFS cases were handled by district detectives who were also responsible for a large volume of other violent and property crime cases. DPD decided to centralize the investigation of NFS cases and assign them to a new and specialized unit, the Firearm Assault Shoot Team (FAST). This new unit was designed to investigate NFS cases with the same priority as DPD gave to homicide cases. Launched in 2020, FAST began with 5 detectives and, by 2023, was staffed with 11 detectives along with two supervisors. FAST detectives were selected based on their ability to work effectively with victims and community members. They received extra training, had priority access to the DPD crime lab and other resources, and maintained strong partnerships with outside agencies such as the U.S. Bureau of Alcohol, Tobacco, Firearms, and Explosives and the Denver District Attorney’s Office.

FAST detectives are trained to make strong connections with victims and witnesses. After NFS events are reported, the lead detective seeks to connect with the victim as soon as possible, typically at the hospital. The norms established for this unit stress that interactions with victims

and witnesses be conducted in a respectful and empathetic manner, striving to build a strong rapport with victims and their loved ones. To the extent that victims or witnesses are dishonest, FAST detectives educate them on the ramifications of this behavior, including holding their phones and vehicles for evidence searches and pursuing charges for attempting to influence a public official. Detectives may additionally leverage their ATF partnership for those suspected of active involvement with criminal activities by pursuing leads and resolving open warrants.

Study Design

In this study our primary outcome is whether the investigation resulted in at least one arrest. One alternative is whether the case is "cleared" by the investigation. The definition of clearance encompasses arrest, but also "exceptional means" where the detectives have a suspect but for some reason cannot arrest that person. Exceptional clearances are not included because they do not serve the purposes of justice and prevention. Arrest is a common end point for an evaluation of police activity, but we acknowledge that it is just an intermediate step on the way to the final court outcome of conviction and sentencing.

The study uses a quasi-experimental design to estimate the effects of the FAST Unit on NFS arrest rates between the pre-intervention period (2017-2019) and the intervention period (2020 – 2023). For these 7 years, we compare the trajectories of arrest rates for NFS to those for gun crimes without injuries (GC), gun homicides, and burglaries investigated by other DPD detectives. The purpose of the comparison groups is to account for other drivers of variation in clearances rates including departmental resources and leadership, investments in management or technology and external events such as the COVID-19 pandemic which occurred shortly after the rollout of FAST.

Importantly, FAST did not investigate all NFS cases during the intervention period (see SI Appendix, Table S1). Its purview excludes shooting cases connected to ongoing gang violence. These cases are assigned to the Special Operations Response Team (SORT), who investigated about 25% of NFS cases during the pre-intervention period and a little more than 18% of cases during the intervention period. District detectives and other units investigated 75% of NFS cases during the pre-intervention period and only 5% of NFS cases during the intervention period. The resources available to SORT and other investigative units were not affected by the creation of FAST. The direct impact of FAST is then on the investigation outcomes of 77% of NFS cases that were assigned to FAST detectives. In what follows, we estimate the effect of FAST on outcomes for all NFS cases (regardless of which unit investigated them) and then refine the estimate of the FAST impact by analyzing just the effect of the FAST "treatment" on those cases that were actually "treated" by the FAST unit.

We then report the results of an exploratory analysis of the mechanisms by which FAST increased arrest rates. FAST investigations were successful in collecting more evidence of various sorts, and we analyzed their relative importance in achieving a successful outcome.

Results

Fig. 1 presents annual arrest rates for NFS cases (N=1,117) and GC cases (N=7,629), respectively, between 2017 and 2023. Annual percentages of NFS cases that resulted in an arrest rose by 14.3 percentage points, from a mean of 25.9% during the pre-intervention period to a mean of 40.2% during the intervention period. In contrast, annual percentages of GC cases that resulted in an arrest decreased by 4.2 percentage points from a mean of 30.6% during the pre-intervention period to a mean of 26.4% during the intervention period. This simple comparison suggests that the annual mean NFS arrest rate rose by 18.5 percentage points from the pre-intervention to intervention period relative to GC case clearances.

Table 1 presents the main intent-to-treat (ITT) estimates from our differences-in-differences (DID) regressions, using both logistic regression (Model 1) and OLS regression (Model 2). Referring to the estimates from logistic regression, FAST led to an increase in the odds that an NFS case resulted in an arrest by a factor of 2.38 (p<.001; 95% CI = 1.658, 3.405).

The OLS estimates imply that FAST led to an 18.6 percentage point (p<.001; 95% CI = 0.113, 0.259) increase in the arrest rate for NFS cases during the intervention period relative to the GC control group. As shown in Table 1, impact estimates are very similar when we introduce controls for victim age, sex, and race, as well as number of victims, and indoor crime location. All models use robust standard errors clustered by police district and by year-quarter.

DPD units other than FAST investigated 176 (23%) of the NFS cases during the intervention period. Table 2 presents the results of our two stage least squares (2SLS) regressions that estimate the treatment effect on the treated (TOT). Reflecting the fact that FAST investigated a substantial majority of NFS cases in the post-period, there is a strong first-stage relationship between intervention exposure (i.e., NFS case during the intervention period) and FAST investigation (F = 2,892, p < .001). The TOT estimates point to an 18.5 percentage point increase (p < .001; 95% CI = 0.144, 0.228) in the likelihood of arrest for cases assigned to FAST because of the intervention. Similar results were found in a variety of alternative specifications: the inclusion of district and year-quarter fixed effects (Coef. = 0.180, p < .001, 95% CI = 0.136, 0.223); RSEs clustered by district*year-quarter (Coef. = 0.163, p < .001, 95% CI = 0.115, 0.211); and the inclusion of day of week and time of day controls (Coef. = 0.205, p < .001, 95% CI = 0.166, 0.244) (see SI Appendix, Table S2).

As an additional robustness check, propensity score matching was used to identify pre-intervention NFS cases with characteristics similar to cases later assigned to FAST during the intervention period. The average treatment effect on the treated (ATT) was first estimated using nearest neighbor one-to-one matching with replacement and caliper = 0.10 with robust standard errors (see SI Appendix, Table S3). Results after matching indicated that FAST-investigated case arrest rates were approximately 16.5 percentage points higher than comparable pre-intervention cases (ATT=0.165, p < 0.001, 95% CI =0.099, 0.231).

Further sensitivity analyses examined the ATT estimated via alternative propensity score matching specifications (see SI Appendix, Table S4). Estimated treatment effects were consistent across approaches with ATTs ranging from 0.141 to 0.189 (all p < 0.05). Across all propensity score model specifications, FAST-investigated cases exhibited higher arrest rates than matched pre-intervention cases. These analyses suggest that the findings were not driven by the selection of a particular propensity score matching procedure. Similarly, results from the doubly robust (DR) estimate from a logistic regression suggest that the FAST treatment was associated with a 68% increase (p<.05; 95% CI = 1.113, 2.541) in the odds that an NFS case resulted in an arrest during the intervention period relative to the odds that a similarly situated NFS was cleared by arrest during the pre-intervention period (see SI Appendix, Table S5). Results from the DR estimate from an OLS regression suggest FAST-investigated NFS case arrest rates were approximately 16 percentage points higher than arrest rates for comparable pre-intervention NFS cases (p < 0.05, 95% CI =0.084, 0.235) (see SI Appendix, Table S5).

The results of placebo outcome tests comparing NFS arrests to clearances for burglary cases unlikely to be connected to gun violence support a unique effect of FAST (see SI Appendix, Fig. S1). During the pre-intervention period, DPD cleared 56.7% of gun homicide cases and 18.3% of burglary cases. During the FAST intervention period, these arrest rates shifted only slightly, with DPD clearing 59.7% of gun homicide cases and 15.3% of burglary cases. For both gun homicide cases (OR = 1.182, p = 0.442) and burglaries (Coef. = -0.009, p = 0.588), DID estimators suggest there was no significant change in arrest rates relative to GC cases between the pre-intervention and intervention periods (see SI Appendix, Table S6). When gun homicides are used as a comparison group, the FAST treatment was associated with significant increases in the odds that an NFS case resulted in an arrest during the intervention period relative to the pre-intervention period (see SI Appendix, Table S7).

In general, NFS case files contained evidence of more investigative activities relative to GC case files during the pre-intervention and intervention periods (see SI Appendix, Table S8 and S9). Some of these differences are likely due to the more serious nature of NFS cases – at least one victim in each case was shot. NFS cases were much less likely to have cooperative victims (37%) when compared to GC cases (72%) during the pre-intervention period. The victim cooperation gap is likely due to differences in how these cases come to the attention of the DPD. NFS cases are more likely than GC cases to originate with calls by third parties (medical

personnel, onlookers, associates of the victim) rather than the victim. In contrast, GC cases (such as a gun robbery or threat with a firearm) likely only become known if the victim reports the crime to the police – which suggests an inclination to cooperate with the police.

Table 3 presents investigative activities reported in DPD database systems for the NFS cases during the pre-intervention and FAST intervention periods. When these periods are compared, FAST detectives were substantially more likely to respond to the scene, Crime Scene Unit responses increased, and investigators executed more residential, vehicle, and cell phone search warrants. Victim cooperation also increased markedly, from 37% before FAST to 57% afterward.

An important question is whether the increase in investigative activities associated with FAST can fully account for the increase in the arrest rate. Table 4 incorporates the full set of investigative measures, including scene-response resource indices and detective activities, in a logistic regression analysis. (The principal components analysis is presented in SI Appendix, Section 3). Once these investigative inputs are included, the FAST indicator is statistically negligible, suggesting that improvements in clearance rates can be accounted for by measured changes in investigative practice associated with FAST. Victim cooperation remains a key predictor, increasing the odds of arrest by approximately a factor of 3.8 (p<.001; 95% CI = 2.683, 5.506).

