FY21 - SPI ShotSpotter Expansion Evaluation – Final Report

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EXECUTIVE SUMMARY

The Saint Louis Metropolitan Police Department (SLMPD) received a Smart Policing Initiative (SPI) grant in 2021. Despite changes to the original proposed approach and plan, the department successfully implemented a revised plan. ShotSpotter became operational in March 2025, and cameras and LPRs were installed shortly before the project end date.

Key Findings:

- **ShotSpotter substantially expands police awareness of gunfire.**

In the expansion zone, ShotSpotter accounted for roughly 75% of all gunfire incidents brought to police attention. Citywide, ShotSpotter detected tens of thousands of gunfire events that would otherwise have gone unreported.

- **ShotSpotter performs reliably and conservatively.**

Evidence recovery rates and match rates to confirmed shootings are consistent with prior evaluations in St. Louis and other cities. The system produces few false positives and is more likely to miss acoustically shielded gunfire than to generate erroneous alerts.

- **Gunfire is heavily underreported by the public.**

Only a small fraction of gunfire incidents generates 911 calls (10-20%). ShotSpotter fills this gap, especially during nighttime hours when public reporting drops sharply.

- **Preliminary crime impacts are promising but not conclusive.**

Early data show a notable reduction in gun-involved aggravated assaults in the expansion zone relative to comparison areas. Homicide numbers are too small for meaningful analysis, and the short timeline limits statistical certainty.

- **Investigative returns diminish quickly**.

ShotSpotter generates large volumes of shell casings, but gun arrests do not increase proportionally. This suggests that indiscriminate follow-up on every alert is not an efficient use of investigative resources.

Overall Assessment

The SPI project successfully expanded surveillance infrastructure in a high-need area and demonstrated that ShotSpotter provides meaningful situational awareness and investigative value. While the short implementation window limits conclusions about crime reduction, the technology clearly improves the city's ability to detect and respond to gunfire. Continued monitoring and intermittent evaluation is recommended

I. INTRODUCTION and PROBLEM STATEMENT

In 2021 the Saint Louis Metropolitan Police Department (SLMPD) was awarded a Department of Justice Smart Policing Initiative Grant (SPI). The grant was intended to improve the response to gunfire in North St. Louis, an area that has historically suffered from gun violence. It became quickly clear that the department would be unable to implement the original personnel-centered plan as manpower dwindled from about 1,200 to 800 sworn officers. After deliberation with the TTA provider and BJA, the department agreed to make the project more feasible by focusing on technology and expanding its ShotSpotter coverage *and* connecting crime fighting reduction efforts with high visibility cameras and license plate readers. Even with a one-year extension the implementation was difficult to execute as continuing personnel shortages, supply chain restrictions and leadership changes presented ongoing challenges. Nonetheless the SLMPD executed the deliverables before the performance period concluded by September 2025to expand ShotSpotter coverage to a one square mile area in the Dutchtown area of St. Louis in March 2025 and deploy LPRs and High visibility cameras in key ingress/egress routes during Summer of 2025.

This final report details the results of both the implementation and impact of the project. Because the cameras were installed late toward the project deadline, no data could be collected on their efficacy so the impact evaluation focuses primarily on the impact of the ShotSpotter expansion.

The City

St. Louis is a city on the Missouri banks of the Mississippi river with a current population of around 280,000 residents[2]. Like other industrial cities across the United States, St. Louis struggles with high crime, and especially gun violence. For decades the city has remained in the top tier for homicides and gun violence, not because the city or police department are unwilling to address the issue, quite the opposite. Gun violence remains a difficult to solve problem across the country; entrenched social problems coupled with the easy availability of firearms and narcotics make addressing gun violence a 'sticky' problem.

St. Louis is not unique in that respect, but it is hindered by additional issues. For example, the city is its own county, separating from St. Louis County in 1876. As a result, the city has been unable to incorporate suburban communities, meaning its tax base is intimately tied to the economic forces that have more broadly shaped urban industrial cores in the latter half of the 20th century. As St. Louis' economic fortunes waned since the 1960s, it has been unable to offset population and tax losses, straining city services to this day. While some communities have seen revitalization in recent decades, the vast majority of North St. Louis and parts of South St. Louis remain deeply impoverished with all the connected social problems, including crime.

Gun violence in St. Louis has been a significant problem for decades and is marked primarily by concentrations in the city's Northside neighborhoods. While reported crime has steadily decreased since 2020, the city's homicide and shooting rates remain

[2] https://www.census.gov/quickfacts/fact/table/stlouiscitymissouri/PST045224

exceptionally high in a national context. Moreover, the city's declining population keeps homicide rates elevated even when raw numbers stabilize. For example, between 2020 and 2024, the city lost nearly 22,000 residents [3]

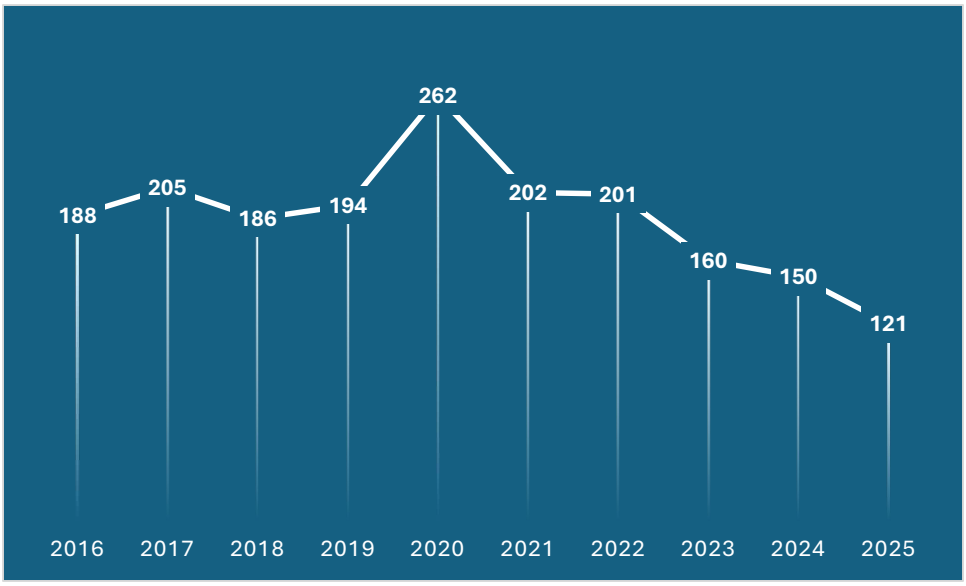


Figure 1. Homicides in St. Louis: 2016-September 2025 [4]

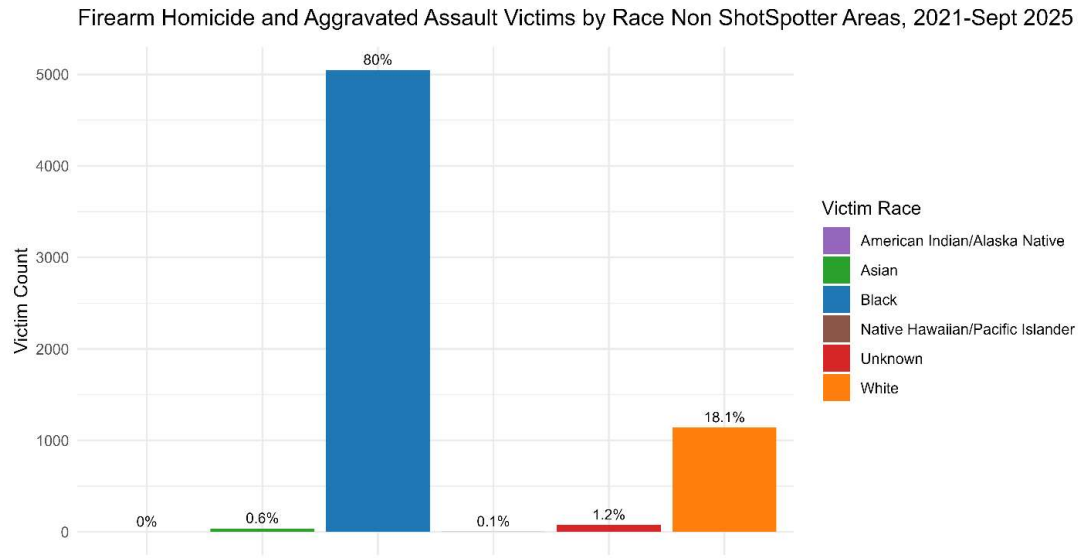
Whereas homicides saw a multi-decadal peak in 2020 with 262 victims (87/100,000), the 2024 low of 150 (54/100,000) still earned the city a top national spot in per capita homicide rates.

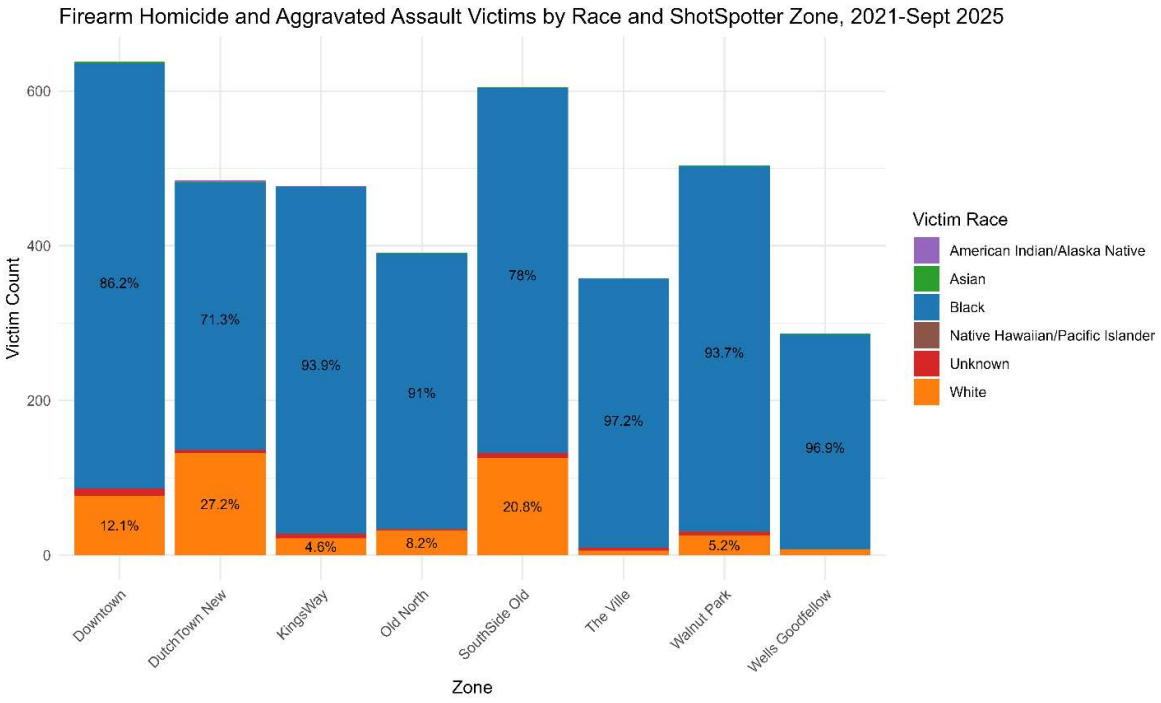
Even though St. Louis is roughly evenly split between Black and white residents, the concentration of gun violence is one that primarily impacts the city's economically

[3] https://fox2now.com/news/missouri/st-louis-sees-second-largest-population-drop-in-the-u-s-metro-areas-census/

[4] Source: https://slmpd.org/homicide/homicide-statistics/

disadvantaged -and primarily black- communities.





Figures 2 and 3. Race of Homicides and Aggravated Assaults by Area [5]

[5] Source: SLMPD Records Management Data Extract

It is evident from these data that most gun crime victims in St. Louis are African American. Although offender data were not immediately available -and generally are more sparse- the demographic overlap between victims and offenders is well known. Even in communities that are more racially mixed, such as the ShotSpotter expansion zone[6], the bulk of the victims (around ¾) are Black, substantially outpacing their share in the community population (see Figures 2 and 3).

Technological solutions to reducing (gun)violence have historically focused on St. Louis majority Black neighborhoods, but in recent years activists and politicians reasonably demanded greater attention to equity in policing practices. However, geographic equity in surveillance may ultimately still focus on the specific racial and ethnic groups as crime risks for different groups are not evenly distributed.

