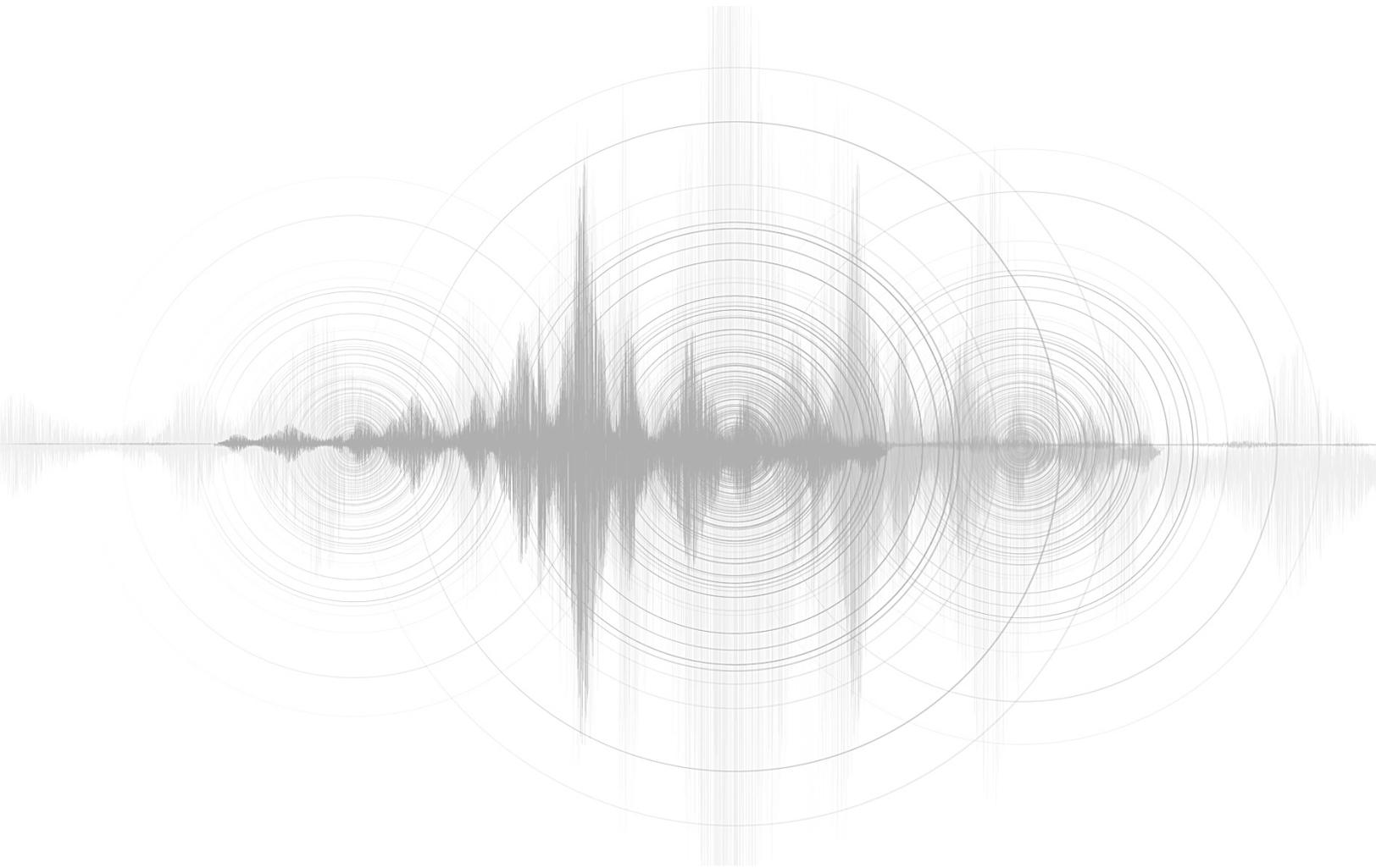Policing
Project
NYU School of Law

MEASURING THE EFFECTS OF SHOTSPOTTER ON GUNFIRE IN ST. LOUIS COUNTY, MO

Prepared by the Policing Project at New York University School of Law

JANUARY 2021

ABOUT THE POLICING PROJECT

We partner with communities and law police to promote public safety through transparency, equity and democratic engagement.

Our work focuses on front-end, or democratic, accountability—meaning the public has a voice in setting transparent, ethical, and effective policing policies and practices before the police or government act. The goal is to achieve public safety in a manner that is equitable, non-discriminatory, and respectful of public values.

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Executive Summary

Gunshot detection systems are used by policing agencies across the U.S. to detect incidents of firearms discharge. The most commonly used gunshot detection system is ShotSpotter, currently deployed in more than 100 cities across the U.S.[1] Such systems typically use sensors, placed strategically throughout a particular area, to pinpoint the location of gunfire.