Greater scene-response resources, more post-scene interviews, and residential and vehicle search warrants are each associated with higher arrest probabilities, whereas forensic evidence collection measures are not. Studies are mixed on the statistical association between forensic analysis of physical evidence collected at the initial crime scene and clearance rates (13, 14, 15). It should be noted that much forensic testing is less for the purposes of identifying a suspect than for making a case against a suspect that would hold up in court. For instance, the arrest of an offender caught at the scene and cooperative eyewitnesses will still involve forensic testing. The gun will be matched to the cartridge casings and bullets, the offender and the gun will be fingerprinted, and often the offender will be tested for gunshot residue.

Discussion

The 2020 creation of FAST enhanced the quantity and quality of investigation resources dedicated to NFS and is responsible for a sharp increase in the percentage of NFS cases that resulted in arrest. Our quasi-experimental analyses suggest that NFS arrest rates increased by roughly 19 percentage points, representing a 73% increase over the pre-intervention NFS arrest rate of 26%. Our results were not generated by a randomized experimental design, so some caution should be exercised in drawing strong conclusions. Nonetheless, the fact that FAST caused an abrupt change in investigation practice, and the robustness of our estimates to multiple model specifications, suggests a causal relationship between FAST implementation and increased arrest clearances of NFS cases.

Using GC as a control was intended to provide an indication of the hypothetical trajectory of NFS arrest rates in the absence of FAST, if these cases had continued to be investigated with the usual priority. In particular, the trajectory of the GC arrest rate reflects the effects of the surge in the volume of cases and various impacts on policing associated with the COVID pandemic and the nationwide “defund the police” movement triggered by the police killing of George Floyd in Minneapolis (May 25, 2020). Like most other cities, the volume of Denver gun violence increased sharply following onset of the COVID pandemic in March 2020. The annual GC count was 49% higher in the post-FAST period (2020-2023) than the “pre” period (2017-19), and the corresponding increase for NFS cases was even larger at 68%. Normally this increase in caseload would cause a decline in the arrest rate. And, in fact, the GC arrest rate did decline (by 4 percentage points). In this context of surging gun violence, it is noteworthy that the arrest rate for NFS increased under FAST.

After the creation of the FAST unit, NFS crime-scene investigations were much more likely to include detectives and the Crime Scene Unit. There was a greater likelihood of obtaining warrants for searching residence, vehicle, or phone. Perhaps most important, the likelihood that the victim was cooperative increased from 37% to 57%. Obtaining cooperation is a high priority in

FAST investigations -- beginning with a concerted effort by lead detectives to interview victims soon after the shooting, and to "convert" victims who initially refuse to cooperate. The increase in cooperation is notable given longstanding challenges in police–community relations, particularly in neighborhoods disproportionately affected by gun violence. When victims are unwilling to cooperate, identifying suspects becomes substantially more difficult, and successful prosecution may be unlikely even when an arrest is made.

Taken together, these findings suggest that the FAST model of investigating NFS cases offers an effective approach to improving arrest rates. The potential societal benefits are considerable. Cycles of urban gun violence are disrupted. Violent offenders who would otherwise continue to shoot at their rivals are more likely to be behind bars. Some who are at risk of criminal misuse of their guns will be deterred. The need for extra-legal retribution will be diminished as justice is provided for more victims and their loved ones. Finally, community trust in the police may improve as more victims are engaged in a respectful manner and investigators demonstrate that they are dedicated to holding culpable offenders accountable in all neighborhoods.

A remaining question concerns the cost of the FAST unit and whether the approach is cost-effective, scalable and potentially transferrable to other cities operating under binding resource constraints (SI Appendix, Section S4). Budget data as well as insider accounts reveal that FAST was created primarily through the reallocation of existing DPD personnel and resources rather than new spending. Although the data do not permit a precise accounting, personnel assignments (16), overtime (17), vehicles (18), and other resources (19) imply annual operating costs of approximately $3.7 million, or about 1.4% of DPD's budget (20, 21), amounting to $5 per Denver resident (22). FAST increased the nonfatal shooting arrest rate by approximately 19 percentage points, corresponding to 36 additional clearances per year during the intervention period. Taking the estimated value of resources consumed by FAST as given, the implied cost is approximately $103,000 per additional clearance. Using an estimated social cost of $8 million per homicide (23), FAST would break even if just one in every 78 additional arrests ultimately prevented a homicide. Using the value of a statistical life used by the federal government of $13.6 million (24), the FAST unit would be cost-beneficial if just one in every 132 additional arrests prevented a homicide.

Methods

Data

The University of Pennsylvania institutional review board approved our data collection methods that ensured confidentiality of human subjects in this study (IRB# 853505). Our unit of analysis for both treatment and control is the case, and the outcome measure is clearance by arrest. Case characteristics and investigation information for each NFS and GC case between 2017 and 2023 was accessed through the DPD's Records Management System (RMS) and coded (see SI Appendix, Section S1). The final sample consisted of 1,117 NFS cases (344 cases from the 2017-2019 pre-intervention period and 773 cases from 2020-2023 FAST intervention period) and 7,629 GC cases (2,547 GC cases from 2017-2019 and 5,082 GC cases from 2020-2023).

A comparison of the basic characteristics of NFS cases and GC cases between 2017 and 2023 suggests some notable differences (SI Appendix, Table S12). GC cases are more likely to involve multiple victims, occur indoors, and have at least one victim who is female or white. GCs are also more likely to involve robbery motives. These differences may reflect both the underlying reality of how guns are used in crime and patterns in the likelihood that the police are notified of gun crime. Gun assaults that are limited to a threat are less likely to become known to the police than if the victim is shot, but if the threat is part of a robbery, it is more likely to be reported than if it arises from an argument. Despite these differences, GC cases remain a reasonable comparison group for NFS cases given the fact that they both involve the criminal use of a firearm and have similar arrest-rate trajectories during the pre-intervention period.

Models

The impact of the FAST unit on arrest outcomes was estimated using a standard non-staggered DID estimator (25) that evaluated the monthly difference in NFS case-investigations outcomes during the four-year intervention period compared to during the three-year pre-intervention period, relative to the same difference for GC case-investigation outcomes. Arrest trends for NFS cases and GC cases were close to parallel during the pre-intervention period (SI Appendix, Section S2) (26). The general equation for our regression models is given by the following equation:

$$Y_{it} = \beta_0 + \beta_1 NFS_i + \beta_2 POST_t + \beta_3 (NFS_i \times POST) + u_i$$

In this model, Y_{it} represents our outcome measure for case *i* during a specific month, *t*. The regressor, *NFS,* is a binary variable identifying whether the case is an NFS or not. The reference group are GC cases. *POST* is a dummy variable for whether the nonfatal shooting occurred in a month (*t*) during the post-intervention period. Our primary interest is in coefficient, β_3, which represents the DID estimate of the product of the *NFS* indicator and the intervention period. β_3 reveals the extent to which case clearance rates changed more for NFS cases than other types of gun cases after the establishment of the FAST Unit. Robust standard errors were clustered by beat and, in a robustness check, also by district-quarter.

Given the possibility for imbalances in the circumstances of NFS cases versus GC cases, the regressions were estimated conditioning on covariates that capture the key characteristics of each incident (e.g., victim characteristics, motives, outdoor v. indoor locations). It is also important to recognize that case investigations were nested within larger DPD districts. We analyzed this nested data structure through the inclusion of district fixed effects. Fixed effects were also used to adjust for year and quarter differences. We report outcomes using both logistic regression and ordinary least squares when outcome variables involved binary conditions (e.g., was the NFS case cleared through arrest? 0 = No, 1 = Yes).

The robustness of these findings was further assessed by using several alternative model specifications. While the primary results are ITT effects which compare post- and pre-period outcomes, we take account of the fact that FAST did not investigate every NFS in the post period. Accordingly, we use 2SLS instrumental variables regression to estimate the treatment-on-the-treated (TOT) effect of FAST. In the 2SLS estimate, treatment assignment (whether a case was a nonfatal shooting in the post-FAST period) was used an instrument for treatment received (whether a case was, in fact, investigated by the FAST unit) (27). Wild cluster bootstrapped standard errors were applied with Webb weights (1,000 repetitions) (28). Next, a series of propensity score models (29) were estimated to identify pre-intervention NFS cases with characteristics similar to cases later assigned to FAST during the intervention period. Propensity scores were estimated using exogenous characteristics associated with FAST assignment: indoor incident, juvenile victim, nonwhite victim, female victim, victim count, and district. ATT estimates were then calculated to measure the effect of the FAST intervention on cases exposed to the treatment relative to similar cases that were not exposed.

Another approach for assessing the existence of FAST treatment effects on NFS clearances involves the development of internal benchmarks that contrast “similarly situated” pre-intervention NFS cases with intervention NFS cases using entropy weighting (30) with doubly robust (DR) estimation techniques (31). We combine the entropy weighting procedure with a regression model that includes the set of covariates so that estimates are DR, meaning that if either the estimates from a regression model or those from the entropy balancing weights are correct, we will have an unbiased estimate of the effects of FAST treatment on NFS cases (32, 33). Finally, to further address the possibility of additional threats to internal validity, we estimated two placebo outcome tests to assess whether any observed effects could have arisen because of general improvements to the DPD investigative process (34, 35). Gun homicide arrest clearance rates and burglary arrest clearance rates in Denver should not be influenced to a large degree by the creation of the FAST unit. As such, we estimated DID regression models like those used to assess the effects of the treatment on NFS case clearances.