Crime solutions do have to adhere to some economic principles to be cost-effective; installing $20,000 cameras in an area with little to no crime makes no economic sense, for example. While some would argue that targeting black and brown communities and residents for surveillance technology is unfair and leads to more bias, the issue is -of course- that these groups on the whole are also at highest risk for victimization and potentially could benefit; that is a tension that is difficult to resolve. What the data in figures 1 and 2 further show is that regardless of where one would design a crime

[6] Because ShotSpotter zones do overlay with other geographies the exact demographics of the area can not be calculated.

intervention, using crime concentrations as the reasonable focus means that the risks *and* potential benefits in St. Louis are still primarily focused on Black residents.

The Police Department

The Saint Louis Metropolitan Police department is the primary law enforcement entity in the city[7]. While its *authorized* number of officers has hovered between 1,200 and 1,300 in recent years, its actual *number* of officers dipped below 1,000[8] in 2023, a time when many agencies were struggling with recruitment and retention. While the SLMPD has been able to increase its ranks since, it continues to operate well below its authorized strength today.

After a decade under city control, legislation was passed in 2025 that will return oversight of the SLMPD back to state control. The change was a result of state legislation that received broad support from the Missouri legislature, but received mixed support locally[9]. The transition to state control will conclude in 2026. Despite being caught in political wrangling, the department has continued to uphold its tradition of professionalism with a strong emphasis on training and accountability. The department also has a long history of engaging the community and works closely with other city departments to address public safety concerns. Chief Robert Tracy was hired in 2023 after a nationwide search and continues to lead the department's efforts with a strong emphasis on data-

[7] Federal rangers patrol the Arch Grounds, Missouri Highway Patrol primarily is restricted to the Interstates coursing through the cit, and the St. Louis Sheriff's office has responsibility for court security and inmate transport.
[8] https://fox2now.com/news/missouri/st-louis-police-force-around-20-percent-understaffed/
[9] https://www.stlpr.org/government-politics-issues/2025-03-12/missouri-st-louis-police-department-state-takeover-passes

driven policing and emphasizing the importance of the National Integrated Ballistic Information Network (NIBN).

Police departments are always undergoing changes, but the hurdles in recruitment have particularly impacted the department's ability to invest manpower in pro-active policing, including the current SPI project. Such unforeseen headwinds are not unusual in the policing world more broadly, and they underline the importance of the pivot of this project from a person-based to a technology-based crime reduction solution. The project reflects the broader appetite of police departments nationwide to rely more on technological resources to backfill intelligence and personnel shortages.

The Technology

St. Louis was one of the first cities to adopt ShotSpotter in 2008 when a one-square mile area in the Wells-Goodfellow neighborhood received coverage. The service was expanded in 2013 when larger areas on the North and South Side received coverage and again in 2020 when the Walnut Park and Old North areas received coverage and 2021 when a smaller area covering parts of the downtown area was covered by the service. The latest expansion -covering about one additional square mile- in 2025 was funded by the Department of Justice's Smart Policing Initiative grant. Prior evaluations of ShotSpotter in St. Louis have found relatively few impacts on police operations or the city's crime rates[10].

[10] https://link.springer.com/article/10.1007/s11292-019-09405-x , https://academic.oup.com/policing/article-abstract/6/1/26/1457126

Gunshot Detection Systems (GDS) like ShotSpotter can provide police with fast and accurate reporting of gunfire. GDS works by sensors that detect sound waves that match the patterns observed in gunfire. While some systems rely on a single sensor, ShotSpotter uses a more reliable triangulation methods in which multiple sensors have to detect the signal. The advantage of this is that it more readily excludes fireworks or car backfires, whose sound patterns may mirror that of gunfire, but travel shorter distances. The downside is that relying on multiple sensors means that the system may be more conservative and potentially more vulnerable to technical disruptions.

Most GDS are intended to capture outdoor gunfire, and often have some difficulty detecting gunfire in acoustically challenging conditions, such as a gun fired from inside a vehicle or under a porch. In other words, the efficacy of these systems in detecting gunfire is largely dependent on how much gunfire occurs in outdoor locations [11].

Unfortunately, there are no solid estimates of what proportion of gunfire occurs outdoors. There are multiple reasons for this: (1) most gunfire is never reported, (2) even victims of shootings often do not cooperate with police -many show up in the emergency room, meaning the location of the incident is not always verifiable, (3) gunfire data are complex and difficult to leverage [12].

St. Louis reports roughly 14,000 ShotSpotter activations annually, currently covering roughly 15% of its landmass. Within the ShotSpotter areas roughly 300 firearm homicides

[11] https://popcenter.asu.edu/content/gunshot-detection
[12] https://www.tandfonline.com/doi/abs/10.1080/07418825.2020.1799063

occurred between 2021 and September 2025, representing 40% of citywide firearm homicides and about 38% of all firearm assaults (3,400). Combined, these serious gunfire incidents were accompanied by 68,000 ShotSpotter alerts, representing about 55,000 shooting incidents[13]. This means that for every 16 ShotSpotter incidents one assault occurs, and about 183 Shotspotter incidents to see one homicide. In other words, the majority of gunfire is likely to produce little echo in police crime records. We would be amiss, however, to say the ~51,000 detected shooting incidents without a matching victim are irrelevant events. They matter to people who hear and witness them. Discussing firearm violence in the context of 'non-fatal shootings' – injurious shootings only- trivializes the harm this broader class of gunfire inflicts, regardless of its intent and detection in official records. *All* illegal gunfire represents a potential threat to public safety in densely populated urban areas; at its most innocuous, repeated exposure to the sound alone can make people feel unsafe.

From this harms perspective responding to all gunfire incidents is vital to the health and wellbeing of community members and an additional argument for implementing gunshot detection technology. It is also well known that gunfire is woefully underreported in Calls for Service (CAD) records with estimates ranging from 10-30% of gunfire receiving a call from community members[14]. This means the bulk of gunfire therefore goes undetected and does not receive a meaningful response from public safety agencies.

[13] Determining the number of incidents was done by matching alerts to other alerts within 5 minutes and 500ft. ShotSpotter generates a new alerts after a few seconds pause between gunfire, which makes operational sense, but it does complicate tallying a more common sense incident level view.
[14] https://www.tandfonline.com/doi/abs/10.1080/07418825.2020.1799063

II. PROCESS EVALUATION

Evaluation Purpose

The impact evaluation of the St. Louis SPI project is limited by the delayed timeline of the implementation. With only six months of full implementation of ShotSpotter and even less for the high visibility cameras and license plate readers, limited data are available to thoroughly test the crime impacts of the project. Rather than doing a performative attempt at an impact evaluation of the expansion project, we therefore identify the broader potential insights and benefits of the technology implemented, with a particular emphasis on ShotSpotter functionality. Given the public scrutiny gunshot detection technology has received over the last few years, it is particularly prudent to separate fact from fiction about this technology and assess its effectiveness as a tool by providing a thorough examination of the ability of such systems to (1) detect gunfire, (2) provide evidence and (3) its potential for improving the police response to gunfire alerts.

Process Evaluation

As briefly discussed, the original St. Louis SPI plan was structured to provide a better response to gunfire incidents using a tailored and problem-oriented personnel response. That project was deemed unfeasible as personnel constraints grew quickly in the 2021-2023 period. In addition, a new police Chief was appointed in 2023 which led to some reorganization of other leadership positions in the department. The commander of the North Patrol division who was an advocate of the original plan, left for another department. Furthermore, several highly publicized incidents in Downtown St. Louis required available

personnel resources to be diverted to this area, which meant that the department had trouble finding available officers for the overtime the original SPI project required. By 2024 it became clear that the project as intended was dead in the water given the constraints and reasonable priorities the department had to focus on.

A new plan was negotiated between BJA and the SLMPD, along with a no-cost extension. The new plan, rather than relying on personnel, called for investments in surveillance technology, in particular an expansion of the SLMPDs ShotSpotter coverage but also included additional license plate readers (LPRs) and high visibility PTZ cameras that would surround the new ShotSpotter area to capture potential offenders as they may travel in and out of the area.

Because of the changes in the project scope the plan had to be re-approved by the board of aldermen (BOA). Chief Tracy and the research partner made a presentation for the BOA in June 2024 which led to the board affirming its support of the project[15]. However, progress remained somewhat restricted as the city sought to comprehensively regulate the SLMPDs surveillance technology, which meant the contract with ShotSpotter remained on hold until late 2024. Once all regulatory and administrative hurdles were cleared the project implementation began swiftly in early 2025. ShotSpotter coverage was implemented first. SLMPD analysts performed an analysis of calls for service and crime data to determine which area stood out most in terms of gun violence. Areas in the Dutchtown/Mt. Pleasant neighborhoods provided the best opportunity to address high

[15] https://www.ksdk.com/article/news/crime/high-tech-crime-fighting-tools-expanding-to-dutchtown-mount-pleasant-neighborhoods/63-a060881e-5060-49a3-a83d-82ed2aa6eaa3

levels of gun violence. Other high crime areas were less suitable: Downtown St. Louis already has some coverage of gunshot detection and is blanketed with cameras and LPRs; Many areas in North St. Louis also have ShotSpotter coverage but are more limited in cameras and LPRS due to archaic network infrastructure [16]. The expansion area thus made sense from a data-driven perspective and addressing a high needs and diverse community.

SoundThinking (the parent company of ShotSpotter) began seeking permissions for and installations of its sensors in early 2025 and the service was activated in early March of that year. The new cameras and license plate readers that would supplement the intelligence gathering of ShotSpotter came later as vendor contracts and supply chain shortages slowed progress. License plate readers became active during late Spring 2025 and the high resolution PTZ cameras were installed in July of that year.

Technology projects almost invariably suffer timeline setbacks, but the specific set of circumstances in St. Louis led to substantial delays because the project had to navigate around a combination of factors: personnel constraints, regulatory oversight and the typical slow pace of government contracts. From the perspective of the grant implementation, the outcome was ultimately successful, but the delays presented significant problems for the impact evaluation as the project end date (Sept 30th, 2025) meant that little data had accrued.

16 https://www.researchgate.net/publication/365011819_Mobile_Surveillance_Trailers_in_St_Louis_Evaluating_the_Impact_of_a_Randomized_Control_Trial

Nonetheless, a substantial number of ShotSpotter alerts/incidents in the expansion area were recorded, which will form the basis of the outcome evaluation presented below. Only limited information was accessible for the cameras installed. For this reason we encourage the SLMPD to conduct further research on the efficacy of its technology resources and would support a 1-year follow-up study. We believe that showing the public the results of its surveillance technology resources is a powerful communication to its community and fits in the general trend toward transparency that the public expects. Transparency is best way to encourage participatory democracy but also provides the department with insight into its capital investment and helps direct and allocate future resources more cost-effectively.

ShotSpotter Coverage and Alerts in the Expansion Area

St. Louis currently has eight distinct ShotSpotter areas. The Wells Goodfellow area was one of the first areas to receive coverage in 2008, which was followed up by an expansion in 2013 of the Kingsway, the Ville and Southside locations. Between 2020 and 2021 Downtown, Old North and Walnut Park were also added. The SPI project funded the Dutchtown expansion in 2025 (see figure x below).