Agencies that adopt the technology hope that it can help them reduce gun violence and make communities safer. They report that the technology can alert officers to gunshots that otherwise would not be reported, and that it can reduce officer response times by directing them to a more precise location. But the technology can be quite expensive—costing several hundred thousand dollars or more per year to maintain.

To assess the costs and benefits of ShotSpotter, the **Policing Project at New York University School of Law** and lead social scientist Jillian Carr partnered with the **St. Louis County Police Department** (SLCPD)—a large agency with 800+ sworn officers responsible for patrolling the many jurisdictions to the west of St. Louis City.

The department began deploying its ShotSpotter system in several underserved neighborhoods dealing with persistent crime in parts of the North Precinct in June 2017. Because SLCPD implemented ShotSpotter only in parts of the North Precinct, we compared that geographic area to the rest of the North Precinct over time to determine whether there was a change in relevant public safety outcomes due to the adoption of ShotSpotter.

We found that in areas of St. Louis County that used ShotSpotter technology, police were alerted to four times as many gunshot incidents during the study period than in comparable areas without the technology. Despite responding to more calls related to gunfire, we found that reported assaults, which include gun-related assaults, fell by roughly 30 percent in areas with ShotSpotter. Moreover, the technology did not produce changes in the number or pattern of arrests. Because we did not find racially disparate effects on the prevalence of crime reporting or arrests from the adoption of the technology, ShotSpotter's social costs appear minimal.

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1 ShotSpotter Inc. (n.d). *ShotSpotter Cities*. https://www.shotspotter.com/cities/

Disclosures

Since 2018, ShotSpotter Inc., the California-based company that operates ShotSpotter gunshot detection technology, has provided the Policing Project with unrestricted funding (as do other entities) for our policing technology work in general.

In 2019, the Policing Project completed a privacy audit of ShotSpotter Respond (formerly Flex), the company's proprietary gunshot detection system. Policing Project report authors were compensated for time and travel in conducting this audit and assessment. ShotSpotter CEO Ralph Clark also sits on the Policing Project Advisory Board. This board is advisory only, with no legal authority or governing powers over the Policing Project.

The Policing Project's pre-existing relationship with ShotSpotter and pre-existing audit played a role in initiating this report.

How ShotSpotter Works

ShotSpotter is "a patented system of sensors, algorithms and artificial intelligence" that attempts to detect and locate gunfire.[2] The technology analyzes audio signals from a series of acoustic sensors placed around a geographic area for "impulsive sounds characteristic of gunfire." To ensure the sound is truly gunfire, ShotSpotter technology classifies the sound by comparing it to an audio database of community sounds.

This classification step is intended to distinguish whether the sound is, say, a car backfiring, or an actual gunshot. If the machine classifier codes the sound as gunfire, then the sound clip is sent to a live person to verify. At that point, police are notified and respond to the location. This entire process usually takes less than 45 seconds.[3]

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2 ShotSpotter Inc. (n.d.). *ShotSpotter Technology*. https://www.shotspotter.com/technology/

3 ShotSpotter Inc. (2018, January). *ShotSpotter Frequently Asked Questions*. https://www.shotspotter.com/system/content-uploads/SST_FAQ_January_2018.pdf

Potential Benefits and Costs

"It's not something that we definitely get called out on every time it happens." – St. Louis County Police Department Officer describing the lack of 911 calls about gunshots before ShotSpotter was introduced.[4]

Most jurisdictions that adopt ShotSpotter do so because they seek to reduce gun violence. The technology arguably provides a critical resource in jurisdictions with low levels of community trust in the police or low civic engagement, as officers do not have to rely on community members to report gunshots to 911. As shown by researchers Jillian Carr and Jennifer Doleac in a 2016 study, on average only 12 percent of gunfire incidents in Washington D.C. and Oakland, CA resulted in a 911 call.[5] ShotSpotter is believed to increase the likelihood that police will be aware of gunshots and respond to them.

Another benefit of ShotSpotter is that it helps officers go directly to the exact location of gunshots, making it more likely they will find evidence in order to file a report, issue a citation, or make an arrest related to the gunshot incident. When officers respond to dispatches, including those initiated by ShotSpotter, they typically file a report, issue a citation, or arrest an individual only if there is actual evidence at the scene that shots were fired, due to the prevalence of false positives.[6]

Despite false positives, a number of cities that have implemented ShotSpotter tout increased arrests related to gunfire. Between 2015 and 2017, New York City was alerted to 1,740 shootings and made 61 arrests with the technology; Denver officials claim the technology led to 100 arrests over this same time period.[7] For many of these reasons, St. Louis County adopted ShotSpotter technology in 2017.