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Figures and Tables

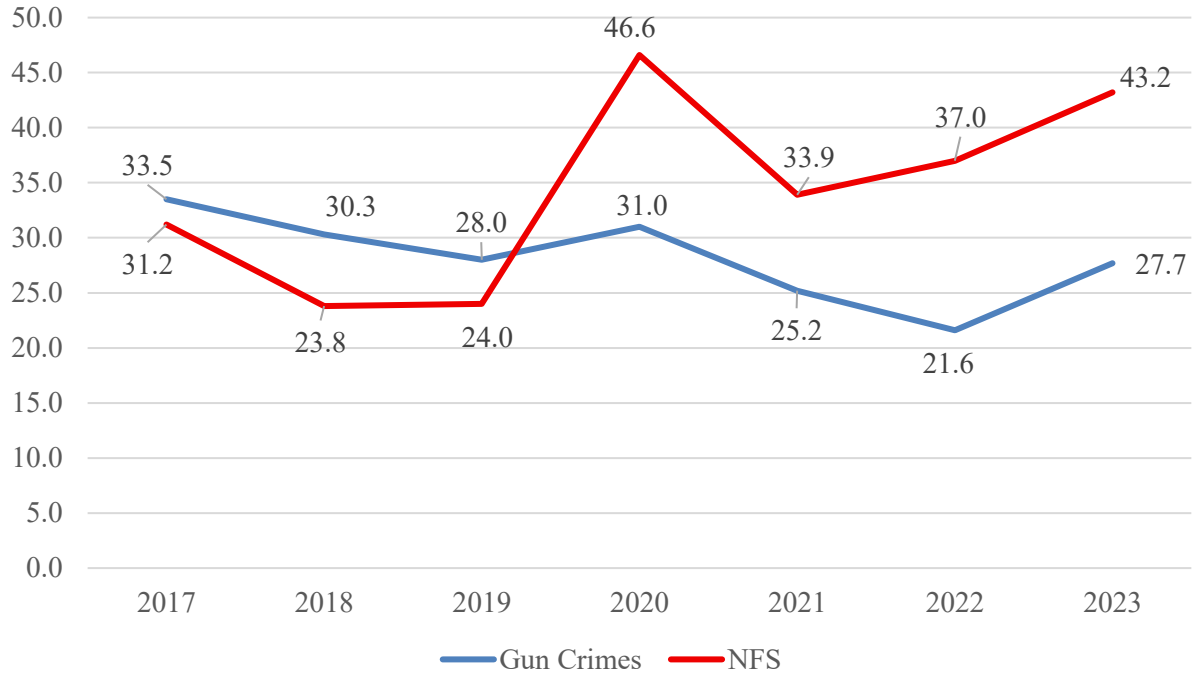


Figure 1. Annual Arrest Rates for NFS and GC Cases

Table 1. Estimated Impact of FAST on the Arrest Rate, Logistic and OLS Regressions with DID Estimators, Using GC Cases as a Control, All NFS and GC Cases, 2017 – 2023

	Baseline		**Controls & Fixed Effects**		**Alternative RSE Clustering**	
	Model 1 – Logit	**Model 2 – OLS**	**Model 1 – Logit**	**Model 2 – OLS**	**Model 1 – Logit**	**Model 2 – OLS**
Nonfatal Shooting (NFS)	.797 (.135)	-.046 (.032)	1.008 (.184)	-.000 (.034)	.994 (.145)	-.003 (.028)
Treatment Period	.802** (.048)	-.044** (.013)	—	—	.787** (.051)	-.047** (.013)
NFS x Treatment Period (ITT)	2.376** (.436)	.186** (.036)	2.367** (.437)	.179** (.035)	2.371** (.395)	.181** (.033)
Youngest Victim <18	—	—	1.045 (.081)	.008 (.015)	1.028 (.083)	.006 (.016)
≥1 Female Victim	—	—	1.309** (.059)	.052** (.009)	1.305** (.069)	.052** (.011)
≥1 Nonwhite Victim	—	—	1.105 (.058)	.019 (.010)	1.111* (.055)	.020* (.010)
2+ Victims	—	—	1.024 (.098)	.004 (.019)	1.033 (.073)	.006 (.014)
Indoor Shooting	—	—	2.463** (.146)	.192** (.014)	2.445** (.149)	.192** (.014)
Constant	.442** (.025)	.306** (.012)	.248** (.035)	.198** (.029)	.284** (.018)	.221** (.012)
N	8,693	8,693	8,686	8,686	8,705	8,705
District Fixed Effects	No	No	Yes	Yes	No	No
Year x Quarter Fixed Effects	No	No	Yes	Yes	No	No
Clustered SEs	Beat	Beat	Beat	Beat	District × Year-Quarter	District × Year-Quarter
Log Likelihood	-5177.05	—	-4976.41	—	-5023.76	—
Pseudo R^2	0.007	—	0.044	—	0.036	—
R^2	—	0.008	—	0.054	—	0.045
Root MSE	—	0.451	—	0.441	—	0.442
Wald x^2 / F	92	28.50	—	—	360.62	45.10
p	.000	.000	—	—	.000	.000

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

Notes: Robust standard errors (RSEs) are reported in parentheses. Reference categories are GC cases (NFS = 0) and pre-intervention period (2017–2019; Treatment Period = 0). The Treatment Period covariate was not included in the models with year × quarter fixed effects that absorbed the overall post-period effect. Overall Wald χ^2 and F statistics were not available for the fixed-effects specification due to the large number of fixed effects included in these models.

Table 2. Estimated Impact of FAST on Arrest Rate, Treatment on the Treated (TOT) Estimated by Instrumental Variables Two Stage Least Squares (2SLS) Regression with Bootstrapped SEs, Using GC Cases as a Control, All NFS and GC Cases, 2017 – 2023

	Stage 1		Stage 2	
	Coef. (SE)	**95% CI**	**Coef.**	**95% CI**
NFS x Treatment Period (ITT)	.773 (.018)	[0.736, 0.809]		
Case Investigated by FAST			.185 (.021)	[0.144, 0.228]
	F (34,40)	2891.67	Wald x^2 (34)	14912.43
	p	.000	*p*	.000
	R^2	.757	R^2	.018
	Root MSE	.125	Root MSE	.448

Note: To estimate the TOT, we used a method known as the "contamination adjusted intention to treat" (CA ITT) that uses two-stage least squares instrumental variables (IV) regression analysis to adjust for the bias created by contamination. In this analysis, the quasi-experiment is treated as an IV, with treatment assignment as the "instrument." The effect of FAST treatment assignment on outcome observed (intention to treat analysis) is adjusted by the percentage of assigned cases that ultimately receive the FAST treatment. Stage 2 bootstrap $p < .001$. The *p*-values and 95% CIs for Stage 2 are from a wild cluster bootstrap using Webb weights. The conventional beat-clustered SE is shown in parentheses.

N = 8,686

Table 3. Investigative Variables by Pre-Intervention and Intervention Periods: All NFS Cases, 2017 -2023

Category/Variable	Pre-Intervention (n=344)		Post-Intervention (n=773)		
	Mean	Median	Mean	Median	Cohen's |*d*|
# of Responding Officers	9.32	9	10.30	9	0.17
# of Detectives Responding to Scene	0.65	0	1.46	1	0.83
Detective Responded to the Scene (Y/N)	0.46	0	0.85	1	0.94
# of CSU Personnel Responding to Scene	1.34	1	1.92	2	0.46
Crime Scene Unit Responded to Scene (Y/N)	0.68	1	0.81	1	0.30
Victim Cooperative (Y/N)[1]	0.37	0	0.57	1	0.41
# of Ear Witnesses	2.63	1	2.14	1	0.17
# of Eyewitnesses	2.16	2	2.12	1	0.02
# of Scene Interviews	4.75	4	4.61	4	0.03
# of Post-Scene Interviews	1.70	1	1.26	1	0.23
# Videos Collected	0.74	0	1.72	1	0.11
# of Casings	4.05	1	6.45	2	0.24
Casings Collected (Y/N)	0.63	1	0.77	1	0.32
# GSR Tests Performed[2]	0.48	0	0.47	0	0.00
# Prints Collected[2]	0.48	0	1.08	0	0.17
# DNA Collected[2]	0.49	0	0.73	0	0.06
# Residential Search Warrants	0.08	0	0.25	0	0.38
# Vehicle Search Warrants	0.11	0	0.34	0	0.45
# Social Media Warrants	0.05	0	0.14	0	0.20
# Cell Phone Warrants	0.13	0	0.34	0	0.35

Notes: Meaningful differences between pre-intervention and post-intervention groups would be noted by Cohen's *d* standardized mean differences in excess of |.20|.

[1]Generated from existing victim cooperation variables and represents victims who 1) were cooperative during the initial investigation, 2) were cooperative during the follow-up investigation, 3) provided consistent statements, and 4) did not explicitly refuse to press charges.

[2]Collected GSR, prints, and DNA may not have been submitted for analysis. Dataset also includes number submitted.

