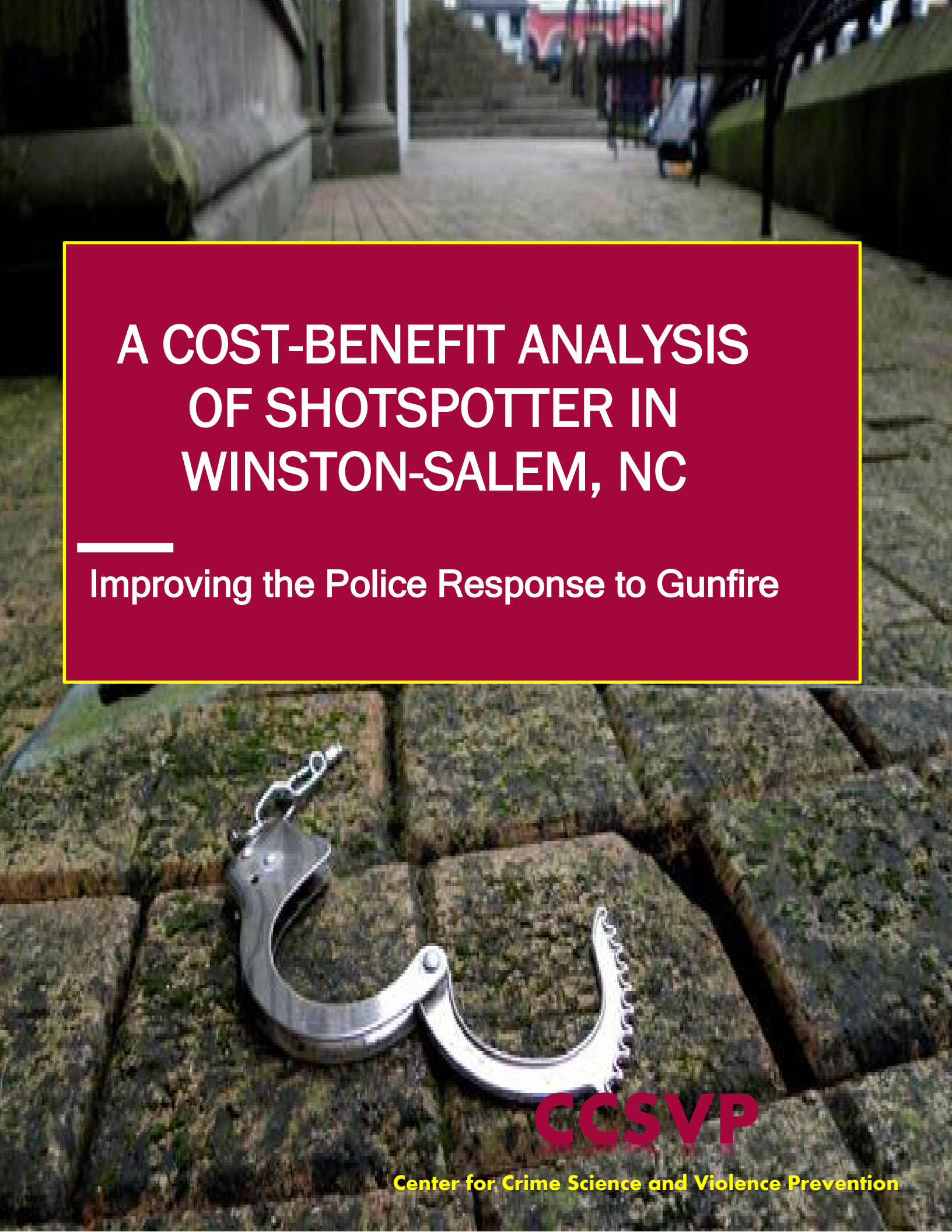

A COST-BENEFIT ANALYSIS OF SHOTSPOTTER IN WINSTON-SALEM, NC

Improving the Police Response to Gunfire

CCSVP
Center for Crime Science and Violence Prevention

INDEX

EXECUTIVE SUMMARY

ShotSpotter's gunshot detection system was deployed in Winston-Salem in August 2021. Since then, nearly 2,000 alerts received a response by Winston-Salem Police.

Results indicate:

- Improved response to gunfire
  - The response to alerts is significantly quicker than those called in by residents (- 5 min.).
  - ShotSpotter calls received significantly more investigative time, which likely indicates improved evidence recovery.
  - Fewer than one in four ShotSpotter alerts also received a call from residents.
- ShotSpotter produces the following actionable results:
  - Shell casings were recovered in 581 incidents (37.1%)
  - Firearms were recovered in 47 (3%) of alerts.
  - Sixty-seven (3.4%) gun-related arrests are connected to alerts.
- Deployment of ShotSpotter is related to a reduction in violent gun crimes:
  - Aggravated assaults are down 26% comparing before-after results in the ShotSpotter area.
  - Comparable area and overall city numbers indicate an increase in aggravated assaults during the same period. Comparatively assaults are down 38% in the ShotSpotter community.
  - In real numbers, there are between 51-75 fewer assaults annually in the ShotSpotter area than would be expected.
- Cost-Benefits:
  - Our estimate suggests that ShotSpotter may save the Winston-Salem community between $5 and $8 Million annually.
  - Average annual implementation cost is estimated between $230,000-350,000
  - This indicates a $15-25 return for each dollar spent.

INTRODUCTION

ShotSpotter is an Acoustic Gunshot Detection System (AGDS) which uses multiple sensors to detect the location of gunfire. Upon positive identification of the sound patterns of gunfire, acoustic events are reviewed by ShotSpotter personnel for accuracy. Once a final determination is made an alert is forwarded to the police agency. Alerts are typically forwarded to dispatchers, also officers may receive notifications directly on their Mobile Data Terminals (MDTs) or mobile phones. Alerts include precise location data, the number of rounds fired and an accurate time stamp of the incident. Audio of the incidents can be streamed as well.