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4 Feldman, E. (2019, June 27). Proposal would expand ShotSpotter to help police pinpoint gunfire. *KSDK News*. https://www.ksdk.com/article/news/crime/proposal-would-expand-shotspotter-to-help-police-pinpoint-gunfire/63-b531605f-13f3-4d5a-a44c-9bec72be8a71

5 Carr, J.,& Doleac, J. (2016, July 28). *The geography, incidence, and underreporting of gun violence: New evidence using ShotSpotter data*. https://www.brookings.edu/research/the-geography-incidence-and-underreporting-of-gun-violence-new-evidence-using-shotspotter-data/

6 In Carr and Doleac (2018), the authors had to exclude data from the week around July 4th for this reason. The timing of adoption of ShotSpotter by SLCPD during peak fireworks season also led to an anecdotal issue with frequent false reports due to fireworks. Carr, J., & Doleac, J. (2018) Keep the Kids Inside? Juvenile Curfews, and Urban Gun Violence. *Review of Economics and Statistics*, 100 (4): 609-618.

7 ShotSpotter Inc. (2018, January). *ShotSpotter Frequently Asked Questions*. https://www.shotspotter.com/system/content-uploads/SST_FAQ_January_2018.pdf

Despite the potential benefits of ShotSpotter, it does not come without costs.

First, it is an expensive technology. ShotSpotter's website reports that the cost for the cloud-based subscription service is "$65-90k per square mile per year, with a $10k per square mile one-time initiation fee."[8] This can cost cities upwards of hundreds of thousands of dollars depending on the size of the implementation area and length of contract. For example, in 2013 Peoria, IL signed a three-year, $405,000 contract with ShotSpotter over a three-square mile area.[9] According to news reports, a two-year contract with ShotSpotter cost St. Louis County roughly $520,000, the first year of which was paid for through a federal grant.[10]

Second, the technology may introduce heightened levels of surveillance in communities, and often in communities of color.[11] Although a recent audit by the Policing Project did not find that ShotSpotter technology posed a threat to individual privacy as audio recordings are purged routinely, it does trigger a range of police responses that can have disparate effects.[12] For example, ShotSpotter can result in heavier police presence in communities of color, negative stereotyping of neighborhoods that have the technology, and greater CCTV surveillance in those areas. This in turn can result in negative encounters between the police and public and possibly more complaints filed by community members against officers.

8 ShotSpotter Inc. (2018, January). *ShotSpotter Frequently Asked Questions*. https://www.shotspotter.com/system/content-uploads/SST_FAQ_January_2018.pdf

9 Associated Press. (2015, March 1). Peoria police expand use of gunshot detection technology. *Daily Herald*. https://www.dailyherald.com/article/20150301/news/303019939 | Gatens, A. & Reichert, J. (2019, December 13). *Police Technology: Acoustic Gunshot Detection Systems*. Illinois Criminal Justice Information Authority. http://www.icjia.state.il.us/assets/articles/Shotspotter-Final-191213T18420528.pdf

10 KMOV4 (2019, January 15). St. Louis County looks at expanding ShotSpotter program. https://www.kmov.com/news/st-louis-county-looks-at-expanding-shotspotter-program/article_60d08616-18c0-11e9-8e91-0b32d146f616.html | Lippmann, R. (2017, June 29). St. Louis County Police turn on sensors they say will combat gun violence. *St. Louis Public Radio*. https://news.stlpublicradio.org/government-politics-issues/2017-06-29/st-louis-county-police-turn-on-sensors-they-say-will-combat-gun-violence

11 Coleman, R., & Brunton, D. (2016, December 14.) "You might not know her, but you know her brother": Surveillance Technology, Respectability Policing, and the Murder of Janese Talton Jackson. *Souls*, 18:2-4, 408-420, DOI: 10.1080/10999949.2016.1230829

12 The Policing Project at New York University School of Law. (2019, July 31). *Privacy Audit & Assessment of ShotSpotter, Inc.'s Gunshot Detection Technology*. https://www.policingproject.org/shotspotter | Stanley, J. (2015, May 5). *ShotSpotter CEO Answers Questions on Gunshot Detectors in Cities*. American Civil Liberties Union. https://www.aclu.org/blog/privacy-technology/surveillance-technologies/shotspotter-ceo-answers-questions-gunshot

Third, policing agencies worry that the presence of ShotSpotter technology may de-incentivize residents who typically report gunfire from doing so in the future, which could result in a loss of valuable suspect information. Caller-initiated 911 reports can produce additional information about an incident, such as suspect descriptions or knowledge of pre-existing relationships between individuals at the scene, that ShotSpotter cannot. According to a 2019 news report, the St. Louis County police said that despite having ShotSpotter in certain areas, they still want residents to call 911 about gunfire to obtain critical witness information.[13]

In this report, we evaluate ShotSpotter in St. Louis County to better understand the costs and benefits associated with the technology. We focus on a set of public safety outcomes, including changes in calls for service, crime rates, arrests rates, and any evidence of racially disparate impacts.