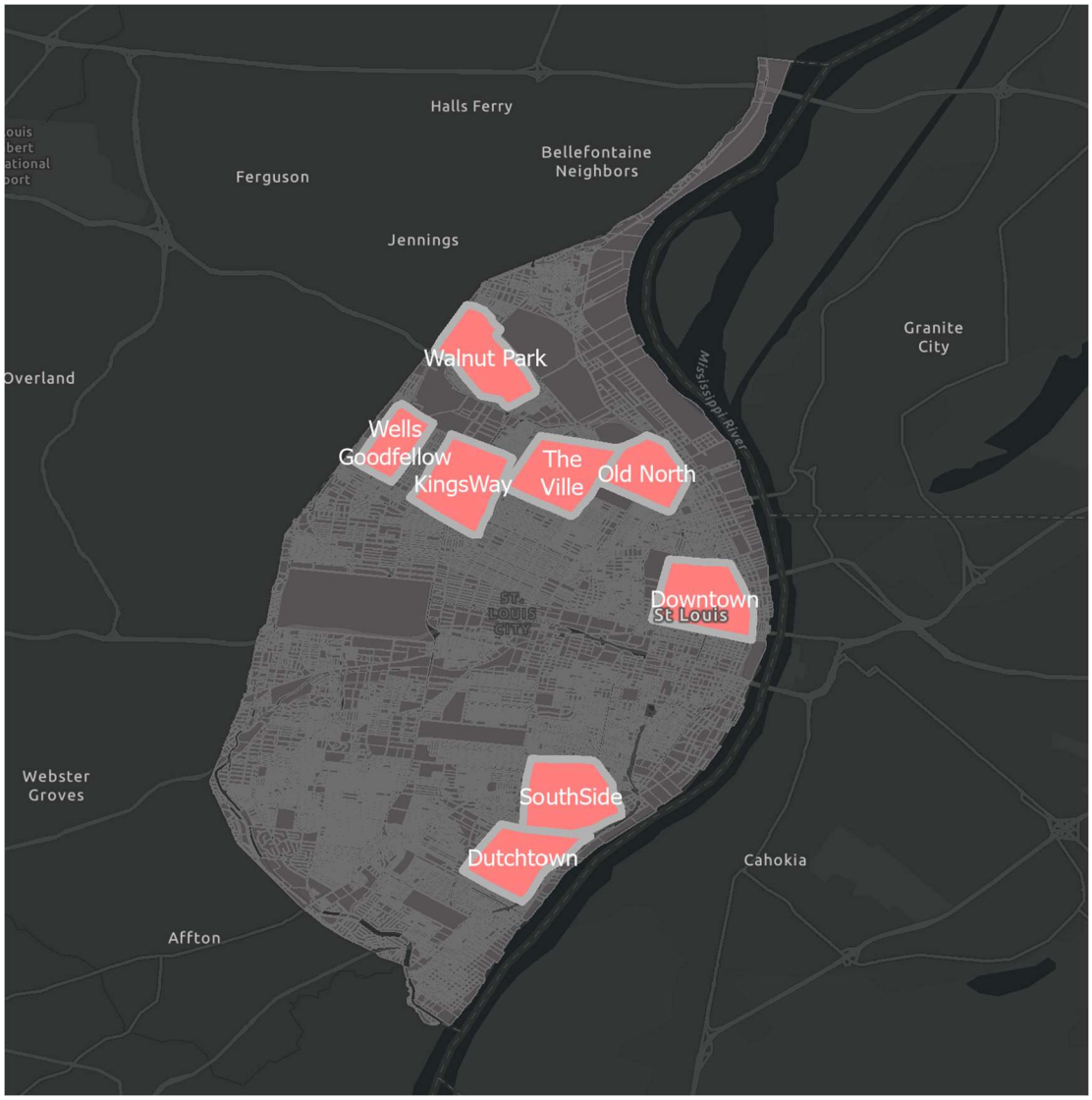


Figure 4. ShotSpotter Zones in St. Louis

As mentioned above, the Dutchtown area (which includes also portions of the Mount Pleasant neighborhood was chosen due it is high volume for Shots Fired calls, but also its high concentrations of assaults and homicides. While there are certainly some higher concentrations remaining to the West, the Dutchtown expansion was the most cost-efficient way to establish coverage within the grant budget and serve a high gun violence area.

Figure 5. Dutchtown and South Side Zones with overlay of Homicides and Aggravated Assults: 2021-September 2025.

Since activation of the service in the Dutchtown expansion area, 652 separate ShotSpotter alerts were generated between March 2025 and September 2025. Combined the alerts detected 2,172 rounds, or an average of 3.3 rounds per alert notification. Overall, the city's gunshot detection system reported 5,979 alerts and 21,267 rounds fired during the same period producing a similar 3.6 rounds per alert. The high volume of alerts and rounds fired in the expansion zone thus matches existing areas, indicating the area selection was appropriate. The expansion zone captured about 11% of the total alerts and just over 10% of rounds fired during this period. To put this in perspective, the effective coverage area[17] of ShotSpottter is around 9.4 square miles with the expansion zone at roughly 1.17 square miles, or 12.4% of the total area. St. Louis city contains 61.7 square miles of land area, meaning that 15% of its total surface area is currently covered by ShotSpotter. As we detailed earlier roughly 40% of homicides and aggravated assaults with firearm occur in this area, meaning that coverage correctly serves areas with a disproportionate gun violence problem meaning the technology is correctly situated in high-needs areas of the city.

[17] ShotSpotter coverage areas are often slightly larger than SoundThinking indicates; effectively there usually is a small area beyond the official coverage maps that generate alerts; we created the maps around the majority of points to create 'effective' coverage maps in order to more accurately capture the areas impacted by the technology. So, whereas the expansion zone is technically 1 SQM the area that actually receives the service is about 1.17SQM

Figure 6. ShotSpotter Alerts in Dutchtown area, March-September 2025

Project Deliverables and Implementation

The SLMPD SPI project faced many headwinds since being awarded funding in 2021. Initially the project was conceived to be focused on improving the response to gunfire alerts and calls for service and using the data generated by alerts to improve problem-oriented policing. This focus proved untenable for a variety of reasons. First and foremost, St. Louis faced significant personnel attrition in the wake of COVID and the broader backlash against police use of force following the George Floyd killing. Coupled with a rise in retirements driven by increased hiring during the 1990s, the SLMPD lost around a quarter of its sworn officers in a few years, most of them assigned to patrol divisions. Since the

original SPI plan hinged heavily on personnel involvement it became quickly clear that the project would not be able to continue in its intended form. In addition to these broader issues, the department also underwent significant personnel changes. In addition, police Chief Hayden retired and was replaced by Chief Tracy. These changes meant that the original project had lost its champion amid broader changes in the organization. After discussions with the TTA provider and BJA a new plan was formulated that would rely little on personnel and instead on improving surveillance infrastructure in an area of the city that had limited resources. The Dutchtown/Mt. Pleasant area had been identified as suffering from relatively high levels of gun violence, and had limited upgrades to its camera systems over the years. It was also an area that was adjacent to an area already covered by ShotSpotter and it was determined that it would make a logical candidate for expansion of the service. After approval for the project scope changes was received from BJA, the SLMPD proceeded with the lengthy city approval process to receive permission to purchase and place the technology in the identified areas. It wasn't until 2025 that the purchase was approved and ready to be deployed, with ShotSpotter service being activated in March 2025 and the high visibility cameras coming online near the end of the project term. While these ultimately meant that the plan was carried out as stated in the revised action plan, it did create issues for the Research Partner in evaluating project impacts. Given the timeline of completion there is simply not enough data to evaluate the impact of the high visibility cameras and how they may have been used in tandem with the gunshot detection system. The ShotSpotter expansion, however, has been in use for six months in

the Dutchtown/Mt. Pleasant area, which provides some data that is analyzed for this report.

III. IMPACT EVALUATION

Data sources

The RP for the project requested multiple sources of data to more broadly assess the functionality, accuracy and actionability of ShotSpotter alerts in both the expansion zone and more broadly in the city of St. Louis. Specifically, quantitative records of ShotSpotter alerts, calls for service, RMS crime incident and arrest data and gun seizures were obtained.

The impact evaluation below focuses on several elements:

(1) Does the system adequately detect gunfire

(2) The impact of ShotSpotter on calls for service metrics

(3) Crime impacts, and

(4) Investigate results

Combined, these elements produce a coherent understanding of how the system is leveraged by the SLMPD and how effective specific elements may be.

A. General Operational Efficacy of ShotSpotter

Between January 2021- and September 2025, the SLMPD received 68,010 ShotSpotter alerts. It is important to note that such ShotSpotter alerts do not represent a gunfire

incident; rather they represent an acoustic activation, and multiple such activations can exist for each gunfire incident or shooting as a few seconds pause between gunfire will generate a new alert. If one is examining the accuracy of ShotSpotter with respect to detecting true gunfire, this creates some issues.

For example, if one examines the proportion of alerts with found evidence (or their echo in the calls for service logs) one runs the risk of substantial undercounting by comparing ShotSpotter alerts to calls for service as crime numbers are typically only assigned the 'primary call when multiple calls exists; with duplicate calls often expunged from analysis. What is more, in St. Louis de-duplication of multiple calls for the same incident occurs by assigning only the most serious call code in a grouping with a crime number. This often means that non-ShotSpotter calls for service (e.g., Shooting, Shots Fired, etc.) are often labeled as the primary call, even though ShotSpotter alerts may have been the first alert to the incident. This especially impacts injurious shooting incidents where often multiple ShotSpotter alerts occur alongside multiple calls from the public.

In order to solve these problems, we explored the internal tags assigned to gunfire calls for service (Shots fired, shots in dwelling/property, Shooting and ShotSpotter alert). In this data we find that 30.5% (n=38,449) of calls for service in ShotSpotter zones are in fact duplicate calls. We next grouped these calls into 'incidents' combining an internal tag (duplicate/case) as the 1st anchoring element in a custom written code function that performs a space-time match (all records are matched 1st to an anchor event, before being allowed to be matched to additional events). This ensures that complaint/crime numbers can be attached to all calls for service for an incident and allows us to explore the types of

calls that exist in a gunfire related incident. While it is plausible that other call types may have been assigned anchor status (for example, an assault with a ShotSpotter alert) the goal here is to compare ShotSpotter alerts, explicitly against only other calls for service that are unique to gunfire events. This means that the counting of incidents with ShotSpotter alerts may be slightly conservative but in practice most alerts should be captured, including ShotSpotter alerts that do not have any corresponding calls from the public.

Table 1 below shows all theoretical possible combinations of call types within the ShotSpotter zones, showing that ShotSpotter alerts without additional call types result in 4.21% of these incidents being assigned a complaint/crime number. The presence of a complaint number is a proxy for either finding property or victims in criminal wrongdoing and thus provides near-definitive evidence for a gun being fired during the incident. For Shots Fired only calls – calls that are generated by the public/officers, 6.27% of incidents generate a complaint number, not markedly higher than ShotSpotter alerts. Important to point out however, is that while Shots Fired and ShotSpotter alerts are often similar in nature, 46,700 singular ShotSpotter incidents occurred versus 'only' 8,899 calls for service for Shots Fired alone. What this means is that ShotSpotter most certainly aids in uncovering substantially more gunfire incidents than the public.

When we include incidents with multiple call types present, ShotSpotter alerts are present in over 81% of gunfire-related calls for service in ShotSpotter areas and 57% of calls for service incidents with a complaint number. Effectively ShotSpotter has a high concordance rate with reported gunfire incident by the public, but -separately and

uniquely- also produces more (numerically) more evidence of gunfire than the public supplies.

CALL TYPE PATTERN	TOTAL CALLS	CALLS WITH COMPLAINT	PERCENT W/ COMPLAINT
SS:FALSE_SHOTS:FALSE_SHOOT:FALSE_SD:FALSE	15	14	93.33
SS:FALSE_SHOTS:FALSE_SHOOT:FALSE_SD:TRUE	1320	803	60.83
SS:FALSE_SHOTS:FALSE_SHOOT:TRUE_SD:FALSE	1143	679	59.41
SS:FALSE_SHOTS:FALSE_SHOOT:TRUE_SD:TRUE	3	3	100
SS:FALSE_SHOTS:TRUE_SHOOT:FALSE_SD:FALSE	8899	558	6.27
SS:FALSE_SHOTS:TRUE_SHOOT:FALSE_SD:TRUE	72	61	84.72
SS:FALSE_SHOTS:TRUE_SHOOT:TRUE_SD:FALSE	161	146	90.68
SS:FALSE_SHOTS:TRUE_SHOOT:TRUE_SD:TRUE	8	7	87.5
SS:TRUE_SHOTS:FALSE_SHOOT:FALSE_SD:FALSE	46700	1964	4.21
SS:TRUE_SHOTS:FALSE_SHOOT:FALSE_SD:TRUE	122	101	82.79
SS:TRUE_SHOTS:FALSE_SHOOT:TRUE_SD:FALSE	244	227	93.03
SS:TRUE_SHOTS:FALSE_SHOOT:TRUE_SD:TRUE	5	5	100
SS:TRUE_SHOTS:TRUE_SHOOT:FALSE_SD:FALSE	3046	530	17.4
SS:TRUE_SHOTS:TRUE_SHOOT:FALSE_SD:TRUE	89	80	89.89
SS:TRUE_SHOTS:TRUE_SHOOT:TRUE_SD:FALSE	157	147	93.63
SS:TRUE_SHOTS:TRUE_SHOOT:TRUE_SD:TRUE	8	8	100
TOTAL	61992	5333	8.6027
SHOTSPOTTER TOTAL	50371	3062	6.0789

Table 1. ShotSpotter Zones CFS gunfire incidents by call pattern

Focusing on the project area since March 2025 (see table 2 below), the pattern is largely similar with slightly higher rates of complaint numbers being generated by the calls for

service in general, including ShotSpotter. A total of 605 reported ShotSpotter Alerts occurred in the area, with 88 (14.54%) being accompanied with other gun-related calls for service. This means ShotSpotter was involved in bringing around three quarters of all gunfire related issues to police, 62% of these without any other immediate evidence. Indeed, ShotSpotter on its own accounts for around 30% of total evidence/crime uncovered in the expansion zone during the period, making it an important tool for responding to the universe of gunfire incidents.