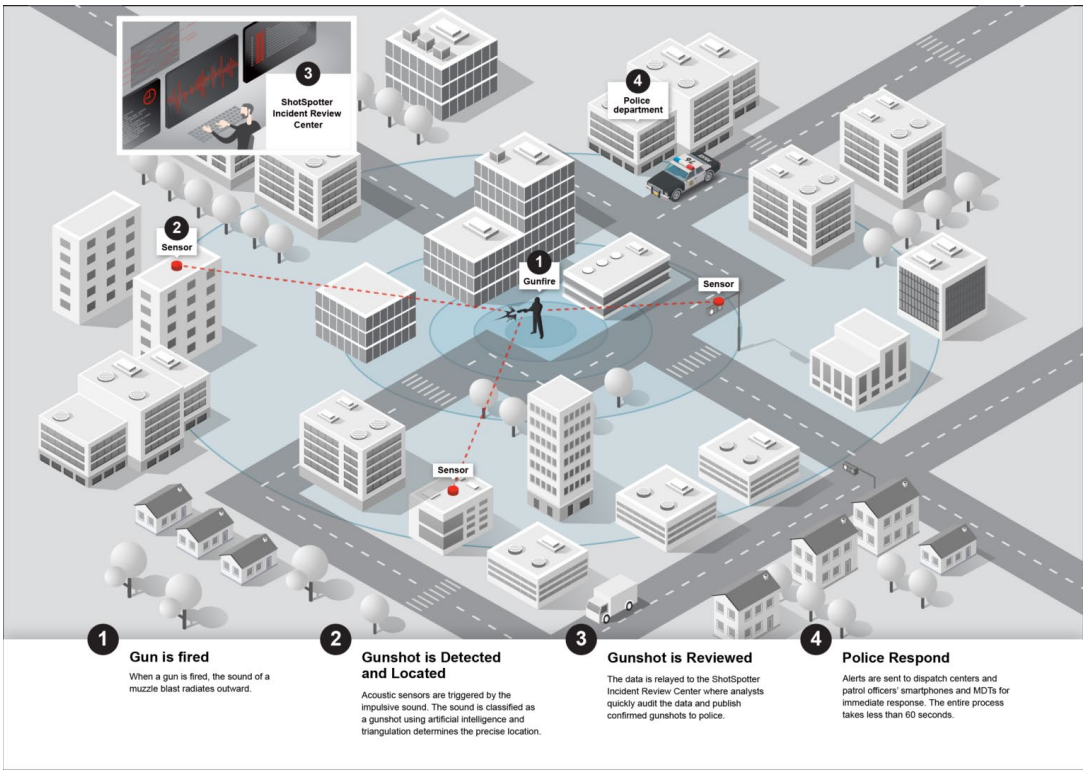

Figure 1. Gunshot detection
Source: https://www.shotspotter.com/law-enforcement/gunshot-detection-technology/

ShotSpotter systems have been deployed in well over 130 cities in the US and the company is currently the leading vendor for gunshot detection systems. While gunshot detection has been criticized for being inaccurate and leading police to many so-called 'false positives'- reported gunfire that turned out to be other loud sounds- this is not supported by recent research (Mares, 2022). In fact, the accuracy of the system appears quite precise (Watkins et al., 2002).

ShotSpotter also utilizes human reviewers to further limit false positives. Gunshot detection has typically been viewed positively by community residents (Haberman et al., 2020; Vovak et al., 2021). Moreover, 2/3 of the general public supports the use of the technology by police[1]. There are, however, some limitations to these systems. For example, they are unlikely to detect indoor gunfire but also have difficulty picking up gunshots fired from a vehicle.

Even though gunshot detection systems are primarily deployed to reduce gun violence, academic research has found mixed results with respect to crime reductions (*cf.* Lawrence et al., 2019; Mares & Blackburn, 2021; Mares, 2023). Implementation differences, however, may explain the degree of success and agency experiences. There is little doubt, however, that gunshot detection improves the speed and precision of the response (Piza et al., 2023).

Below we will quantify some of the results ShotSpotter has brought to the City of Winston-Salem and how it has impacted police practices and outcomes. A cost-benefit discussion will also be provided.

[1] https://morningconsult.com/2021/09/13/data-privacy-security-gunshot-detection-technology-poll/

SHOTSPOTTER IN WINSTON-SALEM, NC

In August 2021 ShotSpotter provided Winston-Salem with a 3 square mile area of coverage for its gunfire detection system. The area covered is located just North-East of Downtown, South-West of Smith Reynolds Airport and intersected by Highway 52[2].

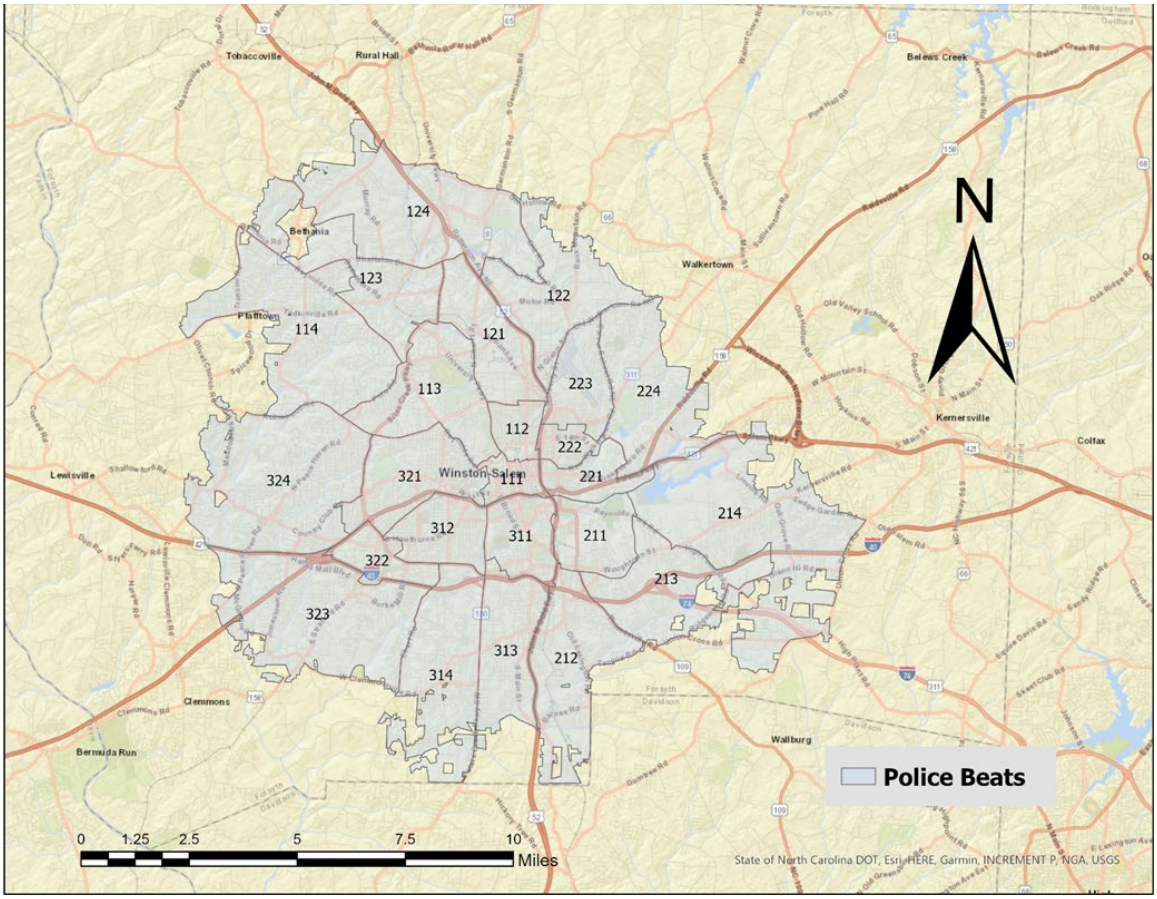

Figure 2. Winston-Salem Police Beats.

Between late August 2021 and December 31st, 2022, Winston-Salem Police Department (WSPD) responded to nearly 2,000 ShotSpotter alerts. In this report we detail the initial results of the technology and the WSPD response to these alerts. We will conclude with a cost-benefit assessment of the technology and implications for current policies and practices.

[2] Please note that the exact coverage area of ShotSpotter is law enforcement sensitive information and therefore not shown.

RESPONDING TO GUNFIRE ALERTS

Winston-Salem PD officers responded to a large number of ShotSpotter alerts in the area that received coverage, but simply responding, of course, does not mean that this is an effective or efficient use of officer time (Blackburn & Mares, 2019). Below we detail some important metrics that provide better context for the data.