Study Design

Research Questions

- How does ShotSpotter impact the number and types of calls for service to which police respond?
- Are officers more likely to file a report related to shots fired in ShotSpotter areas?
- Are there impacts on other types of reported crimes in ShotSpotter areas?
- Do officers make more arrests related to gunfire incidents or possession of firearms in ShotSpotter areas?
- Does the use of ShotSpotter lead to disproportionate impacts on community members of color?
- Does the presence of ShotSpotter change the prevalence of community member complaints against officers?

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13 KMOV4. (2019, January 15). St. Louis County looks at expanding ShotSpotter program.
https://www.kmov.com/news/st-louis-county-looks-at-expanding-shotspotter-program/article_60d08616-18c0-11e9-8e91-0b32d146f616.html

Institutional Context in St. Louis County

The St. Louis County Police Department is located in St. Louis County, Missouri and serves approximately one million residents across eight distinct precincts. The precincts are further divided into 81 smaller "beats." In residential areas, each beat is around two square miles. In industrial and less populous areas, they often are larger.

St. Louis County Police Department employs roughly 1,000 commissioned officers and 328 professional staff members.[14] They serve a racially diverse population that is 68 percent white, 25 percent Black or African American, and 3 percent Hispanic or Latino. The median household income in St. Louis County between 2015–2019 was $67,420, which is similar to the national median.[15]

To better understand the context in which police operate in St. Louis County, below we present patrol statistics. The statistics include the number of a) caller requests for police services, b) officer-initiated incidents, and c) violent and property crimes, across each of the eight precincts. The North Precinct's high number of violent crimes, many of which involved firearms, was a motivating factor in the department's decision to adopt ShotSpotter technology in parts of that area.

Table 1. Patrol Statistics from St. Louis County Police Department

Precinct	No. Caller Requests	No. Officer-Initiated Incidents	Pop. Size	No. of Violent Crimes	No. of Property Crimes
1-North	123,924	66,975	96,458	814	2,606
2-Central	31,158	42,897	76,060	239	748
3-Affton SW	49,509	53,369	98,576	150	1,210
4-South	60,582	35,876	84,561	227	1,887
5-City of Fenton	11,447	20,644	4,181	16	412
6-City of Wildwood	12,854	29,439	35,517	19	109
7-West	26,138	48,700	54,277	77	431
8-City of Jennings	30,936	17,598	14,775	283	668

Note: These numbers come from St. Louis County Police Department's 2019 annual report.[16]

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14 St. Louis County Police Department (n.d.). *Inside the Police Department.* https://www.stlouiscountypolice.com/Who-We-Are/Inside-SLCPD

15 U.S. Census Bureau. (2019, July 1). *QuickFacts: St. Louis County, Missouri.* https://www.census.gov/quickfacts/stlouiscountymissouri

16 St. Louis County Police Department Bureau of Research and Analysis. (2019). *St Louis County Police Department Annual Report.* https://www.stlouiscountypolice.com/Portals/0/County%20Police/Annual%20Report%202019.pdf

The boundaries of the North Precinct and ShotSpotter coverage areas are visible in the below map.