N=1,117

Table 4. Estimated Impact of FAST on Arrest, Logistic Regression, Using Pre-Intervention NFS Cases as a Control, Investigative Activity and Caseload Variables Included, Robust SEs Clustered by Beat, All NFS Cases, 2017 – 2023

	OR (RSE)	***z***	***p***	**95% *CI***
Treatment Period (Post)	1.183 (0.326)	0.61	.541	[0.689, 2.031]
Scene Response				
Resources (Factor)	1.381 (0.139)	3.21	.001	[1.134, 1.682]
Engagement (Factor)	0.955 (0.083)	-0.52	.601	[0.805, 1.133]
Evidence Processing & Forensics				
DNA Tests Submitted	1.285 (0.288)	1.12	.263	[0.828, 1.993]
Latent Prints Submitted	0.803 (0.186)	-0.95	.343	[0.509, 1.265]
Videos Collected	1.530 (0.306)	2.13	.033	[1.034, 2.263]
Follow-Up Actions				
Post-Scene Interviews	2.000 (0.307)	4.51	.000	[1.480, 2.703]
Search Warrants: Residence	5.784 (1.247)	8.14	.000	[3.790, 8.826]
Search Warrants: Vehicle	2.472 (0.503)	4.45	.000	[1.659, 3.685]
Search Warrants: Social Media	1.168 (0.388)	0.47	.641	[0.609, 2.238]
Search Warrants: CDR/Phone	1.775 (0.395)	2.58	.010	[1.148, 2.745]
Victim Cooperation	3.843 (0.705)	7.34	.000	[2.683, 5.506]
Shootings in Past 3 Mos.	0.979 (0.007)	-3.10	.002	[0.966, 0.992]
Control Variables	1.680 (0.397)	2.20	.028	[1.058, 2.669]
Youngest Victim <18	1.109 (0.202)	0.57	.570	[0.776, 1.583]
≥1 Female Victim	1.043 (0.204)	0.22	.828	[0.711, 1.531]
≥1 Nonwhite Victim	0.991 (0.246)	-0.04	.972	[0.610, 1.611]
2+ Victims	2.482 (0.711)	3.17	.002	[1.416, 4.353]
Indoor Shooting				
	0.102 (0.040)	-5.82	.000	[0.047, 0.219]
Constant	1.183 (0.326)	0.61	.541	[0.689, 2.031]

Notes: District fixed effects included but not shown. Evidence processing and follow-up action measures are binary indicators (1 = action occurred). Model controls for the number of shootings occurring within the prior three months. District 7 was omitted because it perfectly predicted clearance outcomes.

Wald $X^2(23) = 604.12$
Prob > X^2 = .000
Pseudo R^2 = .278
LL = -499.49

N = 1,050

SUPPLEMENTAL INFORMATION

Police Can Improve Arrest Rates for Shootings: A Quasi-Experimental Evaluation of the Denver FAST Unit

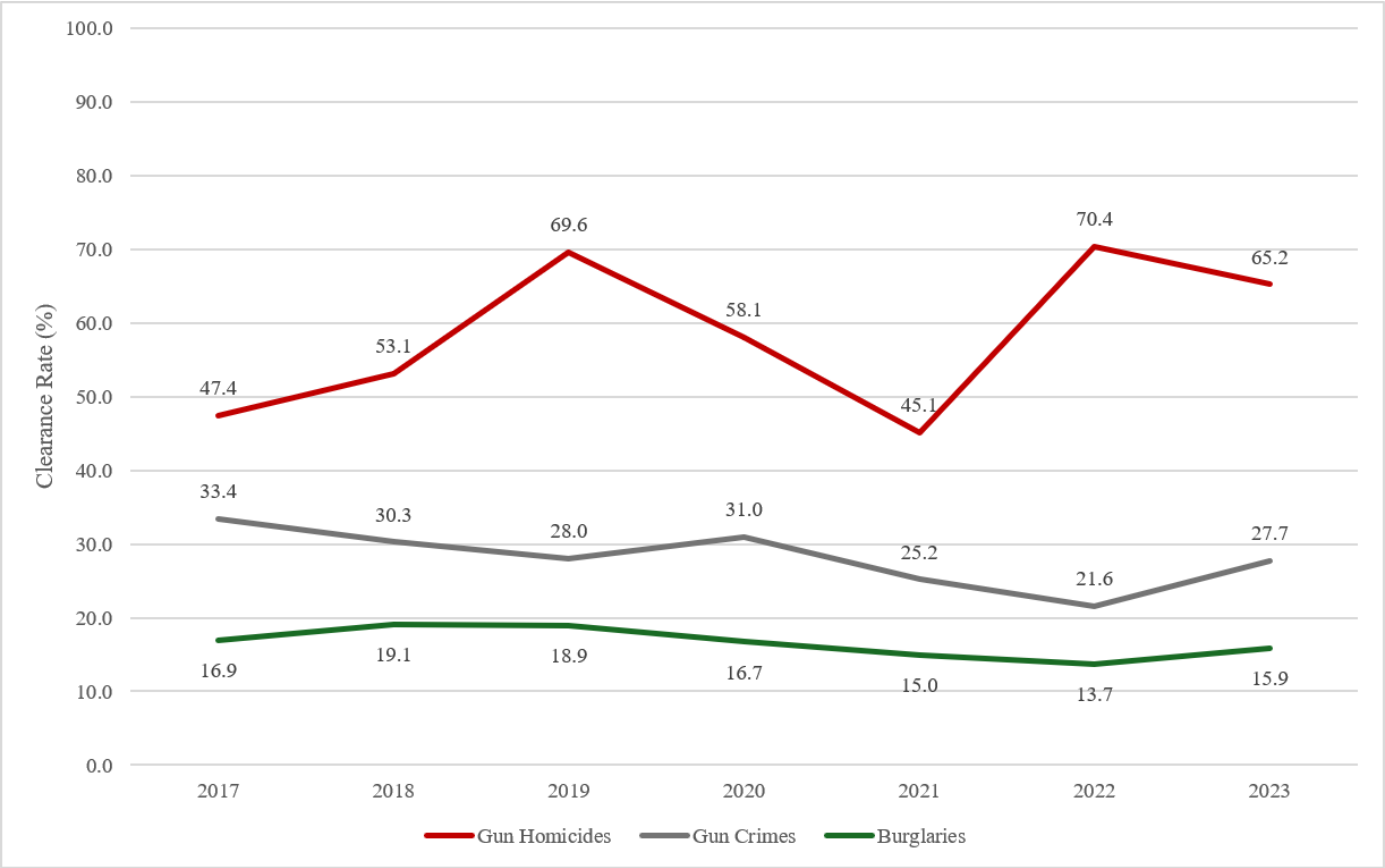


Fig. S1. Annual Arrest Rates for Gun Homicides, Burglaries, and GC Cases

Note: Between 2017 and 2023, DPD reported 433-gun homicides and 244-gun homicide involved an arrest, a 56.4% arrest rate during the study period. DPD likewise reported 34,185 burglaries and 5,620 burglary arrests between 2017 and 2023 (an overall 16.4% arrest rate during the study period).

Table S1. DPD Units Investigating NFS Case by Study Period

	Pre-Intervention Period		Intervention Period	
Investigating Unit	**Number**	**Percent**	**Number**	**Percent**
FAST	0	0.0%	597	77.2%
SORT	87	25.3%	142	18.4%
District 1 Investigations	43	12.5%	4	0.5%
District 2 Investigations	43	12.5%	1	0.1%
District 3 Investigations	26	7.6%	4	0.5%
District 4 Investigations	54	15.7%	2	0.3%
District 5 Investigations	27	7.8%	2	0.3%
District 6 Investigations	54	15.7%	5	0.6%
Homicide	3	0.9%	5	0.6%
Patrol	2	0.6%	0	0.0%
Unknown	5	1.5%	11	1.4%
	344	100.0%	773	100.0%

Table S2. Robustness Checks for 2SLS Regression of the Treatment on the Treated (TOT) Estimates of FAST Impact on Arrest

	Stage 1 Specification	**Stage 2A: District x Year x Quarter FE**	**Stage 2B: District-Year-Quarter Clustered SEs**	**Stage 2C: Day & Time Controls with District FE and Year x Quarter FE**
Case Investigated by FAST Coef. (SE)	.185 (.021)	.180 (.022)	.163 (.025)	.205 (.020)
95% CI	[0.144, 0.228]	[0.136, 0.223]	[0.115, 0.211]	[0.166, 0.244]
Wald x^2	14,912.4	5,588.3	44.1	356,406.1
p	.000	.000	.000	.000
R^2	.018	.042	.006	.027
Root MSE	.448	.443	.451	.446
N	8,686	8,686	8,705	8,676

Notes: The first stage specification includes district fixed effects (FE) and year-quarter FE with SEs clustered by beat. The first second-stage specification replaces these fixed effects with district x year x quarter FE. The second second-stage specification includes no fixed effects and clusters SEs by district x year-quarter. The third second-stage specification includes district FE and year-quarter FE while additionally controlling for incident day of week and time of day. Standard errors are reported in parentheses. The main specification reports the wild cluster bootstrap CI using Webb weights. Robustness check specifications report conventional confidence intervals.

Table S3. Estimated Impact of FAST on the Arrest Rate, Average Treatment Effects on the Treated (ATT) Using Nearest Neighbor Propensity Score Model, Robust SEs, All NFS Cases, 2017 – 2023

Variable	Coef. (RSE)	*z*	*p*	95% CI
Treatment Period	.165 (.034)	4.89	.000	[.099, .231]
Covariate Balance	*Raw*	*Matched*		
Std. Difference	.325	-.000		
Variance Ratio	.984	1.007		

Statistic	Unmatched	Matched
Pseudo R^2	.025	.002
LR Chi-square	30.59	3.45
LR Test p-value	.001	.969
Mean Bias (%)	12.1	3.0
Median Bias (%)	12.5	2.5
Rubin's B	38.0	10.8
Rubin's R	1.08	1.22

Note: Matching used 593 FAST-Investigated cases during the intervention period and 338 eligible pre-intervention cases which were matched using 1:1 nearest neighbor PSM with replacement, caliper = 0.10. Robust standard errors were used.