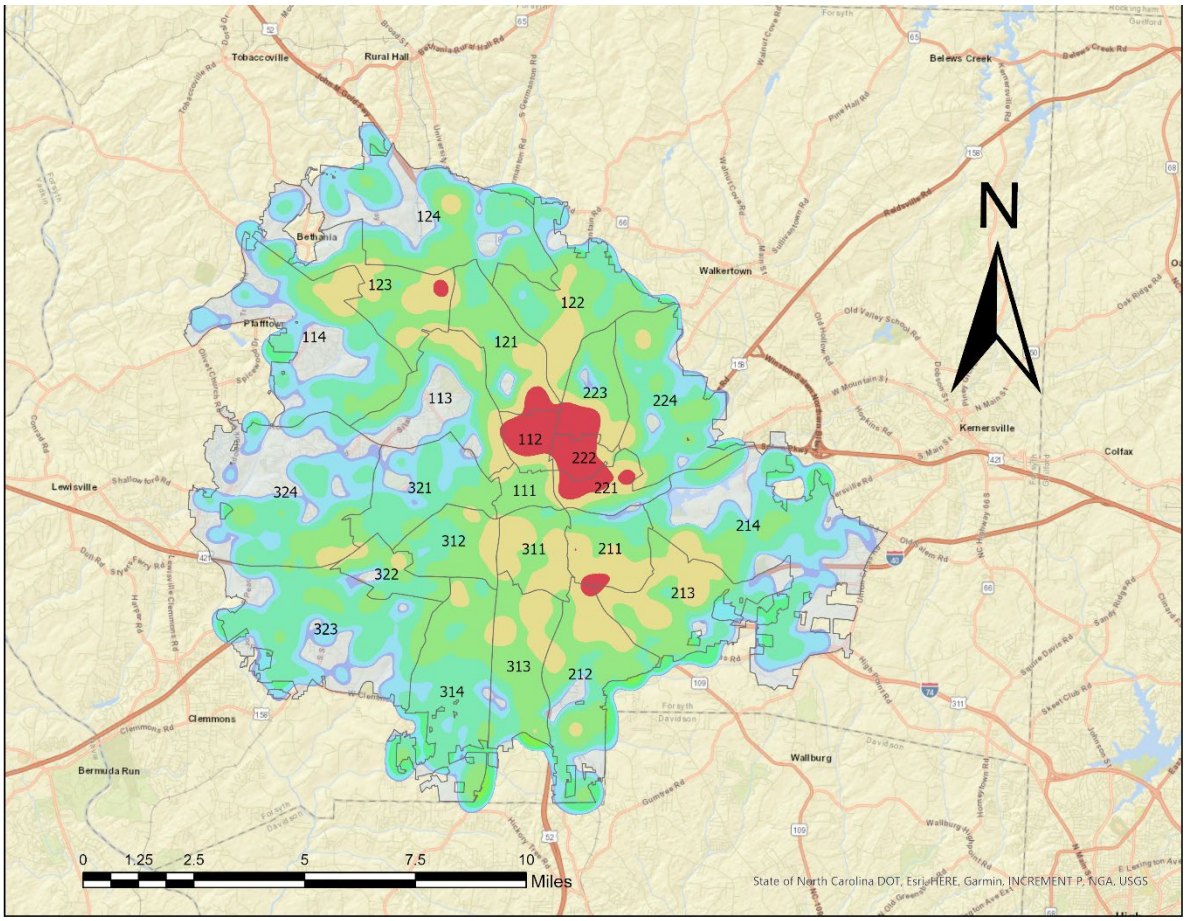

Figure 3. Violent Crime Hot Spots in Winston Salem (red is high violence, blue is low violence).

To make comparisons more meaningful we created a comparison area that shares some key characteristics with the area covered by ShotSpotter. Although no area in Winston-Salem has quite the density of gun-related crimes as the ShotSpotter area we did find an area that has a relatively higher density of gun-related crimes, including several pockets of multi-family housing with even extremer densities (see figure 3). This comparison area is south of Downtown and east of Highway 52, running primarily along Interstate 40. The comparison area is a bit larger than the ShotSpotter area, 4.5 versus 3 square miles, yet both have fairly equitable numbers of calls for service for gunfire and

a reasonably similar number of violent crimes (see table 1 below). That does not mean the two areas are completely comparable but given that implementation of ShotSpotter occurred in the area of highest need, this is the closest comparison we are able to find and better as a comparison against overall city data alone. Both areas share a large proportion of violent and gun offenses in Winston-Salem. Combined they account for 30% of gunfire related calls for service (excluding ShotSpotter alerts) and 33% of violent crimes (excluding sexual assaults) within the city limits.

INCIDENT TYPE	SHOTSPOTTER AREA	COMPARISON AREA	REST OF CITY
DFSA	883	1,012	5,015
DFSAD	238	244	702
SHOOTING*	156	95	354
TOTAL CFS	1,277	1,351	6,071
MURDER[1]	18	13	45
ROBBERY	76	46	364
ASSAULT	508	378	1709
TOTAL CRIME	602	437	2,119

Table 1. Comparison of Calls for Service / Crimes 2020-2022

*Shooting includes call codes for: drive by shooting, person shot and GSW.

[1]. Crime data ends on Dec 13th 2022, and thus does not include the full year.

Figures 4 and 5 below show some interesting patterns when ShotSpotter was activated. In the ShotSpotter area, for example, we see a large drop in Discharging of a Firearm calls for service (DFSA). While those numbers were already trending down somewhat, they really took a dive a few months into implementation and remained extraordinarily low from there. By contrast (figure 6), the comparison area shows mostly steady patterns with a bit of an increase in gun discharges that caused property damage (DFSAD). A rapid decline in what are essentially shots fired calls by the public was also seen in St. Louis

(Mares & Blackburn, 2021) and should not simply be taken as evidence that gun crimes are down. Rather, it may suggest that calls by residents are replaced by ShotSpotter alerts, which now outweigh prior levels of calls by residents.