CALLTYPE PATTERN	TOTAL CALLS	CALLS WITH COMPLAINT	PERCENT W/ COMPLAINT
SS:FALSE_SHOTS:FALSE_SHOOT:FALSE_SD:FALSE	1	1	100
SS:FALSE_SHOTS:FALSE_SHOOT:FALSE_SD:TRUE	14	9	64.29
SS:FALSE_SHOTS:FALSE_SHOOT:TRUE_SD:FALSE	14	7	50
SS:FALSE_SHOTS:TRUE_SHOOT:FALSE_SD:FALSE	191	18	9.42
SS:FALSE_SHOTS:TRUE_SHOOT:FALSE_SD:TRUE	2	2	100
SS:FALSE_SHOTS:TRUE_SHOOT:TRUE_SD:FALSE	2	2	100
SS:TRUE_SHOTS:FALSE_SHOOT:FALSE_SD:FALSE	517	30	5.8
SS:TRUE_SHOTS:FALSE_SHOOT:FALSE_SD:TRUE	1	1	100
SS:TRUE_SHOTS:TRUE_SHOOT:FALSE_SD:FALSE	82	21	25.61
SS:TRUE_SHOTS:TRUE_SHOOT:FALSE_SD:TRUE	3	3	100
SS:TRUE_SHOTS:TRUE_SHOOT:TRUE_SD:FALSE	2	2	100
TOTAL	829	96	11.5802
SHOTSPOTTER TOTAL	605	57	9.4215

Table 2. Expansion Zone, CFS gunfire incidents by call pattern

An important caveat, however, is that it is unfair to say that ShotSpotter 'only' uncovers evidence of gunfire in 4.21% of gunfire related calls in the city and 5.8% in the expansion zone. The system very likely assisted in evidence recovery in cases that also received calls from the public, but this is impossible to tabulate this from the data.

Furthermore, in addition to directly responding to gunfire, the SLMPD has also been doing follow-up investigations when the initial response yielded no immediate evidence. In many cases, a ShotSpotter alert may not lead immediately to evidence recovery, and a follow-up investigation may be necessary to overcome the time and visibility constraints that existed during the initial response (low visibility being the primary issue). Between January 2021 and September 2025, for example, the SLMPD conducted 16,729 such investigations (out 68,010 total singular alerts), those complaints generally yield primarily ballistic evidence (see table 3 below). In this case 3,713, or 22.20% of follow up investigations found confirmatory evidence of gunfire. In the expansion zone 631, follow up investigations were completed yielding 114 complaint numbers (18.07%). Combined with the evidence of all other calls for service we can thus calculate a rough estimate of how many gun crimes are identified by ShotSpotter.

Effectively 28.28% of all ShotSpotter incidents in the city, or 27.49% in expansion zone, yield some type of evidence during either the response or follow up. This number is comparable to evidence of gunfire found in Winston-Salem[18], and is a robust indicator that ShotSpotter identifies gunfire accurately. To be clear, a 28% confirmation rate is by all

[18] https://www.siue.edu/ccsvp/pdf/ShotSpotter2024-public.pdf

accounts a very conservative estimate. It is critical to note that many gun crime scenes may NOT yield easily retrievable evidence. Shell casings are easily missed in urban streets, alleys and yards, particularly if few rounds are fired during an incident. Indeed, with more resources the SLMPD could conceivably gain more evidence, but arguably that also becomes a resource issue and may lead to diminishing returns as 'low hanging fruit' is already pursued.

In short, while some have relied on overly simplistic methods of identifying how often ShotSpotter uncovers evidence of gunfire will seriously underestimate ShotSpotter accuracy in detecting gunfire. Particularly because many shooting incidents have multiple calls for service from multiple sources the trail of what evidence ShotSpotter provides can become murky and produce low yields depending on how an agency's data is sliced and diced. Even with the best feasible tracking it is clear, however, that not all alerts will result in finding evidence of gunfire, but that absence of evidence should not be conflated with evidence of absence as that shows a lack of understanding for the flow of data in police departments and the broader complexity of gunfire situations.

ZONE	TOTAL	W/ COMPLAINT	PERCENT W/ COMPLAINT
THE VILLE	2,284	751	32.881
WALNUT PARK	2,591	833	32.150
DOWNTOWN	1,294	319	24.652
OLD NORTH	1,706	409	23.974
WELLS GOODFELLOW	1,998	465	23.273
DUTCHTOWN /EXPANSION	631	114	18.067
KINGSWAY	2,892	478	16.528
OUTSIDE ZONES	1,179	169	14.334
SOUTHSIDE	2,154	175	8.124
TOTAL	16,729	3,713	22.195

Table 3. ShotSpotter follow-up Investigations: January 2021-September 2025

Indeed, from 2023 the SLMPD increased ShotSpotter follow-up investigations (see figure 7) and an interrupted time series-analysis shows that from this time the department significantly increased its follow up investigations and evidence collection, growing by a statistically significant monthly average of 137 (follow ups) and 42 (complaint number) respectively. The proportion of cases that yielded evidence, however, declined by an average of 13% during this period, indicating that the increase in follow-up investigations while yielding overall more evidence, does reach a point of diminishing returns.

Figure 7. ShotSpotter Follow-Up Investigations January 2021- September 2025

Determining the operational efficacy of gunfire detection systems can be done in multiple ways. Examining calls for service tied to ShotSpotter alerts for evidence of a crime is one way but it suffers from the fact that finding evidence from gunfire is hampered by the amount an effort an agency *can* expend to track down ballistic evidence. Such efforts are inherently tied to executive discretion and personnel availability. Coupled with the fact that evidence may not always be present[19], this provides a rather conservative estimate of how many of the alerts can be considered confirmed gunfire.

[19] Trigger pullers may use revolvers, casing catchers or sometimes even pick up expended shell casings.

Another option to estimate operational efficacy is reversing the search and determine how many confirmed crimes in which a gun was fired have a matching ShotSpotter alert. This approach has its own limitations. For one, determining whether a gun may have been fired during a crime is not always immediately clear for all crimes. NIBRS data, for example, tracks whether a gun was *used* during a crime, but it doesn't necessarily indicate if the gun was fired, used to threaten, or used as a blunt object[20]. In other words, this excludes many crime categories in which guns can be -but are not typically - discharged such as robbery or destruction of property. Even for aggravated assaults, the presence of a firearm in the incident is not a guarantee that the firearm was discharged, although it is typically a slightly more reliable indicator.

Moreover, time and location data for crimes -requirements to match them to ShotSpotter alerts, are often estimates and victims in aggravated assaults are sometimes unreliable witnesses. For example, a gunshot victim may show up at an ER with little reason to cooperate with police. This can introduce significant bias in the accuracy of location and date/time in the RMS data. Even more so, because ShotSpotter is an outdoor gun detection system, it cannot reliably detect indoor gunfire, or even guns fired from within a vehicle. Gunshot victims may be shot in an outdoor setting but collapse indoors, or vice versa, further muddying the waters. A careful approach is therefore warranted and expectations tempered; even if a gunshot detection system would pick up 100% of crimes in which a firearm is discharged it is unlikely that one is able to match these with 100%

[20] While theoretically NIBRS submission SHOULD follow clear rules on use vs presence, in practice this is not always followed, and even the FBI – to the best of our understanding- can't and therefore doesn't check this.

accuracy given the data constraints. Data on gunfire and gun crimes is simply messy and regardless of the way in which one wants to link calls for service/crimes to ShotSpotter alerts, the estimates by nature of that data will be incomplete and typically yield conservative estimates.

In order to match ShotSpotter alerts to crimes the most reliable approach is to match alerts to homicides only. In St. Louis, most homicides involve firearms and most occur outdoors. While focusing on a 'rare' event like homicide narrows the sample size it is the most suitable as aggravated assault victims, for example, can often be uncooperative and show up in a hospital rather than on scene, meaning the location and timing of incidents may often be structurally out of sync. Most homicide victims by contrast expire or are found on scene, providing more accurate time and location windows, although even this is not a universal[21].

The match results presented below (see table 4 below) indicate that ShotSpotter correctly alerted on approximately two thirds of the most likely matches. Recognizing the limitations of the measurement, we want to stress that this is a conservative estimate, meaning that the true match rate is likely a little higher. Without going through the narrative crime reports to verify where and when someone was shot, this is virtually impossible to determine exactly.

Interestingly, alerts are also present in non-trivial amounts for location types for which one would not immediately expect results (such as residence). What this means is

[21] https://www.firstalert4.com/2024/05/14/man-fatally-shot-outside-north-city-home/

that the location type indicators in police data are not always accurate with respect to the inferences we make of them and again underlines the messiness of CAD and RMS data. Having more accurate contextual information about 'where' and 'when' would likely increase the match rate for ShotSpotter alerts to homicides, but without reading all incident narratives this remains speculative. Based on performance for certain location type categories (such as street), results are pushing upwards of 75% for some ShotSpotter zones. In sum, while some uncertainty remains in these estimates it seems reasonable to conclude that ShotSpotter in fact operates quite well in detecting gunfire, with the vast majority of detectable gunfire in homicide events captured.

Location	SS Match	n	Proportion	Wells-Goodfellow	Walnut Park	The Ville	Kingsway	O'Fallon	SouthSide
Indoor	No	37	71.2%	85.7%	66.7%	50%	70%	83.3%	72.7%
Ambiguous	No	13	59.1%	40%	33.3%	100%	66.7%	50%	66.7%
Outdoor	No	50	34.7%	50%	33.3%	32%	37.9%	25%	36.7%
Indoor	Yes	15	28.9%	14.3%	33.3%	50%	30%	16.7%	27.3%
Ambiguous	Yes	9	40.9%	60%	66.7%	0%	33.3%	50%	33.3%
Outdoor	**Yes**	**94**	**65.3%**	**50%**	**66.7%**	**68%**	**62.1%**	**75%**	**63.3%**

Table 4. ShotSpotter Matches to Homicides, select zones that had continuous coverage 2021-2025.

Location	SS Match	n	Match	Wells-Goodfellow	Walnut Park	The Ville	Kingsway	O'Fallon	Gravois Park
Indoor	No	45	86.5%	100%	75%	83.33%	70%	100%	100%
Ambiguous	No	20	90.95	100%	66.7%	66.67%	100%	100%	100%
Outdoor	No	125	86.8%	70%	93.3%	84%	86.2%	80%	93.3%
Indoor	Yes	7	13.5%	0%	25%	16.67%	30%	0%	0%
Ambiguous	Yes	2	9.1%	0%	33.3%	33.33%	0%	0%	0%
Outdoor	**Yes**	**19**	**13.2%**	**30%**	**6.7%**	**16%**	**13.8%**	**20%**	**6.7%**

Table 5. ShotSpotter dismissed activations matches to Homicides, select zones with continuous coverage 2021-2025.