Image 1: Map of the Northern Precinct in St. Louis County with ShotSpotter Coverage and "Treated" Beats
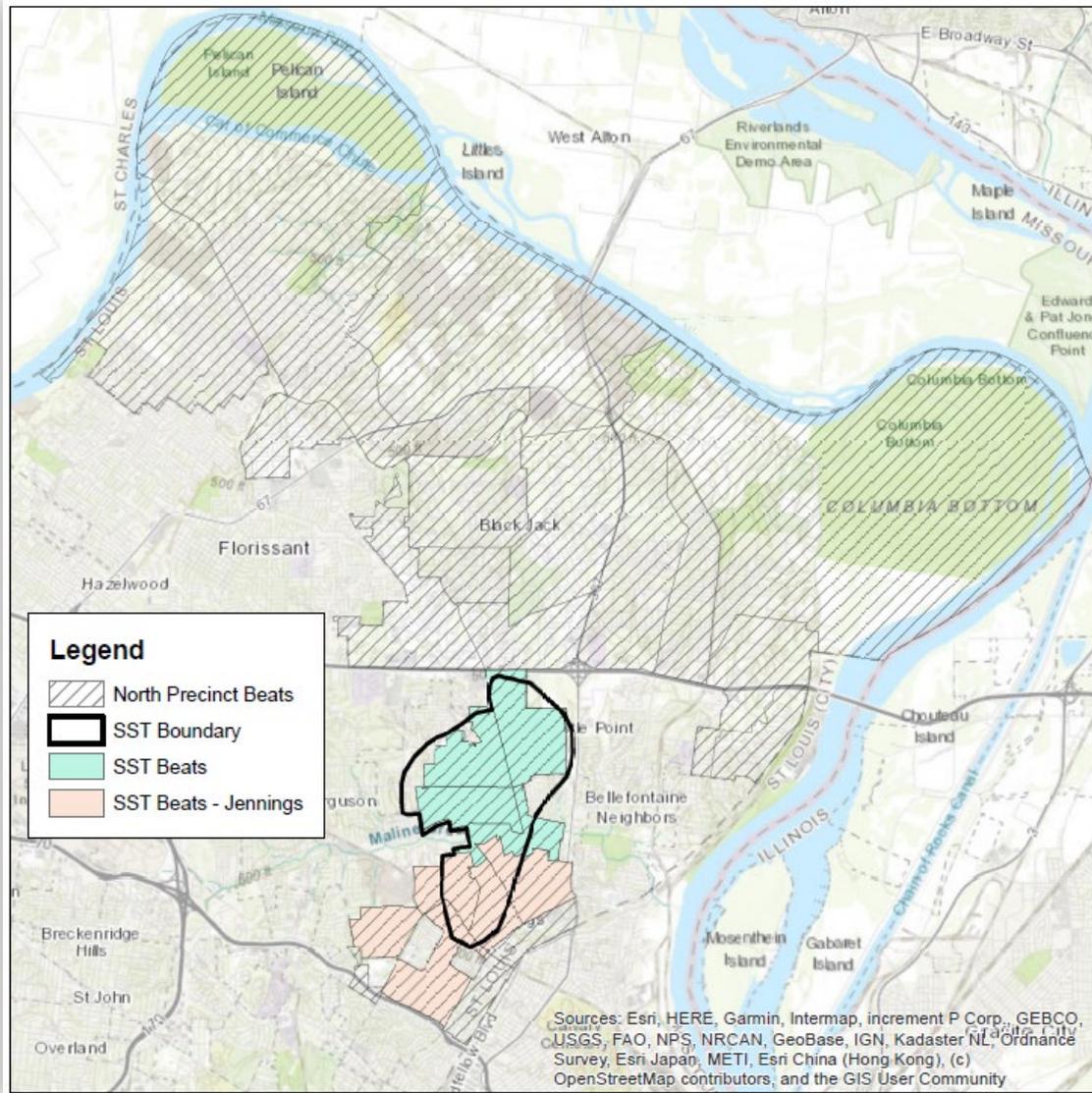
Note: Map created in ArcMap using ShotSpotter coverage and police beat boundaries provided by the St. Louis County Police Department. Street map obtained from ESRI and attributed above.

Methodology

As with evaluating any policy intervention, the challenge is to isolate the effects of the intervention —in this case ShotSpotter deployment—on specific outcomes from changes due to other factors, such as changes in policing practices, seasonal effects, or chance increases and decreases in crime. Ideal experimental design would randomize which neighborhoods were in the treatment group that received ShotSpotter technology and which were in the control group and did not, as in a pharmaceutical trial.

However, that approach likely would have led to an inefficient allocation of expensive sensors. Instead, St. Louis County Police Department selected the areas with the highest gun crime for ShotSpotter implementation, as these places were poised to receive the greatest potential benefit from the technology.

Because ShotSpotter only was deployed in a small number of neighborhoods in the North Precinct, we were able to take advantage of the partial roll out to isolate the effects of the technology. Despite geographic and socioeconomic differences between areas that received ShotSpotter and those that did not, we used trends in crime from before and after the time of implementation as a useful counterfactual.

Suppose that gun crime was increasing across the county when ShotSpotter was first activated. If it continued to increase in places without ShotSpotter, but fell drastically in places with ShotSpotter, we reasonably can attribute the decrease to the technology. Formally, the model used to capture these changes is called a "difference-in-differences" model.

Data

For this analysis, we analyzed several datasets provided to us by the St. Louis County Police Department. All the datasets include the exact locations where an incident occurred, so we are able to determine whether the incident occurred in a place with ShotSpotter technology.

First, we focused on calls for service. This dataset captures caller requests for police services, as well as gunfire alerts detected by ShotSpotter. The data includes the initial nature of the incident,

whether an officer was dispatched in response to the incident, the number of units that were dispatched, and the location to which they were sent.

Second, we analyzed data on reported incidents. When an officer discerns that a crime incident has occurred, they file an incident report with a number of details. Not all calls for service result in an incident report and not all reports start with a call for service. An officer can initiate an incident report if they witness a criminal act in progress or one is reported directly to them.

Third, we analyzed data on arrests. We observed whether an arrest was made, as well as the offense the arrest was for, and the demographics of the arrestee. These data were linked to the call-for-service data.

Fourth, the St. Louis County Police Department provided us with data on citizen complaints against the department, but this is such a low frequency event that we were unable to make many inferences about changes in complaints due to ShotSpotter.

Note that we do not include datasets generated by ShotSpotter sensors in our analysis, beyond the impact that they have on the number of calls for service officers take in response to reported gunshots. This is for a simple reason: ShotSpotter sensor data only exist in places with the technology, making comparison to places without the technology impossible.