Table S4. Estimated Impact of FAST on the Arrest Rate: Using Propensity Score Matching Sensitivity Analysis

Specification	ATT (RSE)	95% CI
Nearest neighbor, 1:1, caliper = .10	.165 (.034)*	[.099, .231]
Nearest neighbor, 1:1, caliper = .05	.189 (.087)*	[.018, .360]
Nearest neighbor, 3 neighbors, caliper = .10	.141 (.051)*	[.041, .241]
Radius matching, caliper = .10	.160 (.031)*	[.103, .217]
Radius matching, caliper =.05	.154 (.031)*	[.095, .214]
Kernel matching, Epanechnikov, bandwidth = .06	.157 (.031)*	[.097, .216]

Note: For all propensity score matching models, robust standard errors were used. All NFS cases between 2017 and 2023 were considered for these analyses.

*p<.05

Table S5. Estimated Impact of FAST on the Arrest Rate, Average Treatment Effects on the Treated (ATT) Using Doubly Robust Estimation via Entropy Weighting, Robust SEs Clustered by Beat, All NFS Cases, 2017 – 2023

A. Covariate Balance Before and After Entropy Weighting

Variable	Treated	Raw Untreated	Weighted Untreated	Std. Mean Diff. Before	Std. Mean Diff. After
Indoor Shooting	0.1315	0.0769	0.1312	0.179	.001
2+ Victims	0.1180	0.1391	0.1184	-0.063	-.001
Youngest Victim <18	0.1096	0.1716	0.1109	-0.179	-.004
Nonwhite Victim	0.7538	0.8284	0.7546	-0.184	-.002
Female Victim	0.1922	0.1746	0.1920	0.046	.001

B. Entropy Weighting Regression Analysis:

	Model 1 - Logistic				Model 2 - OLS			
Variable	OR (RSE)	*z*	*p*	95% CI	Coef. (RSE)	*t*	*p*	95% CI
Treatment Period	2.14 (.405)	4.01	.000	[1.475, 3.100]	.160 (.037)	4.28	.000	[0.084, 0.235]
	Wald X^2			129.77	*F* (11,34)			18.11
	Prob > X^2			.000	Prob > *F*			.000
	Pseudo R^2			.059	R^2			.075
	LL			-714.689	Root MSE			.458

Notes**:** Entropy balancing weights were applied to pre-intervention comparison cases so that the weighted covariate distributions matched FAST-investigated cases. Standardized mean differences after weighting approached zero for all balanced covariates. Models 1 and 2 include but do not show results of the matching covariates. Model 1 reports odds ratios from a weighted logistic regression. Model 2 reports coefficients from a weighted linear regression. Robust standard errors are clustered by beat.

N = 931
Treated Cases = 593
Control Cases = 338
Weighted Control Total = 593

Table S6. Placebo Analyses of the Estimated Impact of FAST on Arrest Rates

A. Estimated Impact of FAST on the Arrest Rate, Logistic Regression with DID Estimators, Using GC Cases as a Control, Robust SEs Clustered by Beat, All GC and Gun Homicide Cases, 2017 – 2023 (N=8,042)				
	OR (RSE)	***z***	***p***	**95% CI**
Gun Homicide	3.044 (.549)	6.17	.000	[2.137, 4.346]
Treatment Period (Post)	0.807 (.043)	-3.99	.000	[0.726, 0.896]
Gun Homicide x Post	1.182 (.295)	0.77	.442	[0.876, 2.069]
Constant	0.437 (.019)	-19.19	.000	[0.403, 0.477]
LR X^2	178.35			
Prob > X^2	.000			
Pseudo R^2	.019			
LL	-4764.69			
B. Estimated Impact of FAST on the Monthly Arrest Rate, OLS Regression with DID Estimators, GC Cases as a Control, Robust SEs, Monthly GC and Burglary Arrest Rates, 2017 – 2023 (N=168)				
	Coef. (RSE)	***z***	***p***	**95% CI**
Burglary	-.118 (.011)	-10.38	.000	[-0.141, -0.096]
Treatment Period (Post)	-.030 (.007)	-4.56	.007	[-0.043, -0.017]
Burglary x Post	-.009 (.016)	-0.54	.588	[-0.040, 0.023]
Constant	.304 (.010)	29.26	.000	[0.283, 0.324]
F Statistic	78.43			
Prob > *F*	.000			
R-squared	.597			
Root MSE	.051			

Note: The DPD could not provide us with case-level arrest rate information for burglary incidents between 2017 and 2023; they could only provide us with aggregated monthly burglary arrest rates (measured as the ultimate arrest rate for cases occurring in a specific month). As such, for the comparison of burglary arrest rate trends with GC rate trends, DID regression of arrest rates on FAST treatment was estimated with monthly arrest rates as the units of analysis (N=168).

Table S7. Estimated Impact of FAST on the Arrest Rate, Logistic Regressions with DID Estimators, Using Gun Homicide Cases as a Control, All NFS and Gun Homicide Cases, 2017 - 2023

	Model 1 – Fixed Effects (Year x Quarter)	Model 2 – Fixed Effects (District & Year x Quarter)	Model 3 – Controls & Fixed Effects
	OR (RSE)	OR (RSE)	OR (RSE)
Nonfatal Shooting (NFS)	0.250** (.057)	0.248** (.057)	0.238** (.057)
NFS x Treatment Period (ITT)	1.729* (.475)	1.764* (.488)	1.750* (.488)
Youngest Victim <18	—	—	1.361 (.234)
≥1 Female Victim	—	—	1.428* (.217)
≥1 Nonwhite Victim	—	—	0.670** (.092)
2+ Victims	—	—	1.435* (.243)
Constant	1.453 (.548)	1.457 (.590)	1.765 (.737)
N	1,498	1,484	1,481
District FE	No	Yes	Yes
Year x Quarter FE	Yes	Yes	Yes
Log Likelihood	-952.244	-941.399	-927.487
Pseudo R^2	0.063	.066	.078
Wald x^2 / F	114.87**	117.45**	139.04**

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

Notes: Robust standard errors (RSEs) are reported in parentheses. Gun homicide case is the reference category for nonfatal shooting (NFS = 0). The Treatment Period covariate was not included in the models with year × quarter fixed effects that absorbed the overall post-period effect.

Table S8. Investigative Variables by Case Type, All NFS Cases and GC Cases, 2017-2019

Category/Variable	NFS Cases (n=344)		GC Cases (n=2,547)		
	Mean	Median	Mean	Median	Cohen's |*d*|
# of Responding Officers	9.32	9	2.91	2	2.16
# of Detectives Responding to Scene	0.65	0			
Detective Responded to the Scene (Y/N)	0.51	0	0.12	0	0.95
# of CSU Personnel Responding to Scene	1.34	1			
Crime Scene Unit Responded to Scene (Y/N)	0.68	1	0.28	0	0.89
Victim Cooperative (Y/N)[1]	0.37	0	0.72	1	0.78
# of Ear Witnesses	2.63	1	0.35	0	1.36
# of Eyewitnesses	2.16	2	0.68	0	0.98
# of Scene Interviews	4.75	4	1.10	0	1.48
# of Post-Scene Interviews	1.70	1	0.40	0	1.10
# Videos Collected	0.74	0	0.46	0	0.34
# of Casings	4.05	1			
Casings Collected (Y/N)	0.63	1			
# GSR Tests Performed[2]	0.30	0			
# Prints Collected[2]	0.37	0			
# DNA Collected[2]	0.22	0			
# Residential Search Warrants	0.08	0			
# Vehicle Search Warrants	0.11	0			
# Social Media Warrants	0.05	0			
# Cell Phone Warrants	0.13	0			

Notes: Meaningful differences between NFS and GC groups are signaled by Cohen's *d* standardized mean differences in excess of |.20|.

[1]Generated from existing victim cooperation variables and represents victims who 1) were cooperative during the initial investigation, 2) were cooperative during the follow-up investigation, 3) provided consistent statements, and 4) did not explicitly refuse to press charges.

[2]Collected GSR, prints, and DNA may not have been submitted for analysis. Dataset also includes number submitted.

N = 2,891

Table S9. Investigative Variables by Case Type, All NFS Cases and GC Cases, 2020-2023 (intervention period)

Category/Variable	NFS Cases (n=773)		GC Cases (n=5,082)		
	Mean	Median	Mean	Median	Cohen's |*d*|
# of Responding Officers	10.30	9	2.88	2	2.35
# of Detectives Responding to Scene	1.46	1			
Detective Responded to the Scene (Y/N)	0.87	1	0.06	0	2.75
# of CSU Personnel Responding to Scene	1.92	2			
Crime Scene Unit Responded to Scene (Y/N)	0.81	1	0.19	0	1.59
Victim Cooperative (Y/N)[1]	0.57	1	0.68	1	0.23
# of Ear Witnesses	2.14	1	0.27	0	1.48
# of Eyewitnesses	2.12	1	0.55	0	1.15
# of Scene Interviews	4.61	4	0.85	0	1.75
# of Post-Scene Interviews	1.26	1	0.33	0	0.95
# Videos Collected	1.72	1	0.58	0	0.29
# of Casings	6.45	2			
Casings Collected (Y/N)	0.77	1			
# GSR Tests Performed[2]	0.31	0			
# Prints Collected[2]	0.90	0			
# DNA Collected[2]	0.27	0			
# Residential Search Warrants	0.25	0			
# Vehicle Search Warrants	0.34	0			
# Social Media Warrants	0.14	0			
# Cell Phone Warrants	0.34	0			

Notes: Meaningful differences between NFS and GC groups are signaled by Cohen's *d* standardized mean differences in excess of |.20|.