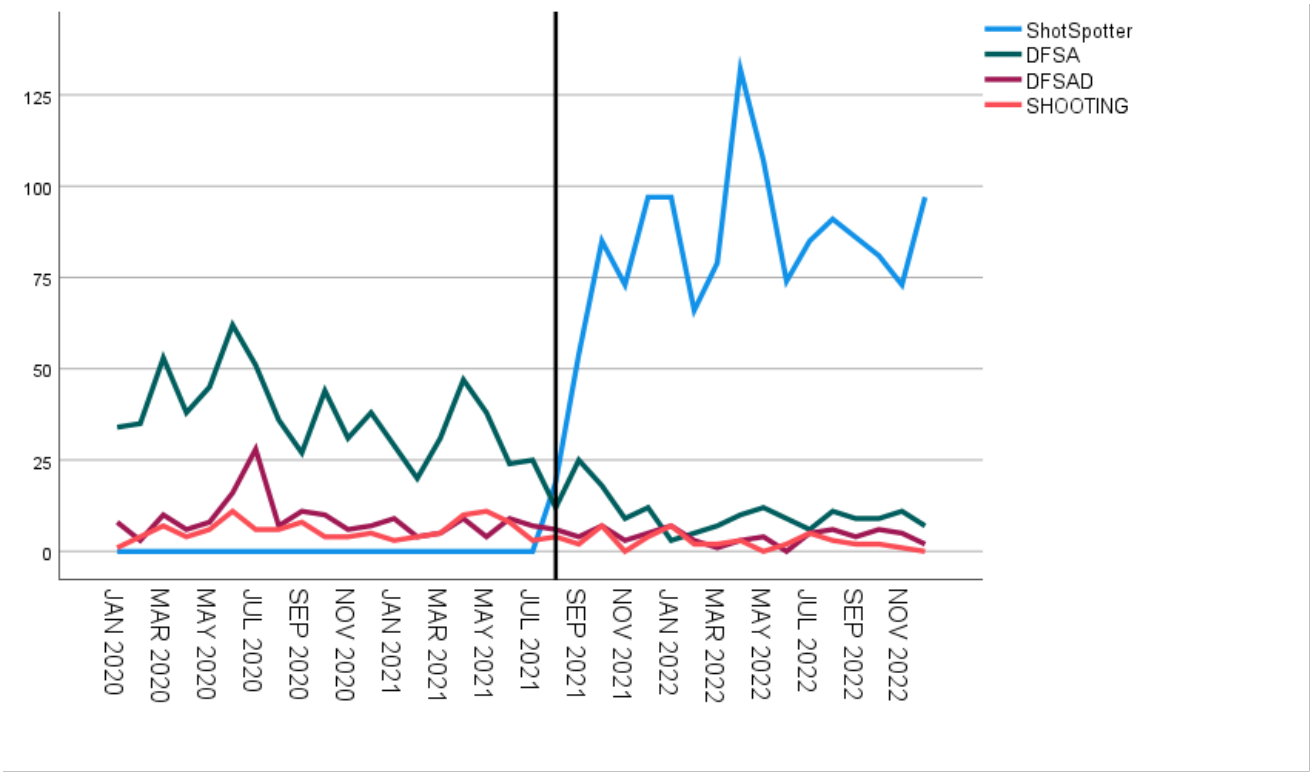

Figure 4. ShotSpotter Area. Monthly trends in gunfire related calls for service.

Figure 5. Comparison Area. Monthly trends in gunfire related calls for service.

To explore how ShotSpotter impacts the response to gunfire we first examine response-time information, comparing discharging events reported by community members to ShotSpotter alerts. In table 2 below we can see that ShotSpotter alerts get dispatched more than 5 minutes faster than calls by residents, which is statistically significant. While travel time to the scene of a gunfire incident takes slightly longer for ShotSpotter alerts, this difference is only 13 seconds. This means that from the time a gun is fired to the moment police arrive, ShotSpotter responses receive a 5-minute advantage.

Interestingly also is that ShotSpotter investigations appear to take much longer (7+ minutes) than calls from community members. This makes some sense as knowing the precise location of gunfire increases the chances of finding evidence.

	SHOTS FIRED (DFSA)	SHOTSPOTTER ALERTS
DISPATCH TIME	8.84	3.62***
TRAVEL TIME	6.75	6.87*
INVESTIGATIVE TIME	41.06	48.29**
TOTAL TIME	54.79	55.65
CASES	168	1,395

Table 2. Calls for service times in minutes in ShotSpotter area.
Statistical significance is based on Mann Whitney U tests: * p<.05, ** p<.01, *** p<.001

What the prior table does not tackle is whether the implementation of ShotSpotter has implications for how gunfire is responded to. To do so we compare response times before and after ShotSpotter implementation for several areas in Winston-Salem. Here we focus on gunfire-related calls (ShotSpotter and DFSA) for service. Table 3 below shows that the area covered by ShotSpotter has a significantly lower dispatch time, but significantly longer travel, investigative and consequently total time. Interestingly, dispatch times lengthened significantly in both the comparison and remainder of Winston-Salem, which makes the time-saving even more impressive. Where prior to ShotSpotter, dispatch times were within a minute of each other across the three different areas, after implementation, the ShotSpotter area dispatched calls for service in nearly half the time, or 4 minutes faster.

	BEFORE	AFTER
SHOTSPOTTER AREA		
DISPATCH	5.77	4.19***
TRAVEL	5.53	6.85***
INVESTIGATIVE	42.78	47.51***
TOTAL	53.03	55.56***
CASES	715	1563
COMPARISON AREA		
DISPATCH	6.77	8.277**
TRAVEL	7.73	7.64
INVESTIGATIVE	35.05	34.54
TOTAL	48.01	54.92
CASES	560	451
REST OF CITY		
DISPATCH	6.07	8.92***
TRAVEL	8.59	9.22***
INVESTIGATIVE	33.20	35.40***
TOTAL	46.69	53.95***
CASES	2845	2349

Table 3. Comparison of calls for service times before/after ShotSpotter implementation.
Statistical significance is based on Mann Whitney U tests: * p<.05, ** p<.01, *** p<.001

Interestingly both the ShotSpotter area and the rest of the city experienced an uptick in the time it took officers to get to the scene of an incident. While it is easy to read too much in these numbers, we suspect the increased travel times may simply be an outcome of declining officer numbers. As police agencies face growing attrition this is not terribly surprising. Investigative times changed significantly for both the ShotSpotter area and the rest of Winston-Salem with the former increasing proportionally the most. We believe this is likely an outcome of the more serious nature of incidents in the ShotSpotter area which requires more resources, but also may be connected to the fact that the proportion of ShotSpotter calls to DFSA calls in that community is severely out of balance.

In sum, results of response times indicate that implementation of ShotSpotter fundamentally altered the times it takes police to get to gunfire and how long police investigate the crime scene. These results stand in contrast to the comparison area, which saw the exact opposite. It is fair to read such results as a positive development and improving the WSPDs ability to better serve the community. While the geographic accuracy and reporting speed of ShotSpotter is probably a large benefit to police, crucial information about shootings is often relayed by community members. Keeping residents connected to police and reporting gunfire is therefore extremely important.

RESULTS OF SHOTSPOTTER RESPONSES

Because a new ShotSpotter Alert can be generated after a few second pause in gunfire it is important to clean ShotSpotter data prior to further use. We therefore remove alerts that occurred within 30 minutes and 500ft of one another to create a better representation of the number of unique gunfire incidents (Huebner et al. 2021). Out of the 1,965 alerts recorded we found that they represented 1,595 distinct incidents. A few alerts lack additional data, mostly recent cases for which all investigative details may not have been available, and are also excluded from analysis. According to data tracked by WSPD, out of 1,567 unique shooting incidents with complete data, firearms were recovered in 47 (3%) incidents, and casings were recovered in 581 incidents (37.1%) with a total of 1,577 casings. We should point out as well that the number of casings recovered by responding to ShotSpotter alerts (3 sqm) nearly matches the 2,101 casings found by responding to calls for service from the community in the entire city (134 sqm)

Like other cities, few of gunfire incidents in Winston-Salem also generated calls for service from community members (Huebner et al.,2021; Mares 2022). In only 287 (18.3%) cases was a ShotSpotter incident accompanied by a community call. Crime-wise, ShotSpotter alerts were connected to 41(2.6%) aggravated assaults, 3 robberies and 7 homicides. Seventeen initial (1%) arrests were enacted, which is higher than reported in other locations (Mares & Blackburn, 2021), but this only counts arrests made during the initial response. A combined total of 67 (3.4%) gun-related arrests were made in connection to responding *and* investigating ShotSpotter alerts, suggesting that benefits of the system may extend beyond the initial response.

Delving a bit more into the data we also look at which factors may explain why some ShotSpotter incidents may be more likely reported by residents. To do so a statistical model was developed that measures the likelihood of a ShotSpotter alert also receiving a report by a community member (yes/no). We explored several possible explanative factors including: (1) the total number of rounds fired during the incident (2) the number of ShotSpotter alerts per incidents, (3) whether the alert led to the scene of a violent crime and (4) temporal variation (month, day of the week and hour of the day) as there is

quite a bit of variability in when alerts occur (see figure 6 below, for example).