In addition to exploring the alerts ShotSpotter forwards to the SLMPD (table 4) we also explored 'dismissed' ShotSpotter activations (table 5). These dismissed activations are effectively activations of the system in which the algorithm decides that the sounds pattern falls below acceptable thresholds for being identified as gunfire. It stands to reason that some true gunfire ends up in this group. Between 2021 and Sept 2025, 68,010 gunfire alerts were forwarded to the SLMPD and 168,554 additional activations were dismissed as non-gunfire. Both forwarded and dismissed activation were matched to all 27,947 unique crimes that occurred in the ShotSpotter zones during that time period. We were able to match 7,101 crime events to ShotSpotter alerts (25.4% of crimes received a match), versus 1,714 from the non-gunfire activations (6.1% received a match), suggesting that ShotSpotter alerts forwarded to police may be slightly conservative and may prevent up to a quarter of gunfire events not leading to a notification being received by the police department. To be fair, that is a rough matching procedure and may absorb matches that

are purely coincidental. Nonetheless we did find a fair number of activations that were not forwarded in the dismissed categories for homicides. While we absolutely understand that any alert system must have hard boundaries that are conservative rather than inundate police with false positive, it does mean that police agencies should not rely strictly on the alert notifications ShotSpotter provides but also actively use the dismissed data when looking for the exact location of reported incidents.

Overall, ShotSpotter does appear to accurately identify most gunfire. The matches to homicides and the outcome of calls for service indicate that -quantitatively- the system behaves as well as is reasonably measurable with noisy data.

B. Changes in Calls for Service

Some research has indicated that implementation of ShotSpotter may reduce the number of Shots Fired calls. We explored this by conducting a difference-in-difference (DID) analysis of the counts of different gunfire related call types before and after the implementation in the expansion zone and comparing it to two comparable ShotSpotter zones[22]. The analysis was done on weekly data, using a seasonally comparable (March-September) 2-year pre-implementation period. Because some of the potential comparison zones are also relatively new and because most of the other zones saw some impacts of

[22] Older ShotSpotter zones were used as comparisons as they have been covered by ShotSpotter technology for at least five years. This is preferable over trying to find comparable areas without ShotSpotter when most of the contiguous high gun violence areas are already covered, especially considering that ShotSpotter geographies poorly align with other spatial boundaries (neighborhood, ward, census tract etc.).

the large EF-3 tornado that struck St. Louis in May 2025, the most feasible comparisons are the nearby SouthSide zone and the Walnut Park zone on the city's far North side.

Results of the DID analysis (see table 6 below) indicate a slight but statistically insignificant drop in Shots Fired calls for the expansion zone, compared to the SouthSide zone, but effectively flat results for the Walnut Park zone. Shooting calls for service are more typically associated with aggravated assaults and homicides. The DID analysis for this call type shows that compared to both comparison zones, the expansion zone saw a substantial reduction in shooting calls for service, for Walnut Park this reduction was statistically significant, indicating the implementation of ShotSpotter comparatively reduced the volume of these calls in the expansion zone by about 55%. That indicates a substantial reduction in such calls, but the overall volume of these calls is quite limited, so the results should be considered in that light. Shots in dwelling showed a relative decline in the expansion zone compared to the SouthSide zone, but this was not statistically significant; results compared to the Walnut Park area are essentially flat. In sum, we found no substantial evidence that ShotSpotter reduces calls for service for Shots Fired or Shots in Dwelling, but did find some indication that implementation of the service reduced calls for Shootings. In other words, it seems unlikely that ShotSpotter has attenuated reporting behavior, but may have impacted actual assaults. Shooting calls for service, for example, are extremely likely (~60%) to result in a complaint number being generated, whereas shots fired (~6%) far less so.

OUTCOME	TERM	ESTIMATE SOUTHSIDE	P-VALUE	ESTIMATE WALNUT PARK	P-VALUE
SHOTS FIRED	(Intercept)	16.379***	0.000	6.032***	0.000
	treated	0.856+	0.088	2.328***	0.000
	post	1.119	0.364	0.856	0.244
	I(treated * post)	0.712+	0.069	0.93	0.706
SHOOTING	(Intercept)	1.429*	0.026	1.114	0.465
	treated	0.78	0.267	1	1
	post	1.175	0.501	1.419	0.108
	I(treated * post)	0.542	0.114	**0.449***	**0.032**
SHOTS IN DWELLING/ PROPERTY	(Intercept)	0.986	0.921	0.886	0.370
	treated	0.739	0.138	0.823	0.321
	post	1.178	0.536	0.874	0.612
	I(treated * post)	0.751	0.468	1.013	0.974

Table 6. DID analysis of changes in call volumes for Expansion Zone and Two Comparison Areas

C. Response Times

Another element that could be impacted by the expansion of ShotSpotter, is response times. Some have suggested that gunshot detection could have a negative impact on overall police response times by gumming up the response to other incidents. In order to test this idea we begin by examining how ShotSpotter implementation may affect median response times in the expansion zone compared to other ShotSpotter areas for both ShotSpotter and Shots Fired Calls. Calls were filtered by date (March 2025- September 2025) to incidents in which only one call type occurred (ShotSpotter or Shots Fired), as the SLMPDs CAD system does not allow clear disambiguation of call times when multiple calls occur.

Raw numbers indicate that the expansion zone has slower dispatch and travel times compared to other ShotSpotter zones, but longer investigative times. Interestingly and despite substantial real difference in the dispatch times between shots fired and ShotSpotter dispatches, results did not achieve statistical significance. What that indicates is that in the expansion zone, calls may intermittently sit in the call queue for long periods. This is not unexpected due to officer shortages, but also may point to the fact that such personnel shortages are not always a problem but rather that response bottlenecks occur during specific times.

	All SST zones			**Expansion Only**	
	SST Only n=3974	Shots Only n=474		SST Only n=372	Shots Only n=136
Dispatch [n.s]	6.1	5.15	Dispatch [n.s.]	14.55	11.55
Arrive [n.s.]	10.2	8.10	Arrive [n.s.]	10.6	9.2
Investigate* **	7.8	11.95	Investigate [n.s.]	12.0	14.00
Total* **	40.8	42.95	Total [n.s.]	52.50	55.15

Table 7. Median response times with Mann Whitney U test significance comparing ShotSpotter to Shots Fired Calls.

Small differences between ShotSpotter response times and Shots Fired response times could themselves have some basis in the temporal distribution of these events. ShotSpotter alerts are far more likely to be reported during nighttime hours, when fewer officers are available to respond. To explore this, we plotted the frequencies of each call type by hour revealing an interesting pattern.

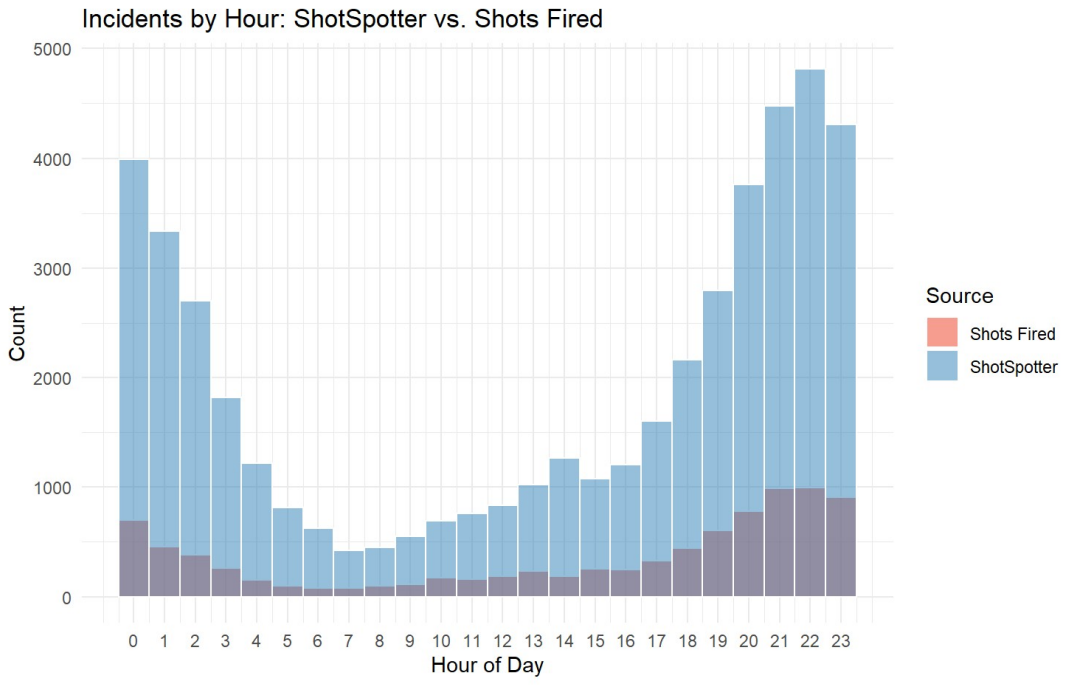


Figure 8. ShotSpotter Alerts and Shots Fired CFS by hour, All ShotSpotter Zones

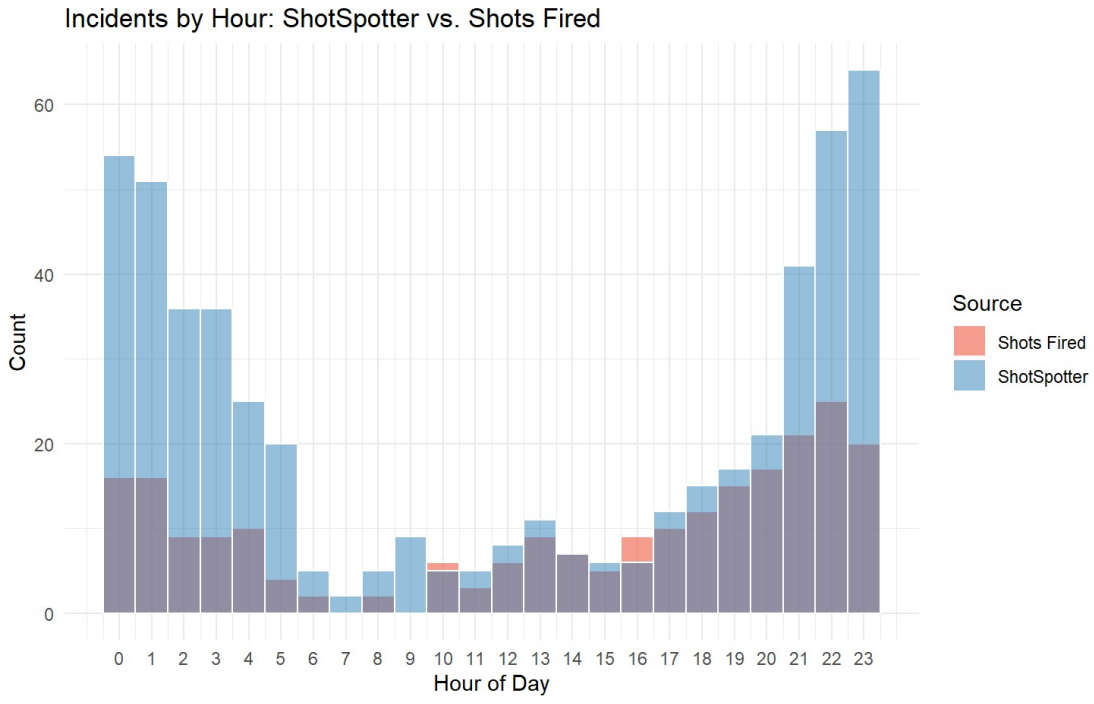


Figure 9. ShotSpotter Alerts and Shots Fired CFS by hour, Dutchtown Zone only

Figures 8 and 9 above reveal a clear temporal divergence between ShotSpotter alerts and resident-reported Shots Fired. While both sources track gunfire across the day, they diverge sharply during nighttime hours, precisely when community vigilance drops. In the expansion zone, residents demonstrate higher baseline reporting, yet even there, calls for Shots Fired taper off as routine activities wind down and people are asleep.

This pattern underscores ShotSpotter's role as a temporal reporting buffer: it sustains gunfire detection when human surveillance falters. Just as routine activity theory can explain victimization risk, it may well explain crime reporting patterns. When gunfire occurs outside the bounds of public presence, reporting volume contracts, leaving technological solutions to fill the gap. Indeed, outdoor shooting victimizations are far more likely to occur during nighttime, which means victims may not be noticed as readily as during the daytime, making the technology a potential life-saver by directing police to the locations of shootings. In other words, reporting by the public is more likely to miss outdoor shooting events than gunshot detection technology as it appears less attuned to the frequency of victimization throughout the day (see figure 10 below).