Results

Changes in Dispatches for Calls for Service

We first measure the effect of ShotSpotter on the volume and type of calls-for-service that the St. Louis County PD received from April 2015 through October 2018.

In *Figure 1*, we consider the total number of units dispatched in response to calls for service over time in areas with and without ShotSpotter, measured quarterly. The vertical red line marks the moment when ShotSpotter first was activated (June 26, 2017). Everything to the right of the vertical red line captures moments in time when ShotSpotter was active, and everything to the left captures times before ShotSpotter was in use. The solid blue line displays the quarterly sum of total units dispatched to police beats covered by ShotSpotter—referred to as the "treated" areas. The red

dashed line displays the same, but for police beats not covered by ShotSpotter—referred to as the "not treated" areas.

Figure 1. Total Count of Dispatches
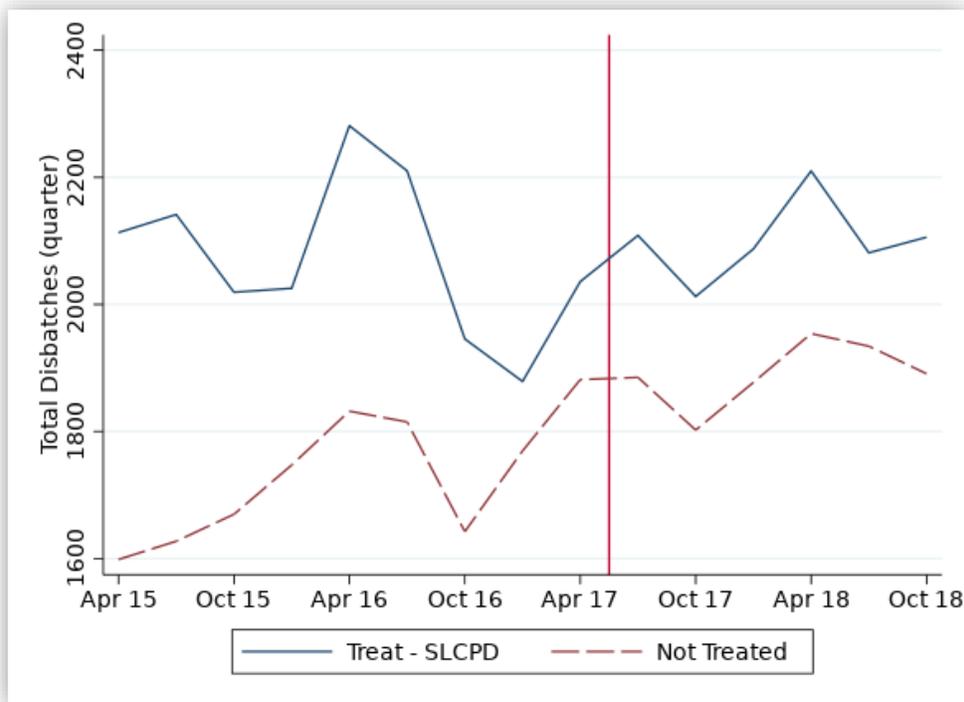
We see that the treated areas (those with ShotSpotter) have more police units dispatched to their neighborhoods both before and after implementation, relative to those areas without ShotSpotter. This is consistent with the fact that St. Louis County Police Department intentionally selected areas with high numbers of incidents for ShotSpotter implementation.

Next, we report changes in the number of calls for service that we can attribute to ShotSpotter. We find an increase of over one call for service per day in beats with ShotSpotter technology (this equates to 39 more calls per month, although this result is not statistically significant). The increase in calls for service primarily is driven by two types of calls: calls to report gunshots and calls about domestic violence.

With statistical confidence, we can say that ShotSpotter implementation led to the police being alerted to four times as many gunshot incidents during the study period. Before ShotSpotter was implemented, the average number of calls for service to report gunshots was seven per month.

After ShotSpotter was implemented, the average number of reported gunshot calls for service increased to 31 per month.

This increase likely is a result of ShotSpotter technology alerting the police to more gun-related incidents, though we cannot say with confidence the exact breakdown between ShotSpotter alerts and caller 911 requests due to data limitations. A 2018 news report suggests, however, that most of the increase we observe is due to ShotSpotter alerts, as only 12 percent of ShotSpotter initiated events between June 26, 2017 and June 9, 2018 were accompanied by a 911 call.[17]

Figure 2 illustrates these findings by showing that the "treated" areas, represented by the blue solid line, experienced a dramatic increase in the number of gunshot related calls for service after the 2017 implementation. We do not see a similar increase in areas without ShotSpotter.