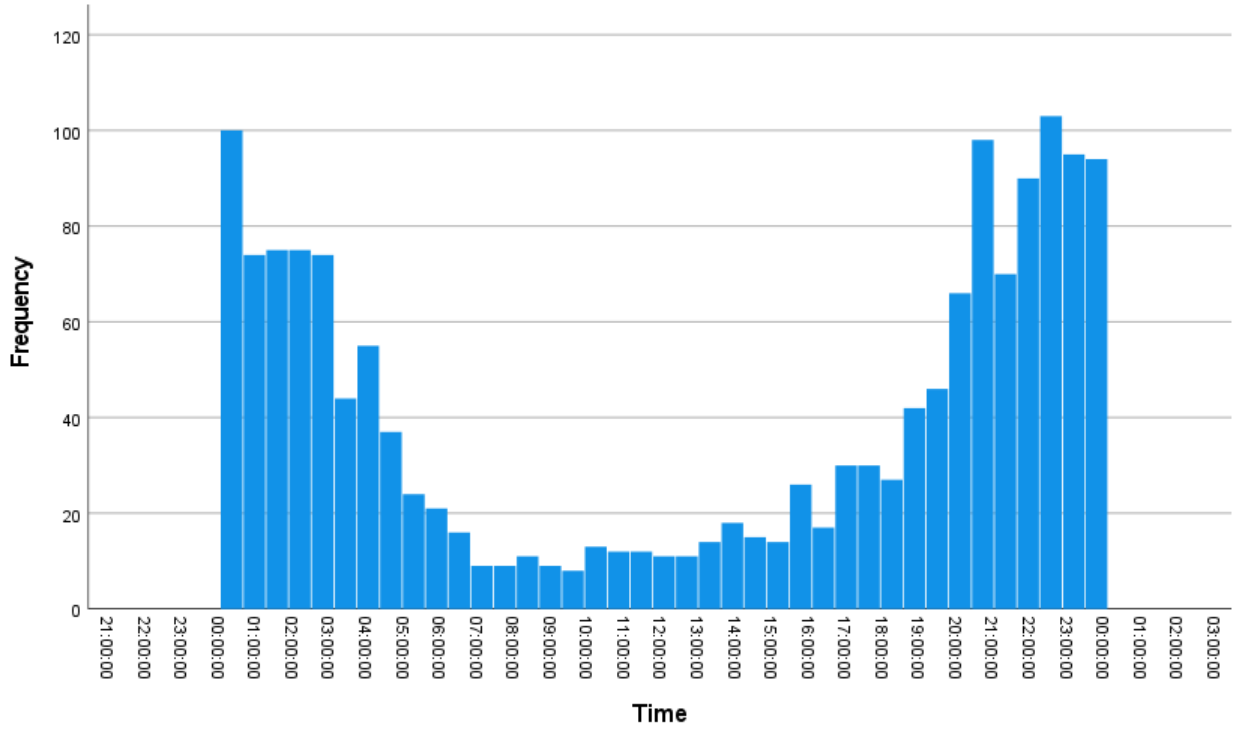

Figure 6. Time chart of ShotSpotter alerts.

Findings of the statistical analysis indicate that the only statistically important factors impacting reporting by residents is the number of rounds fired during an incident *and* whether the incident was connected to a violent crime (assault, homicide or robbery). Each additional round fired increases the likelihood of receiving a community call by around 13%. This is not surprising; more rounds mean more clarity on whether a loud sound is actually gunfire and also increase the chances that more people heard the gunshot. Violent crimes are also far more likely to receive calls from the community, probably because victims or bystanders notify 911. Our analysis suggests that violent crimes are 14 times more likely to be called in by community members than gunfire incidents without a victim.

In more tangible terms, 78.4% of ShotSpotter alerts in which a serious violent crime occurred receive a community call, whereas only 16.3% of gunfire incidents without a victim generate such a call. This also means that nearly ¼ of crimes did not receive a call from the public and that ShotSpotter alerts provided a faster response for victims. Some may not have been uncovered altogether, or failed to yield a crime scene. A good number of assault victims often show up at hospitals and refuse to cooperate with police, which can leave the crime scene unknown and hampering investigations (Mares, 2022).

CRIME REDUCTIONS

One of the key reasons police departments purchase gunshot detection is to tackle gun-related violent crime (Mares, 2023). Winston-Salem only has had ShotSpotter for a little over a year, which makes extremely thorough approaches to measure the impact not quite feasible yet. We can, however, provide some initial insights into the efficacy of ShotSpotter by comparing before and after levels of violent crimes.

Below (figures 7-9) we compare multiple crime incidents in the ShotSpotter area, the comparison area and remainder of the city. First let's examine total DFSA, or illegal discharging of a firearm[3]. In the ShotSpotter area a substantial uptick in such incidents occurred once ShotSpotter became active (represented by the black vertical line). Reported incidents increase from around 30 to about 70 per month. This is not surprising as ShotSpotter uncovers more such events. In the comparison area, the number of such incidents appears mostly stable, with no discernable trend. The remainder of the city also looks fairly stable with perhaps a bit of an overall upward trend, but clearly nothing comparable to the substantial break seen in the ShotSpotter area.

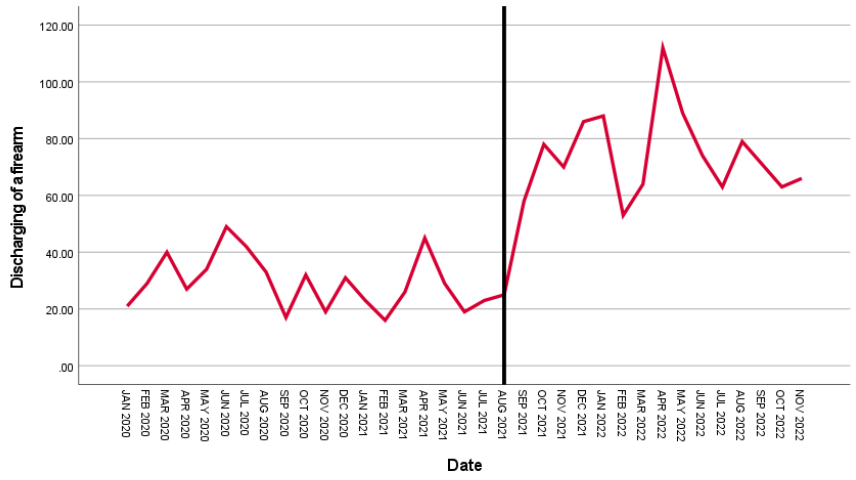

Figure 7. Discharging incidents -ShotSpotter Area.

[3] In WSPD RMS system this includes ShotSpotter alerts that are sustained as such, but also other calls for service in which a firearm was found to be discharged but in which no person was injured.

Figure 8. Discharging incidents - Comparison Area.