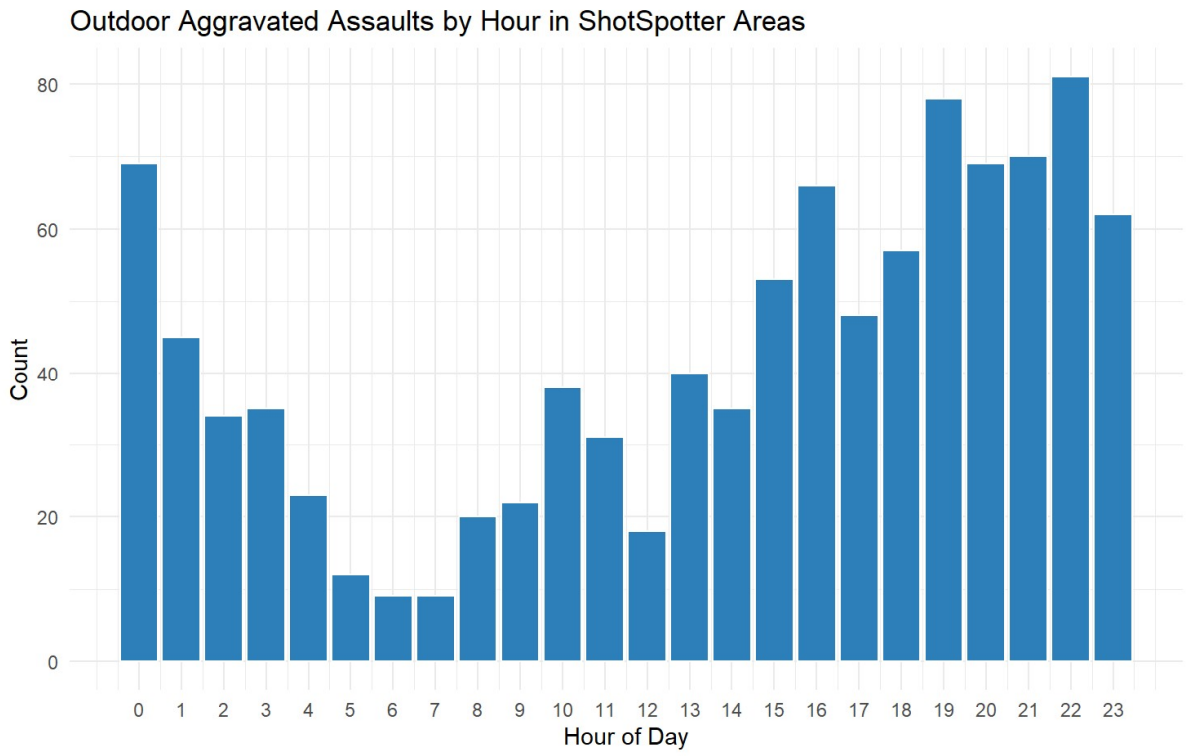


Figure 10. Outdoor Aggravated Assaults by Hour in all ShotSpotter Area

To further explore whether the changes in calls for service had a significant impact on the response times we performed another DID regression, comparing the new expansion zone to the nearby SouthSide zone. While this comparison is not ideal as both zones abut each other, meaning they operate in the same administrative context and under the same leadership. Because the areas are similar in population structure and have a similar mix of residential and commercial spaces, this comparison provides the most valid assessment.

Results of weekly DID analysis indicate that as the number of calls increases post ShotSpotter deployment (about 18 extra weekly calls for gunfire due to the new technology) there is no overall significant impact on the total time spent on calls. Dispatch time, however, increases substantially by nearly 9 minutes, as does travel time by almost 4

minutes. Investigative time is significantly reduced by nearly 5 minutes offsetting the increases in the other categories. In other words, what we are see in gunfire related calls for service post implementation is that ShotSpotter calls take longer to dispatch -because they are lower priority than shooting calls for service *and* the are more likely to occur at night when fewer officers can respond rapidly.

Nonetheless, dispatch times were already increasing, meaning that personnel bottlenecks were already occurring (see figure 9) but became elevated in the new expansion zone. What the comparison shows is that while overall time on calls is effectively flat, dispatch time for gunfire-related calls for service increases substantially but is offset by reductions in investigative time. Thus, while ShotSpotter calls do add to the overall call volume (about 17 per week) of the expansion zone, the overall response time for gunfire alerts is effectively flat. More ShotSpotter alerts in late evening/early night hours when personnel constraints are more severe, means simply that such alerts will sit in the queue for longer. This also explains why investigative times are significantly shorter as the only way for officers to make up time is by reducing investigative time. That, however, may not be the only reason why investigative time decreases. An alternative explanation is that investigations are difficult to do *well* at night when it is dark and locating evidence and witnesses is more difficult. In other words, what the results in our view are showing is that ShotSpotter, while not disrupting, the overall response to gunfire calls for service, may bottleneck during the nighttime. Adding personnel to the evening/night shifts could solve these issues, or at least better balance out differences in response times during the day.

OUTCOME	TERM	ESTIMATE	STANDARD ERROR	P-VALUE
TOTAL TIME	(Intercept)	33.762	8.962	0.000
	treated	4.886	1.977	0.014
	post	**17.193**	**2.577**	**0.000**
	I(treated * post)	7.98	5.499	0.147
DISPATCH TIME	(Intercept)	0.653	6.77	0.923
	treated	-0.241	1.384	0.862
	post	**14.57**	**2.737**	**0.000**
	I(treated * post)	**8.769**	**5.005**	**0.080**
TRAVEL TIME	(Intercept)	9.256	2.203	0.000
	treated	-0.708	0.483	0.143
	post	0.27	0.763	0.723
	I(treated * post)	**3.724**	**1.291**	**0.004**
INVESTIGATION TIME	(Intercept)	23.439	5.168	0.000
	treated	**5.901**	**1.047**	**0.000**
	post	1.368	1.087	0.209
	I(treated * post)	**-4.63**	**1.944**	**0.018**
NUMBER OF CALLS	(Intercept)	44.757	4.11	0.000
	treated	**-28.903**	**0.993**	**0.000**
	post	**-4.02**	**2.4**	**0.094**
	I(treated * post)	**17.654**	**3.093**	**0.000**

Table 8. DID results for Response volume and times Expansion Zone VS Southside

Figure 11 below, for example, shows the expansion zone (StLousMOSOuth2) compared to the nearby comparison area (StLouisMOSouth). This figure shows how ShotSpotter alerts boosted the proportion of calls for gunfire during overnight hours in 2025. While the general dispatch time in both areas has been trending upwards since 2021, reflecting the growing personnel shortages, for the SouthSide zone that number stabilized in 2025. For the expansion zone, dispatch times continue their upward trend in 2025, which is most likely the fingerprint of the additional new ShotSpotter alerts. In other words, while the overall effect of adding ShotSpotter does not appear to negatively impact operations, during overnight hours when ShotSpotter alerts cluster and personnel is least available, response times do appear to suffer. This provides an actionable point for any agency that seeks to implement gunshot detection system: Anticipate that ShotSpotter alerts do not simply smooth out during the day, but will cluster in the late evening, early night hours.

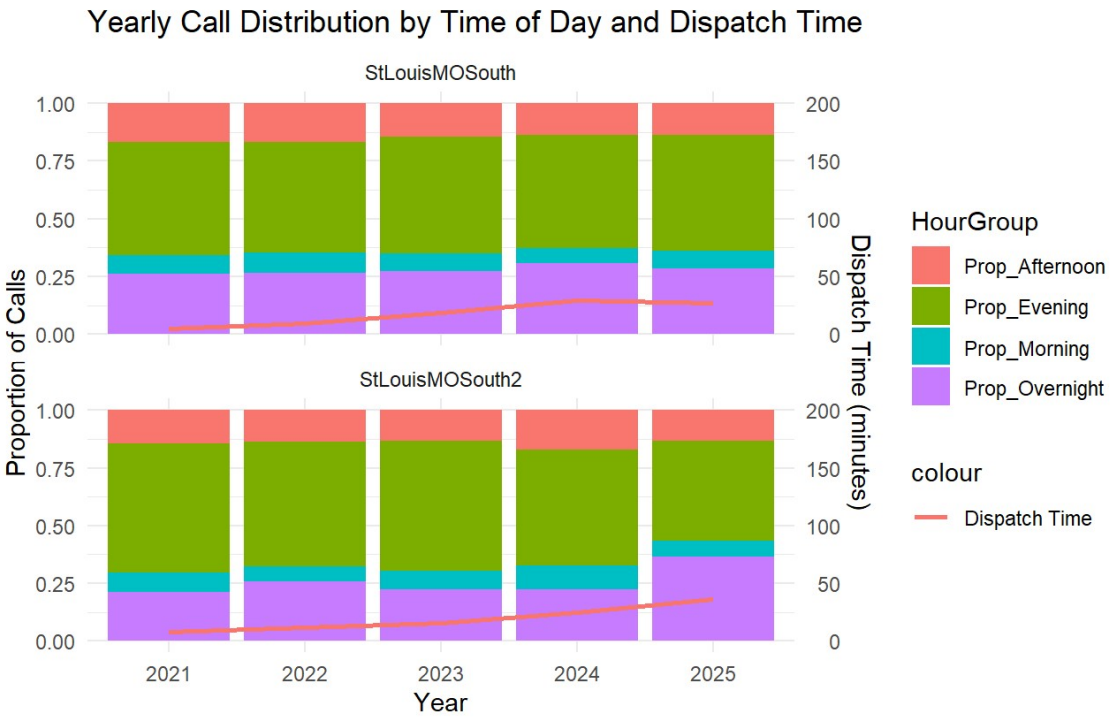


Figure 11. Proportion of Gunfire Calls for Service by year and time of day.

D. Crime Impacts

Determining if and how ShotSpotter impacted crime can be difficult, but it is often the stated reason many agencies purchase the service. The problem in obtaining robust answers is not just because shooting crimes (especially homicides and aggravated assaults) are statistically rare. For St. Louis the expansion was completed less than a year ago, meaning a limited amount of evidence has accumulated. Nonetheless, we believe exploring trends in different crime types is an appropriate way to assess outcomes.

It is important to set the context for expectations of potential impacts. Because ShotSpotter can only accurately detect gunfire outdoors it stands to reason that its impact has to be limited to firearm crimes in which guns are typically fired outdoors, such as

aggravated assaults, homicides, and weapon violations. Robberies by contrast most typically do not involve the discharge of a firearm and therefore are unlikely to be strongly impacted[23].

Aggravated assaults and homicides should be reduced if ShotSpotter can exert a deterrent impact either through a rapid and consistent response (general deterrence), or through the investigative efforts (specific deterrence). Weapon violations, however, may paradoxically increase, as detection of gunfire evidence (shell casings/projectiles/firearms) improves due to ShotSpotter's geographic precision.

Because homicide is statistically quite rare at low spatial and temporal resolutions, we were unable to estimate its unique impact in expansion area. For example, there were 'only' 2 outdoor firearm homicides in the expansion zone, which means statistical models effectively run dry trying to estimate predictions. Below we thus only present results for a variety of contextual conditions for aggravated assaults, and weapon violations. Given the relatively small window post-implementation (about 6 months), we believe it is important to balance pre-implementation data over the same months (March-October) to avoid capturing pre-implementation data that occurred during winter months, which tends to see fewer crimes. We further restricted the pre-implementation data to two years as crimes have dropped quite substantially since 2020 and this would artificially improve the likelihood of finding crime reductions in 2025. In addition -especially for weapon violations,

[23] We did estimate models for robberies as part of robustness checks and found those results showed no impact, flat coefficients and not statistically significant.

2023 saw a department-wide shift in how ShotSpotter follow-up investigations were conducted, effectively introduce an artificial rupture in the series.

Because a DID analysis requires a 'control' area we selected the nearby SouthSide ShotSpotter zone that has received coverage since 2013 meaning any prior ShotSpotter effects should have stabilized. This area is the most suitable comparison area as it is in the same police District, meaning that police practices are most similar, but as mentioned elsewhere this area is also most similar in terms of demographics and housing composition[24].