Figure 2. Calls for Service to Report Gunshots

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[17] Kormann, K. (2018, June 14). Gunshot detection system "ShotSpotter" one year later. *Fox 2*. https://fox2now.com/news/gunshot-detection-system-shotspotter-one-year-later/

We also find some evidence that areas with ShotSpotter experienced an increase in calls for service about domestic violence. Police responded to four additional domestic violence related calls per service per month in areas with ShotSpotter. There is reason to believe this change may signal an increase in community level trust in the police, though further research is needed to understand the mechanisms at play.

Changes in Crime Reporting

Overall crime reporting appears not to have been impacted by the implementation of ShotSpotter.

In *Figure 3*, we report the quarterly averages of reported crime incidents (of any type) for the locations with ShotSpotter compared to those without it. Again, the vertical red line marks the moment when ShotSpotter first was activated (June 26, 2017). Everything to the right of the vertical red line captures moments in time when ShotSpotter was active, and everything to the left captures times before ShotSpotter was in use. The solid blue line shows that locations where ShotSpotter was implemented have higher numbers of reported crimes in general, which is to be expected given optimal decision-making about where to use the technology. We do not see a sharp increase or decrease in crime reporting following the implementation period.

Figure 3. Total Crimes Reported
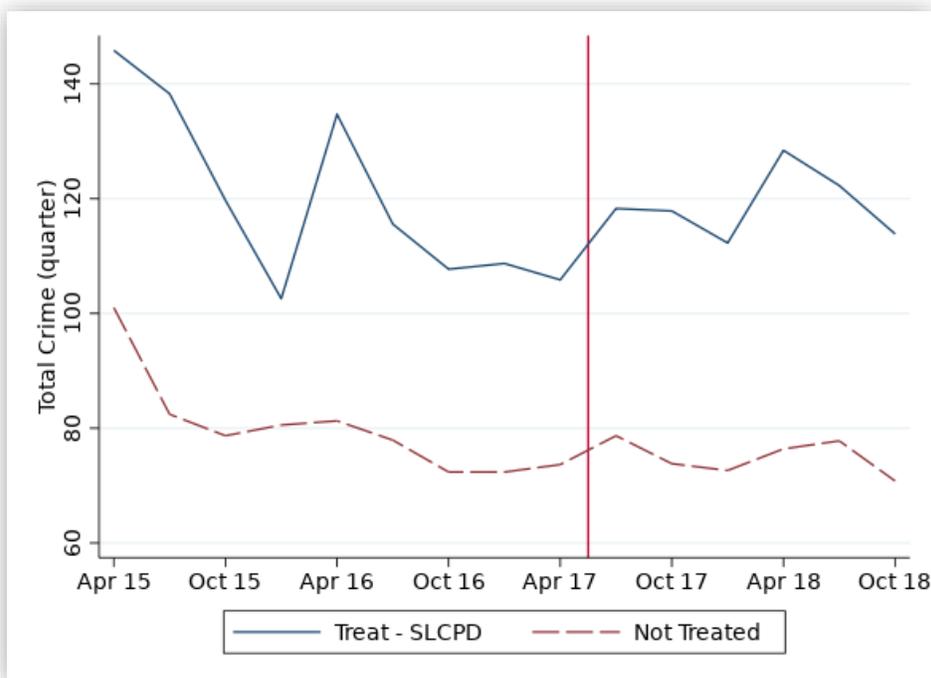
However, when we perform the same type of analysis as above but break out the results by types of crime, we find that the reporting of assaults *falls* in areas with ShotSpotter technology. When an individual uses a gun to physically harm someone without killing them, it is categorized as an assault. The size of the decrease is around 1.2 fewer reported assaults per month per beat. Across the eight beats with ShotSpotter, this accounts for around ten fewer assaults per month that can be attributed to ShotSpotter, or around a 30 percent decline in reported assaults.

The ShotSpotter effect on assaults could occur through a number of channels. First, the swift and accurate response of police to previous shots fired incidents could deter future confrontations from escalating to serious incidents. Second, if previous police responses to ShotSpotter activations result in arrests, the pool of individuals likely to be involved in future assaults could shrink. If these arrestees are detained awaiting trial, or on probation, they may be unable or at least strongly disincentivized to be involved in violent incidents. Third, if any illegally possessed firearms are seized by law enforcement in responding to a ShotSpotter activation, then the stock of firearms available is potentially reduced, which could account for a reduction in these types of incidents.

We do not find statistically significant effects of ShotSpotter on other types of crime. This is not entirely surprising, as there is no reason to expect that ShotSpotter would impact the number of property crimes in an area, for example. The fact that we do not find changes in reporting for other types of crime adds support to the validity of our findings regarding assaults.

Arrests

One of the benefits ShotSpotter reports is that it helps police fight crime by arresting individuals who allegedly are involved in crime. However, we do not find clear evidence to support this claim in St. Louis County. ***We find no evidence that the implementation of ShotSpotter resulted in more arrests related to gunfire incidents, nor do we find any evidence that it resulted in an increase in arrests generally***. Overall arrests appear unchanged by the implementation of the technology.