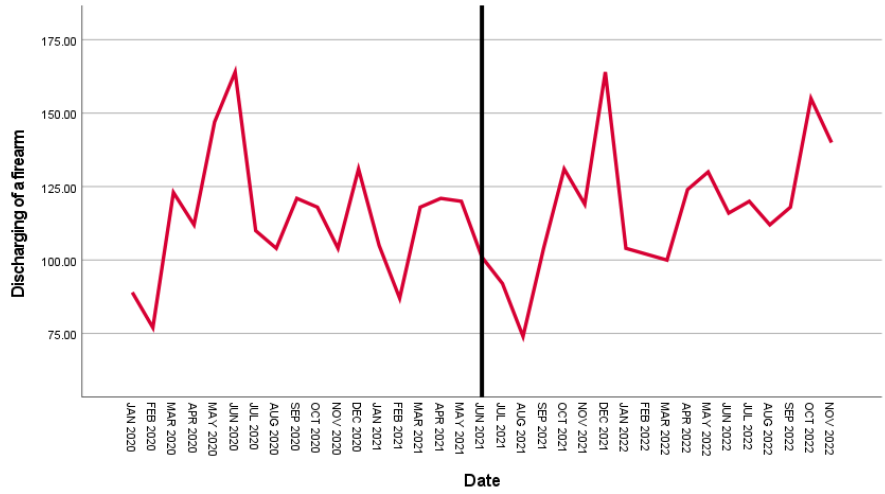

Figure 9. Discharging incidents -Remainder of City.

Turning to more serious violent crime committed with a firearm: homicides, robberies and aggravated assaults (see figures 10-12 below). For the ShotSpotter area we observe lower levels of aggravated assaults after ShotSpotter implementation but see no changes in trends in homicides and robberies, which is most likely an outcome of the relative rarity of these events. By contrast the comparison area and the remainder of Winston-Salem display a growth in assaults levels. What is more, because aggravated assaults are most numerous, they dominate the results we see for the combination of all three violent gun crime types.

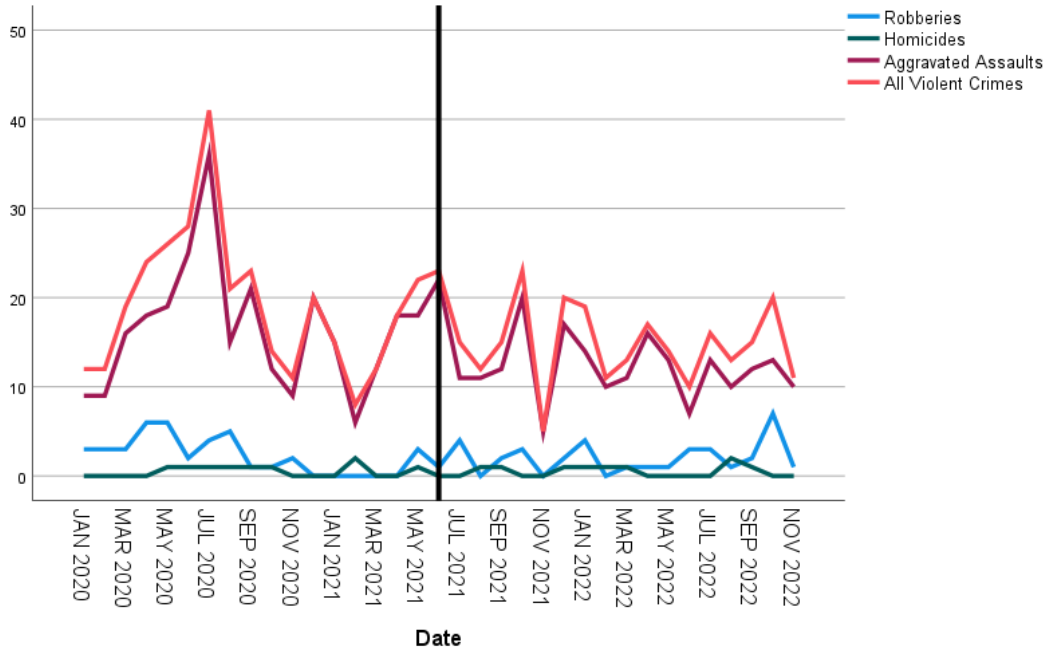

Figure 10. Violent gun crimes -ShotSpotter Area

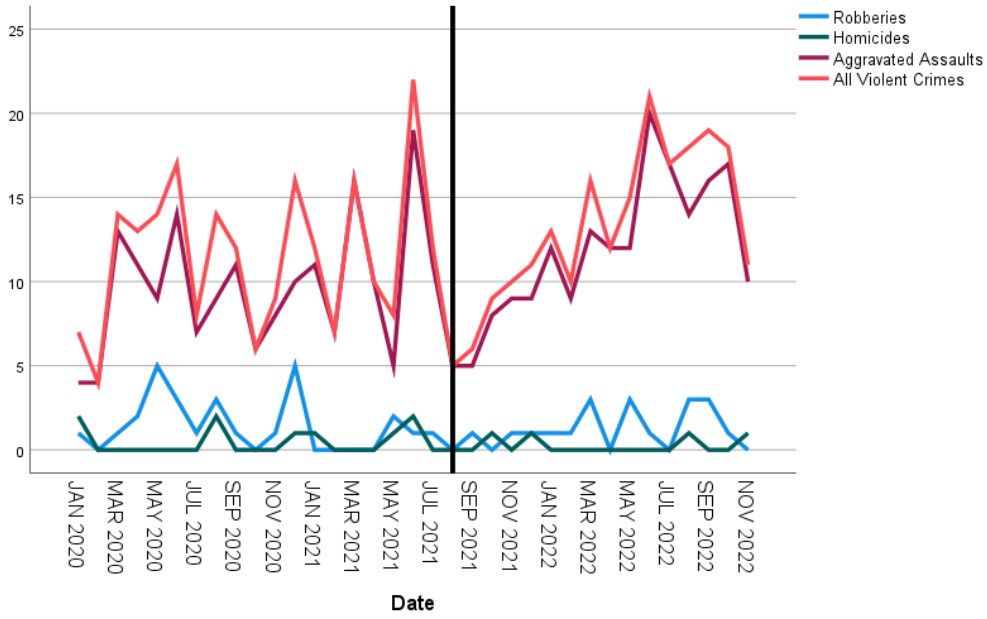

Figure 11. Violent gun crimes - Comparison Area

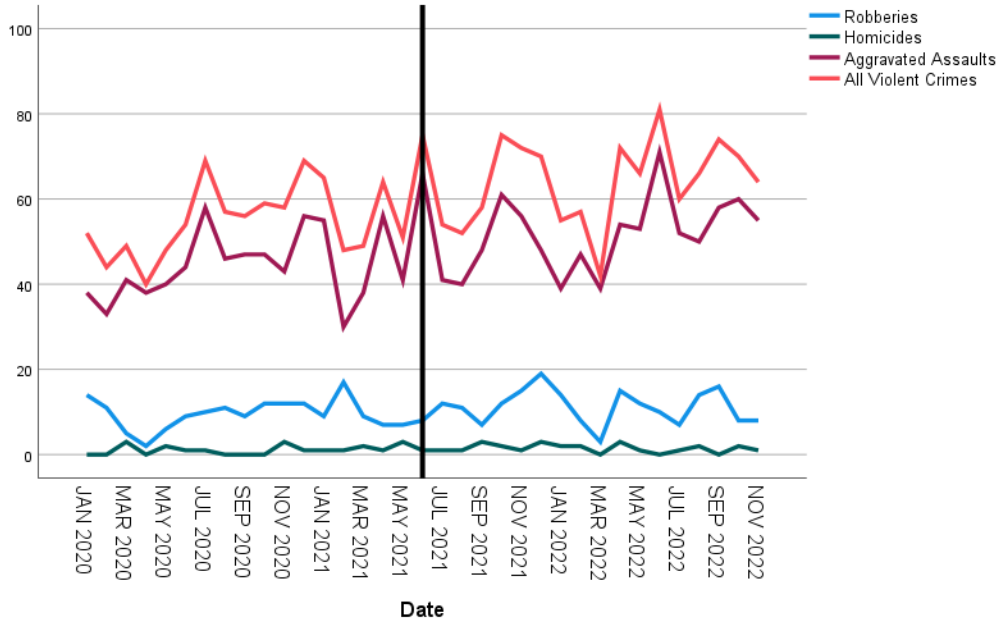

Figure 12. Violent gun crimes -Remainder of City

That said, trends lines are often subjectively interpreted, so it is important to examine whether the trends we described can be verified in statistical analysis. To this end we perform a statistical test (independent t-test) that compare average crime levels before and after ShotSpotter implementation.