Aggravated Assault	**All**	**p**	**Gun Only**	**p**	**Gun and Outdoor**	**p**
(Intercept)	2.93***	0.000	1.399***	0.004	0.929	0.591
Treated	0.898	0.329	0.979	0.9	0.831	0.333
Post	0.81	0.107	0.959	0.81	0.903	0.666
Treated x Post	**0.899**	**0.582**	**0.608***	**0.044**	**0.694**	**0.287**
Weapon Violations	**All Cases**	**p**	**Gun Only**	**p**	**Gun and Outdoor**	**p**
(Intercept)	6.801***	0.000	6.443***	0.000	5.501***	0.000
Treated	0.407***	0.000	0.379***	0.000	0.291***	0.000
Post	1.327**	0.002	1.317**	0.003	1.326*	0.014
Treated x Post	**1.996*** **	**0.000**	**2.166*** **	**0.000**	**3.043*** **	**0.000**

Table 9. DID Results Crime Impacts

[24] Gravois Park is 61% African American and has 24% vacancy rate; Dutchtown is 51% African American and a 19% vacancy rate. Other ShotSpotter zones have both higher levels of African Americans and vacancy. For example, Walnut Park is 94% African American and has a vacancy rate of 22% and Wells Goodfellow is 95% African American and has a vacancy rate of 36%. See https://www.stlouis-mo.gov/live-work/community/neighborhoods

Results (Treated by Post interaction effects) indicate that aggravated results show some effects when compared both to the pre-implementation periods and control neighborhood at the same time, yet the results are only significant for gun-involved aggravated assaults, which show a roughly 40% reduction after implementation of ShotSpotter. When further disaggregated by combining outdoor with gun-involvement, the result mirror those for gun-involved assaults, but do not attain statistical significance, likely because the overall numbers drop, inflating standard errors. In general, these results point to some effects, but with a relatively low post implementation period in which just 28 assaults with firearm occurred (see figure 12 below), these results have to be regarded with some nuance in mind. The results should be seen as promising, but do require follow-up with a wider sample.

Weapon violations display unequivocal substantial increases post-implementation, with the strongest effects when firearm presence in an outdoor setting. The effect size indicates a proportionate tripling in Weapons Violations. This shows the impact of the combination of ShotSpotter implementation with ShotSpotter follow-up investigations and indicates that ShotSpotter is the likely driver of a substantial increase in evidence of criminal gunfire events. It is important to nuance this by saying that ShotSpotter doesn't increase these events, but rather uncovers them, leading to the paradoxical situation where a gun violence prevention tool increases reported crime.

In sum, while we should be hesitant to claim that ShotSpotter reduced aggravated assaults until more data becomes available, results do point in this direction. Unfortunately, however, the more granular categories, are showing some instability due to

low statistical power. In the case of weapon violations, the results are abundantly clear, however, showing a strong impact of the ShotSpotter implementation in the expansion zone[25]

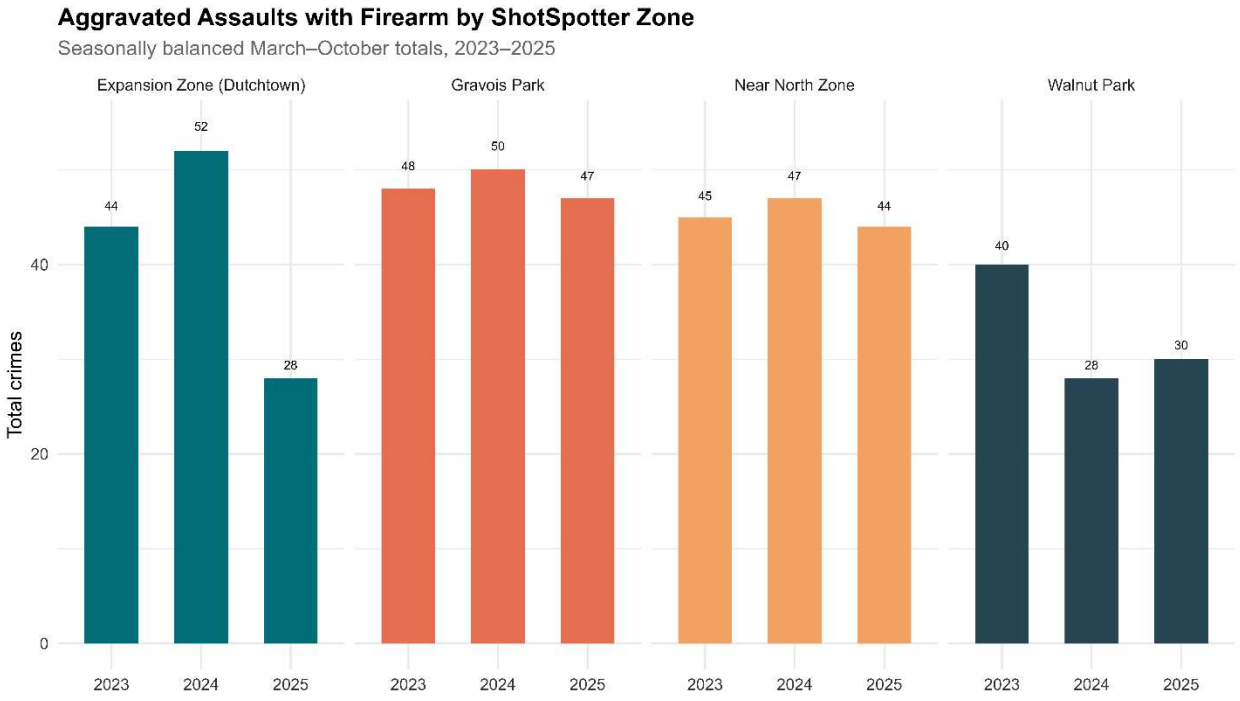


Figure 12. Number of Aggravated Assaults w/Firearm by Year, Select ShotSpotter Zones

[25] We additionally ran the same DID models for another ShotSpotter zone (Walnut Park), which yielded similar results, marginally significant negative coefficients for aggravated assaults, strong significant results for weapons violations.

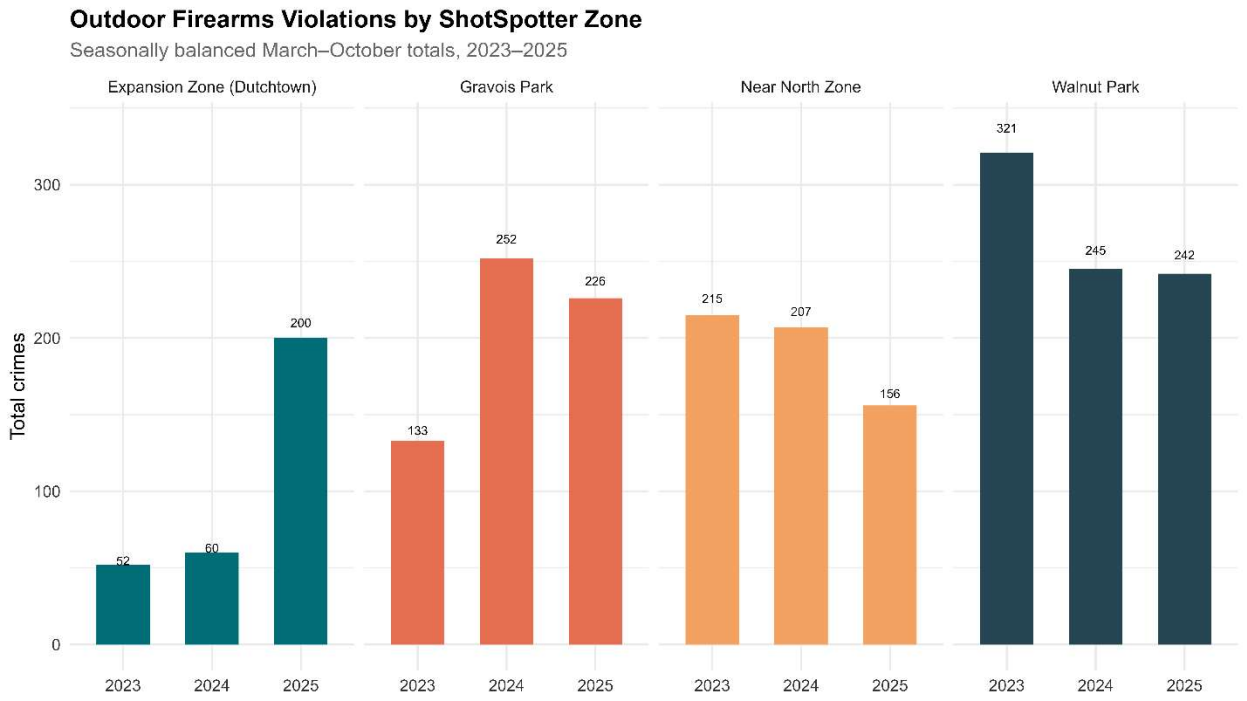


Figure 13. Number of Firearms Violations by Year, Select ShotSpotter Zones

E. Investigative Impacts: Gun Arrests and Firearm Recoveries

Gun arrests and firearm recoveries are the final step in how ShotSpotter alerts may show an impact in SLMPD data. Gun arrests are any arrests in which an offender was arrested with a firearm. This captures all crime types (homicide, burglary, weapons violation, etc.), so it is agnostic to whether a crime happened indoors or outdoors, or even if the gun was used or discharged. We again ran DID models comparing the Dutchtown expansion zone to the SouthSide comparison area and incorporate before- and after-effects (see tables 10 and 11 below). Results of the base model, which does not explicitly use an offset to account for overall levels in crime in which a firearm was present, shows effectively no statistically significant impacts, meaning arrests did not change in the expansion zone after

the implementation. However, once we do incorporate an offset to account for crime level shifts in the data (to account for the large shift in weapon violations uncovered above), we find significant reductions in arrests (~60%). This doesn't mean gun arrests went down; it means the proportion of arrests in relation to the crimes uncovered have decreased. What this practically means is that the increase in weapons violations in the expansion zone, which is likely driven by more thorough investigative efforts, is yielding diminishing returns. In other words, ShotSpotter may bring a lot more shell casings and evidence of gunfire, but it has not led to meaningfully more arrests. This is not to say that ShotSpotter can't lead police to evidence that solves a case, but on the whole chasing every shell casing is unlikely to substantially improve investigative outcomes. What this may signify is that scarce investigative resources may need better prioritization. While NIBIN analysis can certainly be effective in puzzling together networks of gun offenders, it is also possible that a lot of this information is 'dead weight'. A lot of gunfire is likely not assaultive in nature, or committed by high risk offenders, which means that while a system like NIBIN can link gun offenders across crime scenes (great for understanding who is doing what), this does not automatically translate into an enhanced capacity to arrest more offenders. To be fair, gun arrests can lag, and given the short post-implementation period the results of the DID analysis are probably biased toward negative results as some of these investigations may have been ongoing at the time. Nonetheless, the results do suggest that gun arrests are not markedly different post implementation.

	All Cases	***p***	***Gun Only***	***p***	***Gun and Outdoor***	***p***
Aggravated Assault						
(Intercept)	1.571	0.000	0.614	0.01	0.400	0.000
Treated	0.873	0.368	1.14	0.585	0.821	0.501
Post	0.654	0.034	0.651	0.197	0.500	0.127
Treated x Post	0.987	0.960	0.877	0.762	0.869	0.829
Weapon Violations						
(Intercept)	1.385	0.003	1.285	0.030	0.757	0.053
Treated	0.908	0.496	0.834	0.228	0.736	0.151
Post	0.908	0.627	0.867	0.513	0.830	0.574
Treated x Post	0.701	0.207	0.708	0.264	0.988	0.980

Table 10. DID Results Gun Arrests, no crime offset

	All Cases	***p***	***Gun Only***	***p***	***Gun and Outdoor***	***p***
Aggravated Assault						
(Intercept)	0.400	0.000	0.256	0.000	0.207	0.000
Treated	0.945	0.600	1.154	0.431	0.894	0.643
Post	0.763	0.069	0.667	0.169	0.553	0.151
Treated x Post	1.054	0.791	1.129	0.743	0.974	0.965
Weapon Violations						
(Intercept)	0.178	0.000	0.173	0.000	0.120	0.000

Treated	1.876	0.000	1.802	0.000	1.774	0.005
Post	0.705	0.079	0.68	0.073	0.698	0.245
Treated x Post	0.408	0.002	0.389	0.002	0.466	0.080

Table 11. DID Results Gun Arrests, crime offset

Firearm recoveries in St. Louis are substantial, with about one-third of all recoveries in the city originating from incidents occurring within ShotSpotter areas (see figure 14 below). For both ShotSpotter and non-ShotSpotter areas, the general trend has been increasing (roughly a 25% increase between 2021 and 2025), with especially strong increases in 2023 as the department focused more explicitly on gun offenders. Nonetheless the data are too sparse at the weekly level to perform robust analysis for the expansion zone. Coupled with the fact that recoveries may take some time to show up in the data, firearm recoveries provide little insight at this point.