[1]Generated from existing victim cooperation variables and represents victims who 1) were cooperative during the initial investigation, 2) were cooperative during the follow-up investigation, 3) provided consistent statements, and 4) did not explicitly refuse to press charges.

[2]Collected GSR, prints, and DNA may not have been submitted for analysis. Dataset also includes number submitted.

N = 5,855

Section S1. Evaluation Data

S1.1 NFS cases and clearance rates

The research team reviewed and coded all NFS cases occurring within Denver from 2017-2023. NFS cases involving accidental or self-inflicted gunshot wounds were not coded. NFS cases that involved BB guns, air guns, replicas, and other non-firearm weapons were likewise excluded as were law-enforcement involved shootings and gun homicide cases that included nonfatal GSW victims. After making these exclusions, there was an initial sample of 1,145 nonfatal injury shooting cases. The dataset was further refined by excluding 28 "unfounded" NFS cases (2.4% of 1,145). These cases typically involved hospital walk-in gunshot wound victims who provided little or no information. Responding officers were often unable to confirm whether the shooting occurred in Denver. As a result, these cases did not result in further investigative activity.

The final sample consisted of 1,117 NFS cases – 344 cases from the 2017-2019 pre-intervention period and 773 cases from 2020-2023 post-intervention period. As shown in Fig. S2A, the annual number of NFS cases increased after the onset of the COVID-19 pandemic in 2020, as was true in most US cities.

Beginning in 2020, the DPD FAST unit began to maintain a separate database to track the progress of all NFS investigations including those handled by other units. This database recorded whether an investigation resulted in the arrest of a suspected shooter. It also noted "exceptional clearances" and cases designated as "cleared by other arrest." Exceptional clearances generally included cases in which investigators identified a suspect, but an arrest was not made. Such clearances often occur because charges or an arrest warrant were declined by the Denver District Attorney's Office. "Cases cleared by other arrest" included arrests related to a NFS case of individuals who were not directly involved in the assault. For example, an individual arrested for obstructing the investigation of an NFS case would be included in this category. Prior to 2020, these additional clearance designations were not systematically recorded in the available DPD data. Clearances of pre-intervention NFS cases were limited to arrests of suspected shooters and others who were at the scene and directly involved in the assault.

Fig. S2B presents clearance outcomes for NFS cases and distinguishes between cases cleared through the arrest of a suspected shooter (or accomplice) and other DPD administrative clearance classifications. These additional classifications are displayed separately as "excluded clearances" in the figure. Consistent with the goal of our study, defining clearance as the arrest of a suspected shooter provides a consistent measure of investigative outcomes across the full study period. As such, our "clearance by arrest" measure will necessarily differ from clearance rates reported by the DPD. Annual percentages of NFS cases cleared by arrest rose from a mean of 25.9% during the pre-intervention period (2017-2019) to a mean of 40.2% during the intervention period (2020-2023).

Two researchers coded key aspects of each NFS investigation: the initial call-for-service, the management of the initial crime scene, the interviews of witnesses, the collection and forensic testing of physical evidence, and the decision to arrest suspects(s) or submit the case to the grand jury. Data on the circumstances of each NFS case and known victim-offender relationships were also collected and coded. "Cooperative" victims were defined as those who were initially cooperative with investigators at the crime scene and during follow-up interviews. Cooperative victims did not make conflicting statements and did not refuse to press charges against suspected shooters.

These two researchers were trained on how to navigate DPD databases and properly use data collection instruments developed for this project. While most cases were only coded by one or the other of the two researchers, both coded a random sample of 200 of the 1,117 NFS cases. For these cases, Cohen's kappa was used to assess coder reliability for categorical variables and Intraclass Correlation Coefficients (ICC) was used for continuous variables. Subsequent analysis revealed no significant differences in case attributes or reported investigative activities among the two coders. As shown in Table S9, all reliability coefficients exceeded 0.79 with 29 of 45 (64.4%) assessments exceeding 0.89. We conclude the two coders were consistent in their treatment of this complex material.

Table S10 presents the basic characteristics of NFS cases during the pre-intervention and intervention periods. Case characteristics were compared using Cohen's *d* standardized mean difference metrics. Most (86%) of NFS cases involve only one shooting victim, while in 14% of cases there were two or more shooting victims. (In some cases, there were other victims of the assault or robbery who were not shot.) Victims were predominantly male, Black or Hispanic, and age 18-44. Most victims only suffered

one gunshot wound and there were relatively few head injuries: in these respects, the NFS cases differ from gun homicides, since multiple wounds and head wounds have high case-fatality rates. Very few NFS cases occur indoors. Disputes represent the most common motive reported of NFS cases, and only 8% are identified as robberies. Importantly, there are only small differences in the distributions of NFS case characteristics when pre-intervention and intervention periods are compared.

S.1.2 GC cases and clearance rates

Investigation procedures for GC cases were not directly affected by the creation of FAST, and, as such, represent the counterfactual condition to the FAST intervention. These GCs included gun robberies, firearm menacing, and gun assault cases that did not result in injury to victims. After the research team reviewed these cases for the period 2017 and 2023, 440 GCs were excluded from the study. These exclusions included officer-involved incidents, cold reports of property damage from bullet strikes with an unknown date of occurrence, false reports, cases referred to federal law enforcement agencies, and non-firearm gun cases (such as BB, air, toy, and replica guns). The final comparison group included 7,629 GC cases (2,547 GC cases from 2017-2019 and 5,082 GC cases from 2020-2023).

Like NFS trends, the yearly number of GCs increased after the onset of the COVID-19 pandemic in 2020 (Fig. S2C). During the pre-intervention period (2017-2019), the yearly mean was 849. The yearly mean rose by almost 50% to about 1,271 during the intervention period (2020-2023). Annual percentages of GCs cleared by arrest decreased from a mean of 30.6% during the pre-intervention period (2017-2019) to a mean of 26.4% during the intervention period (2020-2023) (Fig. S2D). That reduction is plausibly the consequence of the increase in caseload for general-assignment detectives given the increase in GC incidents during this period.

Twelve researchers coded the basic attributes and a more limited set of investigative actions reported in GC cases. To assess inter-rater reliability, 583 cases (7.6% of 7,629) were randomly selected for double-coding, and the sample was constructed to reflect the distribution of coding responsibilities across researchers. More double-coding cases were assigned to coders who were responsible for larger portions of the dataset. We had originally intended to double-code N = 600 randomly selected cases. Unfortunately, 17 cases were not double-coded due to researcher turnover. Krippendorff's alpha was used for categorical and binary variables because it accommodates multiple coders and unequal coder participation across cases. Additionally, the ICC was used for continuous variables. Subsequent analysis revealed almost no significant differences in case attributes or reported investigative activities among the four coders. Victim gang affiliation, offender gang affiliation, and conflicting statements made by witnesses over the course of the investigation were not reliably coded (alpha <.75) and dropped from subsequent analysis. As shown in Table S11, all other reliability coefficients exceeded 0.79 with 14 of 26 (53.8%) assessments exceeding 0.89. Table S12 presents a comparison of the basic characteristics of NFS cases and GC cases between 2017 and 2023. As described in the main text and suggested by the Cohen's *d* statistics exceeding |.20|, there were some notable differences between these two categories of gun cases.