Crime Type	*SST area*	*Comparison area*	*Rest of City*
Robbery-Pre	2.32	1.42	9.58
Robbery-Post	1.94 (-16%)	1.19 (-17%)	11.19 (+17%)
Homicide-Pre	.47	.47	1.11
Homicide-Post	.56 (+19%)	.25 (-46%)	1.50 (+35%)
Assault-Pre	16.37	9.74	45.16
Assault-Post	12.13* (-26%)	11.75 (+21%)	51.94* (+15%)
Violent-Pre	19.16	11.63	55.84
Violent-Post	14.63* (-24%)	13.19 (+13%)	64.63* (+16%)
Discharge-Pre	29.21	22.11	112.84
Discharge-Post	71.19***(+143%)	22.00 (0%)	119.56 (+6%)

Table 4. Comparison of before/after crime levels.
Statistical significance is based on independent t-test: * p<.05, ** p<.01, *** p<.001

The results indicate that the ShotSpotter area experienced substantial changes in crime incidents and those changes are consistent with those seen in the earlier trend graphs We should caution to readers that both robbery and homicide are relatively rare for the ShotSpotter and comparison areas and that proportionally large swings in those number are expected, we therefore encourage interpretation primarily focus on the more numerous categories of aggravated assault and discharging of a firearm.

For aggravated assaults the ShotSpotter area displays a statistically significant reduction when comparing before/after ShotSpotter implementation, with an average reduction of around 26%. By contrast the comparison area exhibits a non-significant increase of 21% and the remainder of the city experienced a significant 15% increase.

If we take the results from comparison area (+21%) as the likely change the ShotSpotter area would have experienced without the technology the overall comparative reduction for the ShotSpotter area equals 38%[4], which is a substantial number and comparable to results found in Cincinnati (Mares, 2023). When examining violent crime (combining robbery, homicide and aggravated assaults) a similar conclusion may be reached, which also shows the relatively small numerical impact that robberies and homicides have in overall levels of violence. The ShotSpotter area displays a 24% reduction in mean monthly violence numbers, whereas the control area and the remainder of the city experienced a 13% and 16% uptick respectively. Again, considering the comparison area as a benchmark for expected changes in violence levels, the overall likely contribution of ShotSpotter would indicate a comparative 32% reduction.

For discharging of a firearm events the situation is quite different. Here the ShotSpotter area shows a very large and statistically significant increase, more than doubling prior levels. Both the comparison area (0%) and the remainder of the city (+6%) show a fairly stable picture. While these data might be viewed by some as alarming, they are in fact not; in fact, these results are in line with prior work (Mares & Blackburn, 2021) and a simple outcome of more events being reported and sustained through ShotSpotter. The increase is most likely not an actual increase in people discharging firearms, but merely a reduction in underreporting that is common for such crimes.

[4] Assuming the ShotSpotter area would also have experienced a 21% increase, it would have experienced 19.8 assaults instead of the 12.1 reported, which is a 38% reduction from expected.

What is not included above is a small but potentially important impact the improved speed of the police response may have. Several medical studies have pointed out that a quicker response may -in some cases- prevent death or serious permanent disability to victims of gun violence (Goldenberg et al., 2019; Gontarz et al., 2021). Indeed, WSPD identified two cases in which victims received faster medical care that according to medical professionals likely saved their lives; in one case only a ShotSpotter alert led to the victim. While in such cases ShotSpotter may not prevent crime, it reduces the seriousness of the victimization and the severity of harm. Not only does this have positive effects for victims, the cost-savings of preventing lives lost through improved access to medical care is potentially substantial. Considering that the societal cost of a homicides are easily in the millions, but assaults cost only a fraction of this could have substantial repercussion for the overall cost impacts of gunshot detection systems. The problem is that making this argument can only be robustly done with a large sample of data, likely involving multiple cities and a substantial period of observations.

We would be amiss not to point out to some limitations in the analysis. The amount of data is limited, which prevents more robust types of analysis. Also, the comparison area is not fully comparable to the ShotSpotter area, which could under- or overstate the differences. What is more, 2020 data are likely still very much impacted by COVID-19, which may explain some of the reductions in 2021, even though these were not seen city wide or the comparison site. In short, some caution should be given to the conclusions, and they should be regarded as indicative, but not definitive.

COST IMPACTS

Because aggravated assaults are the driving force of violent crime trends in both the ShotSpotter and Comparison area and because this category in particular show significant reductions in crime after implementation of ShotSpotter we can use this to calculate the impact of ShotSpotter on the cost of crime. To do so we can use two established methodologies to explore: (1) estimated additive cost and (2) Willingness-To-Pay estimates. Additive cost approaches are essentially a simple tallying of all the costs that are incurred by crime, such as medical cost, lost wages and criminal justice related costs. Willingness-To-Pay (WTP) approaches rely on economic research that suggests a simple additive cost approach may be less accurate as it does not reflect the subjective value that people assign to crime concerns. WTP estimates instead rely on asking a large number of people how much they are willing to pay for a specific percentage crime reduction.

For an estimated additive cost, we use data from Rand, which estimates the average cost of an Aggravated Assault at $128,937.40[5]. Because the cost of living in Winston-Salem is lower than the national average, we adjust for this[6] and derive a localized cost of $104,826.11 for each aggravated assault. Using the pre-ShotSpotter average **annual** number of assaults in the ShotSpotter area (196.44) and factoring in just the raw crime reductions achieved (-26%) this represents a reduction of 51 aggravated assaults per year, or an annual cost-savings of $5,353,931. If we incorporate the fact that crime went up in the comparison area and use the comparative reduction of 38% this would suggest 75 fewer assaults per year, or a cost-saving of $7,861,958

Using WTP estimates from Cohen et al. (2004) we find that serious assaults are estimated here to cost an inflation-adjusted average of $124,063.39. Adjusted for the cost-of-living in Winston-Salem this brings us to an estimated cost per aggravated assault of $100,863.54. Using again, both the raw and comparative crime reductions calculated this means a cost savings between $5,144,041 and $7,564,766.