Given the limited data for both gun arrests and firearm recoveries, we encourage the department to continue to monitor firearm arrests and recoveries and re-evaluate the outcome at the 1 or 2 year implementation mark. Nonetheless, gun arrest data strongly suggests that pursuing every gunfire discharge with investigative resources may ultimately yield diminishing returns. Logically this suggests that if the reduction in aggravated assaults are truly linked to ShotSpotter implementation, this reduction is most likely an outcome of general deterrence rather than specific deterrence. In other words, the evidence is pointing to the fact that the immediate response to alerts may be more important in preventing gun violence than the investigative efforts. This would suggest that deterrence through gunshot

detection technology may be similar to how crime reductions are achieved through hot spots policing.

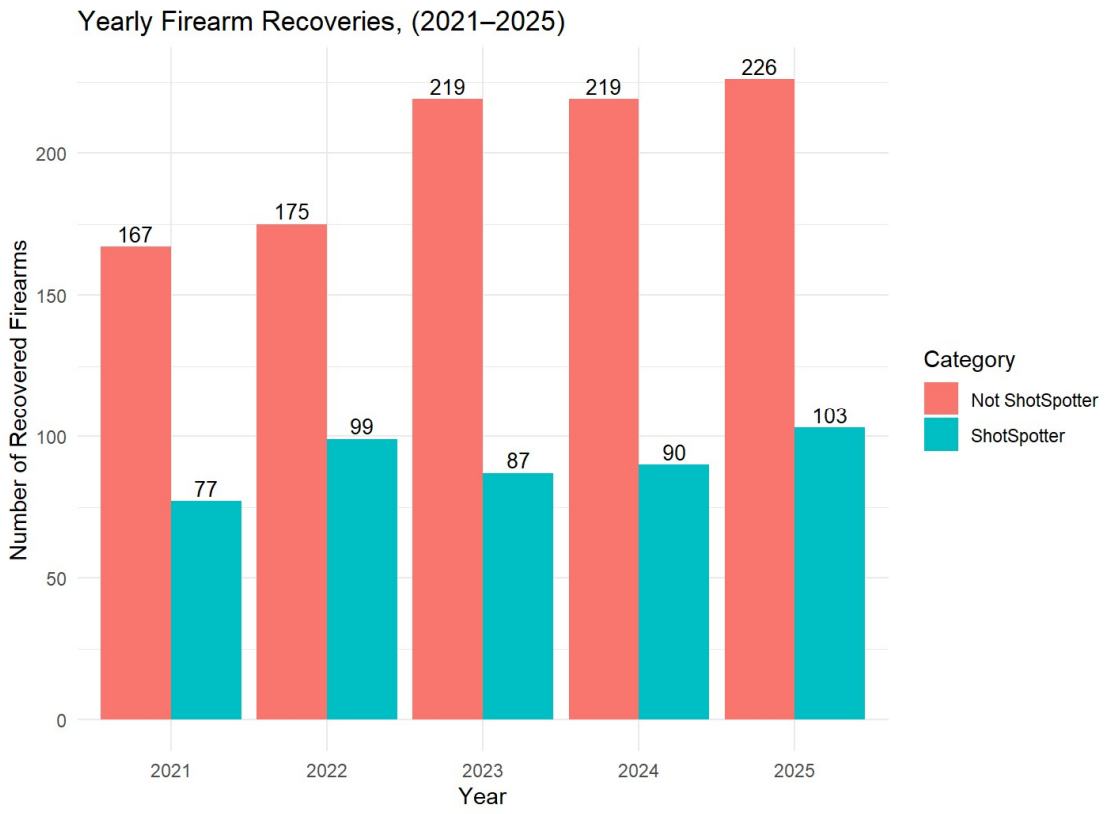


Figure 14. Annual Firearm Recoveries by ShotSpotter Status

IV. CONCLUSIONS and RECOMMENDATIONS

The SLMPD SPI implementation, despite substantially deviating from the initial plan and delays, has ultimately been successfully implemented. Given that the ShotSpotter expansion, was the only element that was reasonably measurable given the timeline of the implementation it has become the key focus of this report and we cannot address how well

the ShotSpotter alerts and cameras systems have been used in conjunction to leverage investigative efforts.

Although difficult to fully assess, results indicate that at least 30% of all ShotSpotter alerts result in some type of gunfire evidence is found by police. About 1 in 10 alerts resulted in evidence during the initial response to the alert, whereas an additional 2 out of 10 alerts saw evidence of gunfire during follow up investigations. We believe the key distinction lies in *how* ShotSpotter alerts are tied to police records. For example, the Chicago Inspector General report[26] indicates a roughly 9% confirmation rate, but did not indicate if these results included follow-up investigations. Furthermore, the current study also deduplicated alerts correctly which ensures that if a shooting has multiple ShotSpotter alerts tied to the same shooting event (or multiple calls for service from the public), these are unified correctly. While some may still view a 30% confirmation rate as a poor performance, it is important to recognize that in many shooting incidents only a single gunshot may be fired, which can be difficult to locate; offenders may also use revolvers, or casing-catchers or could simply pick up shell casings. In other words, many gun discharges in public areas leave practically zero evidence. In that light a 30% confirmation rate should be seen as evidence that the system functions rather well in detecting true gunfire.

In addition, we examined how well ShotSpotter identified gun-related crimes. In particular, we examined homicide incidents and found that outdoor homicides in which a firearm was used had at least one ShotSpotter alert in around 65% of cases, with an

[26] https://igchicago.org/wp-content/uploads/2021/08/Chicago-Police-Departments-Use-of-ShotSpotter-Technology.pdf

additional 10-15% of cases finding matches in activations that were not forwarded to police but were detected. This would signify a roughly 75-80% detection rate, which is similar to field test. Interestingly we also found some matches in ambiguous or indoor locations, which indicates that location type indicators for crime events are not always accurate, further complicating exact metrics and frankly means that truly capturing the universe of outdoor shootings is far more difficult than many criminologists who have studied ShotSpotter suggest it is. Nonetheless, ShotSpotter appears to capture the majority of gunfire, indicating the system -as a whole- functions as intended. This in itself is an important conclusion, as the technology has been described at times as inaccurate; our results, however, show that a more reasonable conclusion is that gunshot detection has a fidelity that appears consistent with field tests.

In the expansion area, results indicate that resident calls for service for shootings saw a substantial reduction (~40%) post implementation, however, these results were not statistically robust. While some studies have indicated that ShotSpotter may hinder responses to other calls for service by 'gumming up' the system, we disagree based on our findings in St. Louis. The differences in perspective occur from the fact that ShotSpotter alerts occur at different times during the day than Shots Fired calls (and most other calls for service, for that matter). ShotSpotter alerts tend to occur at night when most people are asleep and not monitoring their communities. During this time personnel available to respond to these calls is more limited, so it is less a reduced response speed than a mismatch between personnel allocation and the new response reality the technology brings. Further monitoring of these results is recommended, but we do think that carefully

considering personnel allocation is vital when implementing this technology. A slow response time at night could result in preventable deaths and more broadly may impact the deterrent potential these responses can have. We recognize that personnel constraints are not situations a police department prefers and that many factors can determine how staffing resources have to be allocated. That said, from a public health/injury prevention perspective, having a more timely response to gunfire incidents will likely result in more favorable outcomes for shooting victims.

With respect to crime reductions in the expansion zone, some interesting findings were seen. For aggravated assaults with firearm, we found a substantial reduction post-intervention. While certainly more data are required to validate these results, they are encouraging and are similar to results found in recent studies [27].

Even though some prior ShotSpotter evaluations have failed to show crime reductions, we believe that a major factor is that (1) many studies suffer from the relative rarity of these types of crime and (2) these studies often fail to adequately disaggregate crimes that can actually be impacted by ShotSpotter. Restricting aggravated assaults by gun use and ideally by location (indoor/outdoor) creates the universe of crime types that are detectable by gunshot detection. Even with those restrictions gun violence can be difficult to study as the addresses and location types of incidents are sometimes unverifiable as victims show up at emergency rooms and/or are unwilling to cooperate with investigations. We thus encourage academic evaluations of these systems to more

[27] https://link.springer.com/article/10.1186/s40163-025-00259-5

carefully consider how gunshot detection technology may actually impact crime levels and how that impacts measurement choices.

With respect to investigative outcomes (gun arrests and gun recoveries), we found that the increase in weapon violations in the expansion area triggered by more rigorous investigations of gunfire alerts is likely leading to diminishing returns. More investigations do not linearly improve arrest outcomes. It may further indicate that the reductions in shootings and aggravated assaults we observed may not be driven by arrests but rather by improved vigilance and simply responding to gunfire events. In other words, the data currently suggest that responding promptly and having a police presence in gunfire locations may do more to bring down victimizations than investigative efforts. This is not inconsistent with the literature on hot spots policing, for example. It also doesn't mean police should ignore investigative efforts. It does suggest that a timely response to ShotSpotter alerts may generally be more important than what the response itself may concretely yield.

In sum, the SLMPDs SPI's project was implemented successfully and results of the evaluation found several positive elements in the impact this project has had on gun violence in the implementation area. The project evaluation uncovered several practically important elements in the data that agencies should consider as they seek to implement gunshot detection. While results are pointing in the right direction, they also reveal some areas for improvement. Specifically:

1. Align staffing with gunfire patterns.

Gunfire peaks at night, yet staffing is lowest during these hours. Reallocating personnel or adjusting shift structures would improve response times and increase the likelihood of evidence recovery and offender identification. A prompter response could also be ensured by classifying ShotSpotter alerts as Priority 1 events; however, this can be counterproductive as well as it would mean these alerts will compete on equal footing with injurious shooting events.

2. Adopt a triage model for ShotSpotter follow-up.

Not all alerts may necessarily warrant full investigative deployment. Prioritizing multi-round events, alerts near chronic hot spots, and alerts with corroborating calls for service or investigative video may optimize investigative resources.

3. Institutionalize transparency and performance monitoring.

Regular public reporting on ShotSpotter performance, evidence recovery, match rates, response times, and crime impacts, will strengthen community trust and provide the department with data to guide continued monitoring of the efficacy of the technology ensuring sustainability.

The SPI project succeeded in implementing the planned technology and demonstrated that ShotSpotter is a valuable tool for uncovering the true volume of gunfire in St. Louis. The next step is to integrate this technology into a broader operational strategy that aligns personnel, investigative priorities, and public communication with the realities

revealed by the system. With sustained monitoring and targeted policy adjustments, the department can leverage these tools to improve public safety in the communities most impacted by gun violence.

Sustainability

Continuing the successes of this project is primarily dependent on continued funding for equipment and service agreements. The SLMPD has been able to maintain and expand its use of technology and gunshot detection for decades. While this can at times be a struggle grant funding such as Project Safe Neighborhood, the Smart Policing Initiative and funding from community support (e.g. St. Louis Police Foundation) has typically been extremely important in ensuring sustainability of technological resources. In some respects, the transition from local control to state control could prove beneficial. It will ensure that the budget is no longer directly tied to decisions made by the city of St. Louis but rather be driven by the priorities as seen through the state and the Board of Police Commissioners, which will include the Mayor of the city of St. Louis and five governor appointed positions. That said, the reality of operating budgets is outside of the police departments control and the future of the agency's use of technology is in large part dependent on consistent funding streams.

We believe that our ongoing work with academic research partners will provide continuing insights in the optimization of resource allocation, including technology resources. Such partnerships are valuable as they can provide unbiased views of efficacy

which are important to help us understand how the resources provide return on investment. Academic partners help to validate and quantify our impact in a way that can not be replicated internally as communication of this research requires neutral third parties. They also signal our department's openness to transparency more broadly. Community trust in our efforts requires transparency of our data and operational strategies.

Gun violence reduction remains a top priority for the departments and the tools and services the grant supplied have found some validation as resources well spent. Our agency will continue to use these tools to drive the immediate response to, and investigation of gunfire incidents. These operational values are of critical value in leveraging the technology and the department will remain committed to support them as part of their general operating model.