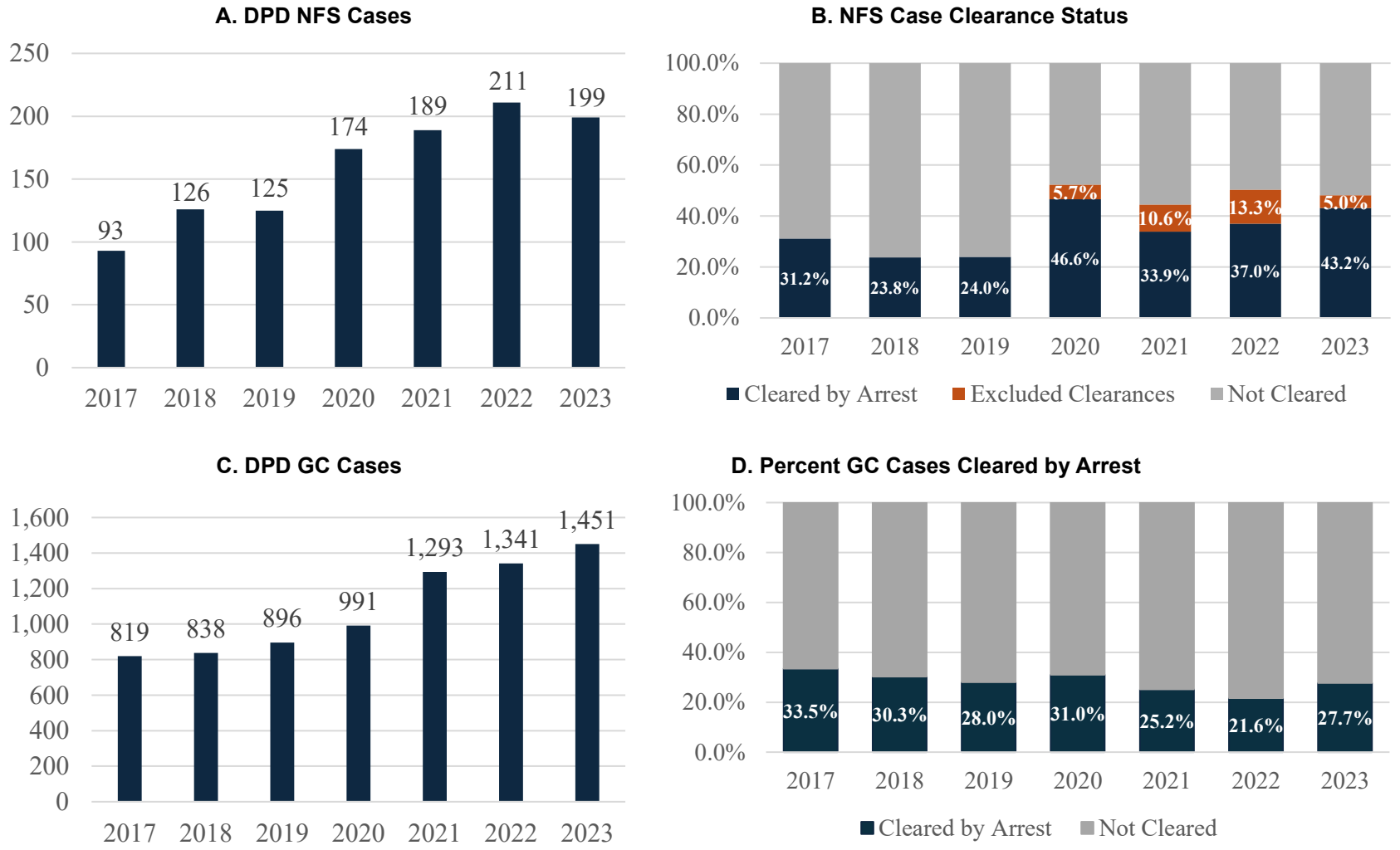


Fig. S2. Annual Cases and Clearance Outcomes

Table S10. Interrater Reliability Results, Randomly Selected NFS Cases

Variable	Type	% Agreement	Reliability (Kappa/ICC[1])	Mean Abs. Diff.
Victim Count	Continuous		0.97	0.02
Offender Count	Continuous		0.95	0.04
Num. Officers	Continuous		0.96	0.68
Num. Detectives	Continuous		0.87	0.17
Num. CSU	Continuous		0.88	0.17
Num. Casings	Continuous		0.99	0.13
GSR Collected	Continuous		0.83	0.09
Prints Collected	Continuous		0.96	0.20
DNA Collected	Continuous		0.81	0.21
Num. Evidence	Continuous		0.97	0.34
Num. NIBIN Lead	Continuous		0.98	0.14
Ear Witnesses	Continuous		0.98	0.14
Eyewitnesses	Continuous		0.98	0.10
Scene Interviews	Continuous		0.95	0.55
PS Interviews	Continuous		0.88	0.28
Video: Incident	Continuous		0.90	0.04
Video: Susp/Veh	Continuous		0.87	0.10
SW Residence	Continuous		0.91	0.03
SW Vehicle	Continuous		0.91	0.04
SW Social	Continuous		0.88	0.01
SW Cell	Continuous		0.79	0.10
Status	Categorical	100%	1.00	
Responding Unit	Categorical	89.5%	0.85	
Investigating Unit	Categorical	97.0%	0.95	
Incident Type	Categorical	84.5%	0.81	
Victim Gang	Binary	99.0%	0.96	
Multiple GSW	Binary	99.0%	0.97	
Head GSW	Binary	99.5%	0.97	
Offender Gang	Binary	98.5%	0.91	
Hosp. Walk In	Binary	97.0%	0.93	
Citizen Call	Binary	96.0%	0.85	
ShotSpotter	Binary	96.0%	0.90	
Scene Located	Binary	98.0%	0.94	
Indoor	Binary	98.5%	0.91	
Det. to Scene	Binary	95.5%	0.89	
CSU to Scene	Binary	98.0%	0.95	
Gun Recovered	Binary	97.0%	0.91	
Vic Coop: Initial	Binary	94.8%	0.89	
Vic Coop: Follow-Up	Binary	92.4%	0.85	
Vic Coop: Conflicting	Binary	94.2%	0.83	
Vic Coop: Refused Charges	Binary	100%	1.00	
Vic Coop: ID'd Suspect	Binary	99.5%	0.98	
Vic Coop: Recoded	Binary	96.0%	0.92	
Cleared by Arrest	**Binary**	**99.0%**	**0.98**	
Days to Arrest	**Continuous**		**0.99**	**1.7**

[1]ICC reported for continuous variables; Cohen's kappa reported for binary/categorical variables.
[2]Of cases cleared by arrest.

N = 200

Table S11. Characteristics by Period: All NFS Cases

Category/Variable	2017-2019 (n=344) Percent	2020-2023 (n=773) Percent	Cohen's |*d*|
Cleared by Arrest	25.9	40.0	.136
Victim Age			
Youngest victim <13	1.8	0.8	.044
Youngest victim 13-17	15.8	12.2	.049
Youngest victim 0 – 17	17.4	12.9	.059
Youngest victim 18 – 24	33.3	28.1	.052
Youngest victim 25 – 34	26.0	30.6	.047
Youngest victim 35 – 44	12.9	18.0	.064
Youngest victim 45 – 54	6.4	6.6	.003
Youngest victim 55 +	3.8	3.6	.004
Victim Sex			
At least one female victim	17.2	18.8	.019
Victim Race/Ethnicity			
At least one nonwhite victim	83.1	78.4	.055
At least one Black victim	40.7	38.8	.018
At least one Hispanic victim	43.3	40.5	.026
Number of Victims			
1 victim	86.3	85.6	.009
2+ victims	13.7	14.4	.009
Indoor	7.6	11.4	.058
Injury Severity			
At least one victim w/ multiple wounds	21.2	24.1	.031
At least one victim w/ head wound	11.0	13.8	.038
Incident Motive			
Dispute	51.7	51.6	.001
Robbery	7.6	8.8	.021
Unknown	29.4	34.4	.050

N = 1,117

Note: Meaningful differences between pre-intervention and intervention groups would be noted by Cohen's *d* standardized mean differences in excess of |.20|.

Table S12. Interrater Reliability Results, Randomly Selected GC Cases

Variable	Type	% Agreement	Reliability (Alpha/ICC[1])	Mean Abs. Diff.
Victim Count	Continuous		0.94	0.09
Offender Count	Continuous		0.84	0.16
Num. Officers	Continuous		0.97	0.25
Ear Witnesses	Continuous		0.93	0.08
Eyewitnesses	Continuous		0.88	0.21
Scene Interviews	Continuous		0.94	0.20
PS Interviews	Continuous		0.82	0.13
Status	Categorical	97.4%	0.98	
Investigating Unit	Categorical	82.0%	0.87	
Incident Type	Categorical	83.4%	0.83	
Victim Gang	Binary	96.6%	**0.64**	
Offender Gang	Binary	93.4%	**0.56**	
Shots Fired	Binary	98.6%	0.98	
Indoor	Binary	96.7%	0.94	
Det. to Scene	Binary	98.1%	0.90	
CSU to Scene	Binary	94.8%	0.91	
Video: Incident	Binary	94.1%	0.90	
Video: Susp/Veh	Binary	87.8%	0.81	
Vic Coop: Initial	Binary	98.8%	0.87	
Vic Coop: Follow-Up	Binary	87.9%	0.81	
Vic Coop: Conflicting	Binary	93.8%	**0.61**	
Vic Coop: Refused Charges	Binary	97.8%	0.92	
Vic Coop: ID'd Suspect	Binary	95.3%	0.92	
Vic Coop: Recoded	Binary	89.1%	0.83	
Cleared by Arrest	**Binary**	**96.7%**	**0.95**	
Days to Arrest	**Continuous**		**0.97**	**2.56**

N = 583

Table S13. Characteristics by Case Type (NFS and GC): 2017-2023

Category/Variable	NFS Cases (n=1,117)	GC Cases (n=7,629)	Cohen's |*d*|
	Percent	Percent	
Cleared by Arrest	35.6	27.8	.059
Victim Age			
Youngest victim <13	1.1	5.7	.070
Youngest victim 13-17	13.3	7.4	.071
Youngest victim 0 – 17	14.3	13.1	.012
Youngest victim 18 – 24	29.7	22.3	.059
Youngest victim 25 – 34	29.2	28.5	.005
Youngest victim 35 – 44	16.4	17.8	.012
Youngest victim 45 – 54	6.6	10.2	.041
Youngest victim 55 +	3.7	8.1	.056
Victim Sex			
At least one female victim	18.3	45.9	.187
Victim Race/Ethnicity			
At least one nonwhite victim	79.9	64.3	.110
At least one Black victim	39.4	23.8	.119
At least one Hispanic victim	41.4	39.7	.011
Number of Victims			
1 victim	85.9	67.5	.134
2+ victims	14.1	32.5	.134
Indoor	10.2	24.2	.112
Injury Severity			
At least one victim w/ multiple wounds	23.2	-	-
At least one victim w/ head wound	13.0	-	-
Incident Motive			
Dispute	51.7	38.8	.087
Robbery	8.4	38.9	.213
Unknown	32.9	21.0	.095

N = 8,746

Note: Meaningful differences between NFS and GC groups would be noted by Cohen's *d* standardized mean differences in excess of |.20|.

Section S2. Assessment of Parallel Trends During Pre-Intervention Period

Among the assumptions supporting DID estimator use, the most important issue is whether there were parallel trends in arrest clearance rates for violent gun events where victims suffer a nonfatal gunshot injury relative to violent gun events where victims were not physically injured (26). The parallel trends assumption, requiring that the groups are following similar trends over time absent the treatment of FAST, is critical to the internal validity of our DID model. To test the parallel trends assumption, we specify an event study specification and report 95% confidence intervals from a regression of clearance rates on the interaction between year dummy variables and treatment / comparison status to determine whether pre-intervention trends were significantly different from zero.