Of course, ShotSpotter costs money and so does the response to the additional gunfire incidents as well as the increasing demand for evidentiary

[5] https://www.rand.org/well-being/justice-policy/centers/quality-policing/cost-of-crime.html with inflation adjusted using https://data.bls.gov/cgi-bin/cpicalc.pl?cost1=87%2C238.00&year1=200701&year2=202301
[6] https://www.bestplaces.net/cost_of_living/city/north_carolina/winston-salem

processing. The current ShotSpotter contract for Winston-Salem costs the city about $205,000 per year. In addition, the WSPD will respond to additional calls for service (ShotSpotter alerts). While this does not incur additional personnel costs -they are already on duty and responses are primarily in otherwise low volume hours (see figure 6), it will incur additional wear and tear on vehicles and increase gas usage. Using the federal mileage rate of 58.5 cents/mile (2022) we can estimate -very roughly- the cost of the immediate response. Assuming an average speed of 45 miles per hour, or .75 miles per minute the average travel distance to and from a ShotSpotter alert is 2x (.75 x 6.87) = 10.3 miles, or a cost of $6.03. multiplying this by the number of alerts per year (1,500) this would only add just over $9,000 for a single vehicle response. However, it is more likely that two vehicles may respond (supervisor) and in some cases additional vehicles may be needed. To be conservative we believe it is reasonable to put vehicle related response cost at around $25,000.

What is less clear is what the cost of evidence processing may be. ShotSpotter delivers a substantial increase in casing recoveries. From August 2021 through the end of 2022, records show ShotSpotter alerts led to recovery of 1,577 shell casings, compared to 2,101 casings recovered in the entire city through conventional means. Estimating the cost of processing these rounds is not simple, as it involves handling by personnel to file and trace the casings as well as the cost of the machines that perform the tracing. What is more, not all casings recovered will need tracing, some are too deformed to reliable match, some may be part of a large number of similar rounds. Just the same if we want to be extremely conservative and price processing for each casing at $100, the total cost is still fairly non-consequential for the overall cost-benefit picture. Annualizing the casings recovered would mean about 1,200 casings per year at a cost of $120,000.

In sum, while the cost-savings, based on crime prevention can be estimated anywhere between $5,144,041 and $7,861,958, the costs of increased surveillance and enforcement are only in the range between $230,000 and $350,000 per year. It should be pointed out, however, that while the savings are shared by all in Winston-Salem, the costs are entirely on the WSPD side.

CONCLUSIONS AND RECOMMENDATIONS

Results of our analyses show positive results from WSPDs implementation of ShotSpotter's acoustic gunshot detection system. The data indicate a substantially faster response time (~5 minutes) in the ShotSpotter area and a reduction in serious violent crimes committed with a firearm (26-38% reduction in aggravated assaults with firearm). Anecdotally the system also improves health outcomes for victims of gunfire, but this is more difficult to establish with current data. Finally, the system appears to improve investigative outcomes by returning substantially more shell casings and increasing arrests for gun-related offenses. These results are most certainly encouraging and indicative of a sound implementation by WSPD.

As our results indicate, the benefits of ShotSpotter certainly appear to outweigh the cost of the city's investment in the technology with a net annual gain to society of about $5-8,000,000 and a cost between $230,000 and $350,000. Even at the lower end of our estimate the implementation of the system indicates a 15 dollar return for each dollar spent. That by all accounts appears to be a solid investment in limited resources. We believe it is therefore reasonable to support continued investment in the technology by WSPD.

We should acknowledge, however, that the current data are somewhat limited for a more comprehensive evaluation, and we encourage WSPD to continue to track its successes with the system and reevaluate the cost-benefits on an ongoing basis. That said, results are in line with other agencies that have shown adherence to best practices, such as Cincinnati (Mares, 2023).

In sum, ShotSpotter deployment in Winston-Salem shows strong potential and initial success based on the current data. We encourage a more extensive evaluation around the 3-year mark when more data has accrued, and a more detailed analysis is feasible. We also commend WSPD for its tracking of the data and the results connected to their response to ShotSpotter investigations. Close tracking of these results is important because crime reductions by themselves may not only be rooted in deterrence, but also in investigative work. Here we would encourage the department to track how ShotSpotter generated evidence (casings and alert data) assist in prosecution of gun offenders. This will likely become more important over time but can provide insights beyond those examined here.

SOURCES

Blackburn, E., & Mares, D. (2019). *The Hidden Costs of Police Technology: Evaluating Acoustic Gunshot Detection Systems.* Police Chief Magazine. https://www.policechiefmagazine.org/the-hidden-costs-of-police-technology/.

Cohen, M.A., Rust, R.T., Steen, S & Tidd, S.T. (2004). Willingness-To-Pay for crime control programs. *Criminology*, 42: 89-110. https://doi.org/10.1111/j.1745-9125.2004.tb00514.x

Goldenberg, A., Rattigan, D., Dalton, M., Gaughan, J.P., Thomson, J.S., Remick, K., Butts,C. & Hazelton, J.P. (2019). Use of ShotSpotter detection technology decreases prehospital time for patients sustaining gunshot wounds." *Journal of Trauma and Acute Care Surgery* 87(6): 1253–1259.

Gontarz B.R., Siddiqui, U.T., Campbell, B., Gates, J., O'Hare J.M., Green, C., McQuay J. & Shapiro D.S. (2021). Firearm Acoustic Detection in Hartford, Connecticut: Outcomes of a Trauma Center - Law Enforcement Collaboration. *Cureus.* 13(10):e18789. doi: 10.7759/cureus.18789.

Haberman, C., Ruhland, E., Frank, J., Kelsay, J. & Desmond, J. (2020). *Cincinnati Police Department: Price Hill ShotSpotter Survey Evaluation Report.* Cincinnati, OH: Institute of Crime Science.

Huebner, B. M., Lentz, T.S. & Schafer, J.A. (2020). "Heard Shots – Call the Police? An Examination of Citizen Responses to Gunfire." *Justice Quarterly.* DOI: 10.1080/07418825.2020.1799063.

Koren, D. (2018). *ShotSpotter Pilot Assessment*. Las Vegas, NV: Las Vegas Police Metropolitan Police Department: Las Vegas, NV.

Lawrence, D., N. La Vigne, and P. Thompson. (2019). *Evaluation of Gunshot Detection Technology to Aid in the Reduction of Firearms Violence*. Urban Institute: Washington D.C..

Mares, D., and E. Blackburn. (2021). "Acoustic Gunshot Detection Systems: A Quasi-Experimental Evaluation in St. Louis, MO." *Journal of Experimental Criminology* 17: 193–215.

Mares, D (2022). *Gunshot Detection: Reducing Gunfire through Acoustic Technology. Problem-Oriented Guides for Police Response Guide Series No. 14.* Bureau of Justice Assistance: Washington D.C..

Mares, D. (2023). "Evaluating an Acoustic Gunshot Detection System in Cincinnati." In E. Groff and C. Haberman, eds. Forthcoming. *The Study of Crime and Place: A Methods Handbook*. Philadelphia, PA: Temple University Press.

Piza, E.L., Hatten, D.N., Carter, J.G., Baughman, J.H., and Mohler, G.O. (2023). Gunshot detection technology time savings and spatial precision: An exploratory analysis in Kansas City. *Policing: A Journal of Policy and Practice*. https://doi.org/10.1093/police/paac097

Vovak, H., Riddle, T., Taniguchi, T., Hoogesteyn, K. & Yang, Y. (2021). *Strategies for Policing Innovation (SPI) in Wilmington, Delaware: Targeting Violent Crime*. Washington, DC: National Police Foundation.

Watkins, C., Mazerolle L.G., Rogan, D. & Frank, J. (2002). Technological Approaches to Controlling Random Gunfire: Results of a Gunshot Detection System Field Test. *Policing* 25: 345–370.

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CCSVP works with Criminal Justice agencies and community organizations to reduce violence and evaluate ongoing efforts to minimize gun violence. We believe in collaborative, evidence-based and data informed actions to serve public interests and those working in the criminal justice field.

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