Figure 4 shows the quarterly totals of arrests (of any type) for the areas "treated" with ShotSpotter implementation compared to those where the technology is not deployed. We see that arrests overall are higher in areas treated with ShotSpotter, but there is no clear pattern of increased arrests after implementation. Even when we consider arrest by the type of crime (e.g., assaults or gunshot reports), we still find no appreciable effects using the same empirical approach.

Figure 4. Total Arrests Reported
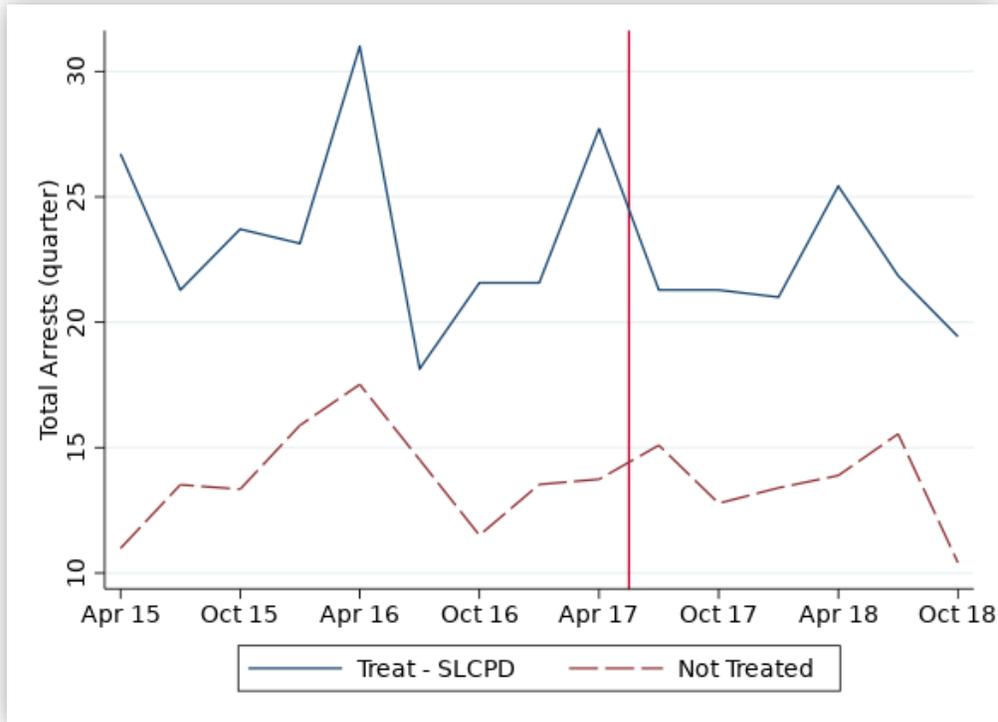
It is difficult to know exactly why we do not find a discernible effect on arrests, but our results suggest that ShotSpotter may deter future confrontations from escalating to serious incidents. We believe this for two reasons.

First, given that the presence of ShotSpotter did not lead to an increase in arrests, it is unlikely that the reason we find no effect on arrests is because prior arrests shrank the pool of individuals involved in future assaults. Second, given that we find an increase in gunfire alerts over the study period, it seems unlikely that the reason we do not find an effect on arrests is because of a reduced stock of firearms. Gunfire still is prevalent in these areas.

Although our results are suggestive of ShotSpotter's ability to deter incident escalation, additional research is needed to test these mechanisms.

Social Costs and Benefits

Although we were concerned that the adoption of a new surveillance technology could lead to differential impacts on communities of color, we did not find any evidence that the technology

exacerbated racial disparities in arrests. However, Black residents already were disproportionately represented in the arrest data we analyzed in St. Louis County: despite constituting 25 percent of the population, they made up approximately 50 percent of arrests. Arrests were more racially disproportionate in the North Precinct where ShotSpotter was adopted.

Because our analysis found that ShotSpotter alerted officers to more gun-related incidents in the North Precinct, which theoretically could result in arrest, it was plausible that the technology would further contribute to racially disparate arrest patterns. However, we found no evidence from St. Louis County that ShotSpotter contributed to an increase in racial disparities in arrests.

Furthermore, when we considered the ways in which arrests are initiated by the police (e.g., either officer-initiated or in response to a dispatch) combined with the race of the arrestee, we still find no relationship. These results suggest that ShotSpotter does not introduce further social costs from policing to St. Louis County.

There are no detectable effects of ShotSpotter on community member complaints, but these are a low frequency outcome.

Conclusion

In short, we found that in areas of St. Louis County that used ShotSpotter technology, police were alerted to more instances of gunfire than in comparable areas without the technology. This increase in gunfire awareness was accompanied by a 30 percent decrease in reported assaults. We did not find any evidence that the technology exacerbated racial disparities in arrests or contributed to a greater number of arrests.