Table S13 presents the logistic regression coefficients, standard errors, test statistics, and significance levels for the year * treatment interactions. The table establishes that there were no significant differences in arrest clearance rate trends in the treatment and control groups during the pre-intervention period. A joint Wald test of the interaction between NFS and pre-intervention years was not statistically significant (X^2= 0.38, p =0.826) and suggests no discernable difference in trends in the pre-intervention period. Fig. S3A and Fig. S3B present visual representations of the yearly coefficients and their 95% confidence intervals, both annually and at the quarter level. Both figures present evidence that pre-trends were parallel leading up to the intervention.

Table S14. Estimated Impact of FAST on Arrest Rate, Logistic Regression Using GC Cases as Controls, Including Year x Treatment Interaction Terms, All NFS and GC Cases, 2017-2023

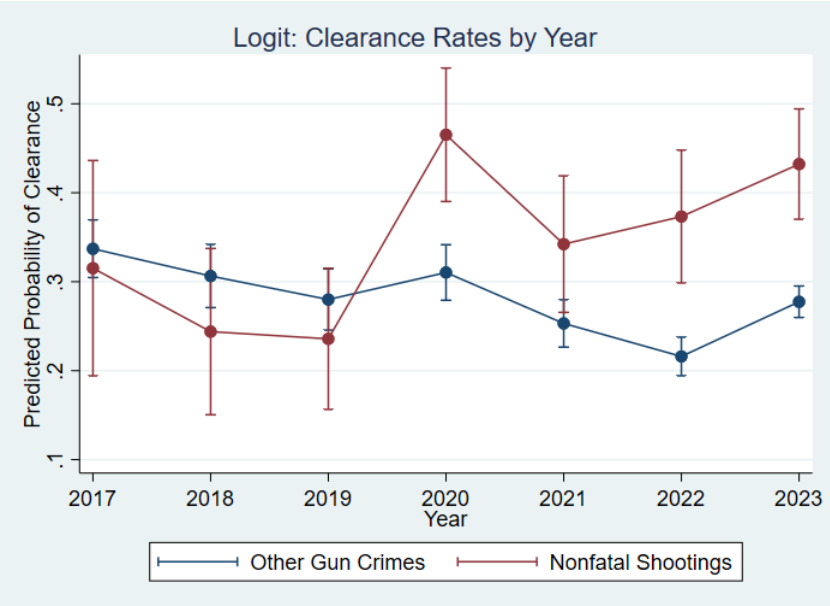
	OR (RSE)	*z*	*p*	95% CI
2018 x NFS	.806 (.284)	-0.61	.542	[0.404, 1.609]
2019 x NFS	.876 (.242)	-0.48	.633	[0.510, 1.507]
2020 x NFS	2.134 (.620)	2.61	.009	[1.208, 3.771]
2021 x NFS	1.695 (.684)	1.31	.191	[0.769, 3.739]
2022 x NFS	2.387 (.650)	3.19	.001	[1.399, 4.071]
2023 x NFS	2.189 (.740)	2.32	.021	[1.128, 4.247]

Notes: Reference categories are GC cases (NFS=0) and year 2017. Model includes year fixed effects, NFS treatment status, and year x NFS interaction terms. Wald test of pre-intervention interaction terms: $x^2(2)=0.38$, p=.826.

Wald $X^2(13) = 228.13$
Prob > X^2 = .000
Pseudo R^2 = 0.0109
LL = -5154.46

N = 8,693

A. Coefficients and 95% CIs for Year * Treatment Interaction Variables



B. Coefficients and 95% CIs for Quarter * Treatment Interaction Variables

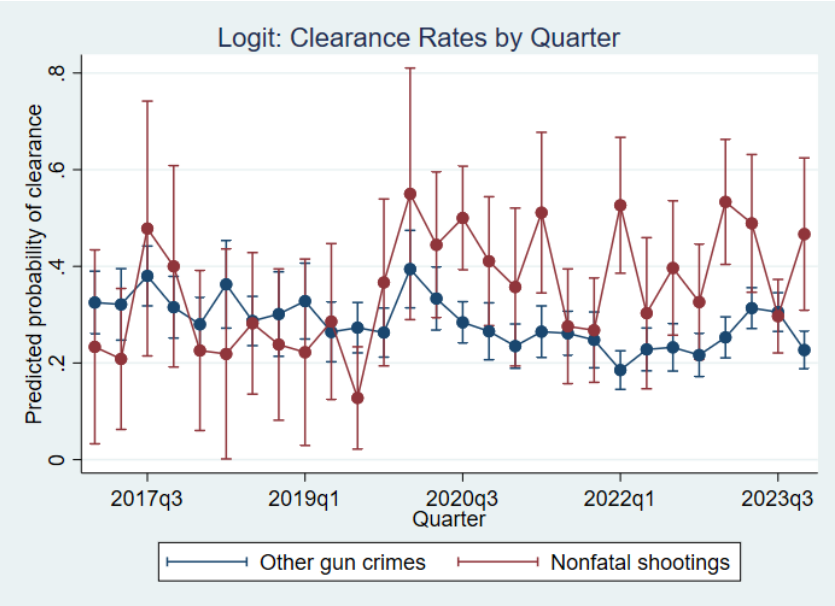


Fig. S3. Estimated Arrest Clearance Probabilities by Treatment Group

Section S3. Principal Components Factors for Mechanism Analysis

Principal components factor analysis was used to construct scene response “Resources” and “Engagement” factors. Endogenous variables with loadings greater than .7 were retained in their respective investigative factor latent variables. The retained Resources factor included the number of responding officers, number of responding detectives, and CSU response (Eigenvalue = 1.67, variance explained = 55.8%). The retained Engagement factor included the number of ear witnesses, number of eyewitnesses, and the number of scene interviews (Eigenvalue = 2.19, variance explained = 72.9%). Factor loadings and uniqueness statistics for the variable in both factors are presented in Table S14.

Table S15. Multivariate Model Factor Analysis, All NFS Cases, 2017 - 2023

Resources Factor Analysis

Variable	Loading	Uniqueness
# Responding Officers	.734	.462
# Responding Detectives	.715	.489
CSU Response	.790	.376

Engagement Factor Analysis

Variable	Loading	Uniqueness
Ear Witnesses	.774	.401
Eyewitnesses	.783	.387
Scene Interviews	.967	.064

Section S4. Additional Detail on the Estimated Cost of the FAST Unit

Our impact evaluation demonstrates that FAST increased clearance rates for nonfatal shootings relative to comparable gun crimes. Estimating the cost of FAST is challenging because the unit was not established as a separate line item within the DPD budget. Instead, DPD created FAST by reallocating personnel and investigative responsibilities within the Major Crimes Bureau. FAST personnel drew on shared departmental resources, including forensic services, patrol officers and vehicles. Thus, the economic value of resources devoted to FAST must be inferred from personnel assignments and broader budget patterns.

These patterns, together with interviews with DPD personnel, indicate that FAST was funded primarily through reallocation rather than new spending. Between 2019 and 2023, DPD's nominal budget increased by 6%, but declined both in real terms and relative to the city's overall budget. At the same time, the Major Crimes budget increased by 23%, consistent with investigative resources being shifted toward nonfatal shootings.

The data cited above suggests that there are two ways to conceptualize the cost of FAST. Under a reallocation framework, the relevant cost is the opportunity cost of assigning detectives and other resources to nonfatal shootings rather than other crimes. Under an expansion framework, the relevant cost is the incremental spending that would be required to establish a comparable unit elsewhere. Because the available data cannot support a precise accounting, our goal is to provide a rough estimate under both perspectives.

With respect to the opportunity costs of the FAST unit, there is limited evidence that this reallocation substantially harmed other police functions. The clearance rate for other gun crimes remained at approximately 28% throughout the study period, while, between 2019 and 2023, the clearance rate for burglaries fell from 19% to 16% and the clearance rate for gun homicides fell from 70% to 65%. These changes are within normal annual variation and are consistent with a national decline in clearance rates that occurred during the COVID-19 pandemic but do not rule out that modest opportunity costs might exist in an environment in which the real police budget fell.

With respect to the economic value of the resources expended on the FAST unit, we note that FAST had expanded to eleven detectives and two sergeants by 2023. Detectives earned approximately $112,000 in base salary and sergeants $122,000. Applying a 1.4 multiplier for benefits, pensions, and payroll taxes implies personnel costs of approximately $2.1 million at the unit's current scale. FAST personnel also worked 4,215 overtime hours annually from 2020–2023, costing approximately $345,000. Vehicle maintenance, repairs, servicing, and fuel added approximately $69,000 annually. Together, these expenditures imply annual operating costs of approximately $2.4 million.

FAST also generated additional forensic, digital and ballistic evidence but unfortunately DPD does not separately account for the incremental cost of analyzing evidence from FAST. The forensic analysis budget increased from $8.2 million to $9.5 million during the study period, approximately matching inflation. If we were to conservatively attribute the entire $1.3 million nominal increase to FAST, total annual resources devoted to the unit would not exceed approximately $3.7 million—about 1.4% of DPD's budget, or $5 per Denver resident.

FAST increased the nonfatal-shooting clearance rate by approximately 19 percentage points. With 193 nonfatal shootings annually during the intervention period, the estimates imply approximately 36 additional cases cleared per year (193*.186 = 35.9). Thus, annual costs of $3.7 million imply approximately $103,000 per additional clearance. This figure implies a relatively low breakeven threshold for potential public-safety benefits. Using an estimated social cost of $8 million per homicide (23), FAST would pay for itself if just one in every 78 additional nonfatal shootings cleared ultimately prevented a homicide. Using the value of a statistical life used by the federal government of $13.6 million (24), the FAST unit would be cost-beneficial if just one in every 132 additional arrests prevented a homicide.