The Effect of ShotSpotter Technology on Police Response Times

WEAI Conference

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Motivation:

Gun Violence in the US:

- 2021: Most gun fatalies ever (Pew Research Center)
- 2022: 647 mass shootings (Gun Violence Archive)
- All-time high mistrust of police (Washington Post)

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Solution?

- ShotSpotter Technology
  - Gunshot dectection
  - "Colorblind"
- Widespread (150+ cities)
  - Our setting: Chicago
- Costly: $11 million a year

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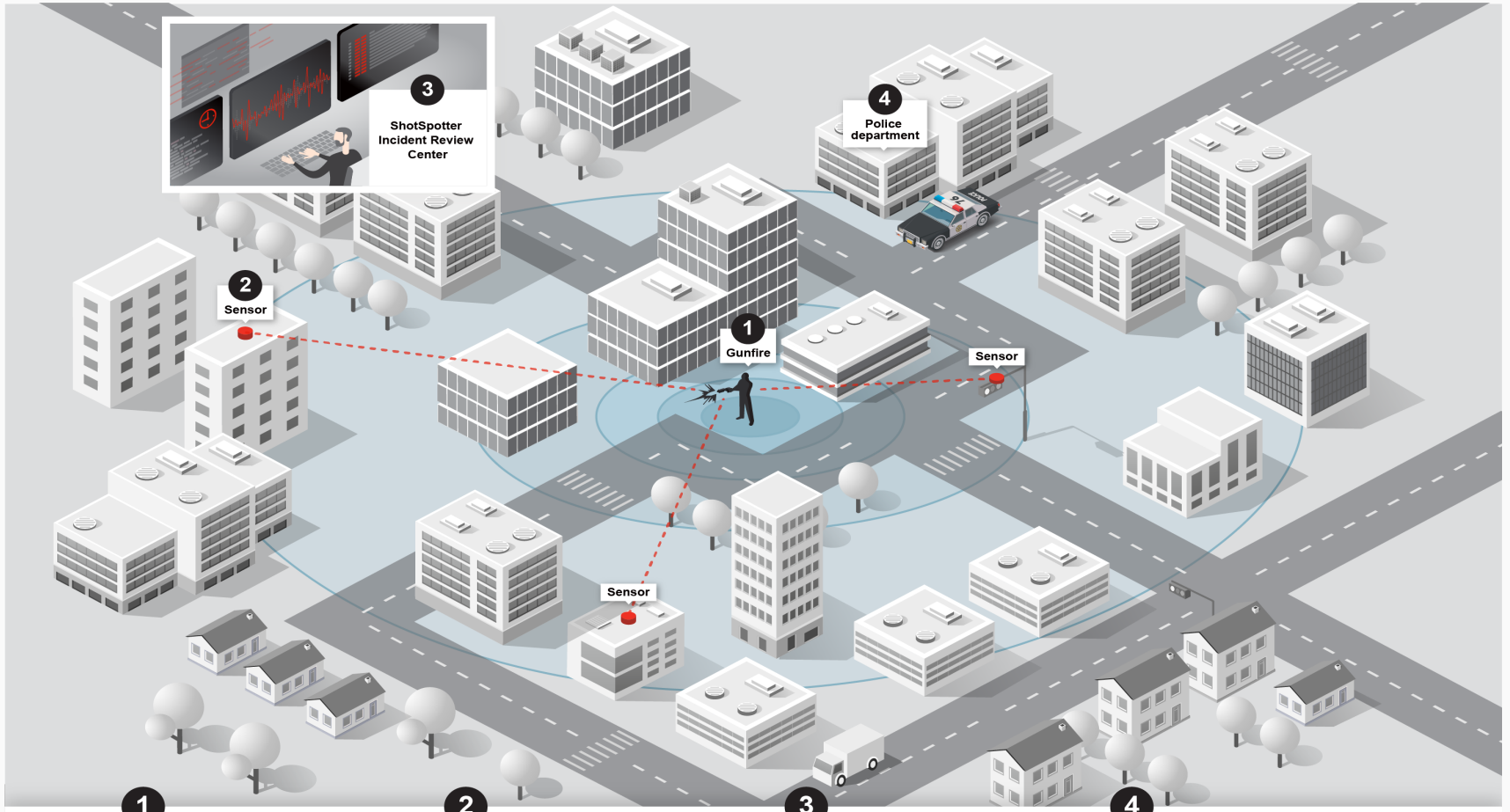
Research Question:

How does investment in ShotSpotter affect the time allocation of scarce police resources ?

- Priority 1 (immediate dispatch): 911 Call-to-dispatch / Call-to-on-scene

What is ShotSpotter and how does it work?



1 Gun is fired

When a gun is fired, the sound of a muzzle blast radiates outward.

2 Gunshot is Detected and Located

Acoustic sensors are triggered by the impulsive sound. The sound is classified as a gunshot using artificial intelligence and triangulation determines the precise location.

3 Gunshot is Reviewed

The data is relayed to the ShotSpotter Incident Review Center where analysts quickly audit the data and publish confirmed gunshots to police.

4 Police Respond

Alerts are sent to dispatch centers and patrol officers' smartphones and MDTs for immediate response. The entire process takes less than 60 seconds.

Why do we care about response times?

> “If police can arrive within one minute of the commission of an offense, they are more likely to catch the suspect. Any later and the chances of capture are very small, probably less than one in ten.”- (Baley 1996)

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Support for Reponse Times:

- Lower response times results in:
  - Less likelihood of an injury (DeAngelo et al. 2023)
  - Higher crime clearance (Blanes i Vidal and Kirchmaier 2018)
- Rapid response most important (College of Policing 2013)

Why would ShotSpotter affect response times?

Police Forces:

- A fixed amount of daily resources

ShotSpotter Resource-Intensive:

- Respond to every alert (Priority 1)
- ~60 ShotSpotter dispatches a day
- ~20 minutes inspecting the scene

Time Wasted?

- Does this time investment come at the expense of other important 911 calls?

Summary of Paper:

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Setting:

- Chicago: 2016-2022
  - Second largest police force
  - Third largest city

Data:

- All 911 call dispatches from Chicago
- Merge with:
  - Police shifts
  - Crime/arrest/victimization data
  - ShotSpotter alerts

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Empirical Strategy:

- Staggered difference-in-difference
  - Variation: ShotSpotter rollouts across police districts

Main Results:

- For Priority 1 911 calls:
  - +1 minute call-to-dispatch (23%)
  - +2 minutes call-to-on-scene (14%)
- Lower arrest rates (5%)
- Lower gun victimization (16%)

Contribution:

In-depth, causal analysis on a wide-spread police technology, whose consequences are relatively unknown.

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Related Literature:

ShotSpotter Specific

Police Technology

Rapid Response

We find unintended (increased response times/lower arrest rates) and intended (lower gun violence) outcomes.

- Economics:
  - Use ShotSpotter as data for alternative crime/mistrust measure (Carr and Doleac 2018, Ang et. al 2021)
- Non-Econonomics:
  - Mixed response time results (Mazerolle et al. 1998, Mares and Blackburn 2021)

Contribution:

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Related Literature:

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Rapid Response

We find detrimental consequences of an expensive, resource-intensive, technology.

- Benefits of Police Technology:
  - Body Worn Cameras → lower use of force/complaints (Zamoff et al. 2021, Braga et al. 2022, Ferrazares 2023)
  - Predictable Policing → less crime (Mastourbi 2020)
  - Tactical Equipment → less crime (Bove and Gavrilova 2017, Harris et al. 2017))

Contribution:

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Related Literature:

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Rapid Response

We identify a determinant of higher response times, and can quantify at a micro-level.

- Effects of Response Times:
  - Less likelihood of an injury (DeAngelo et. al. 2023)
  - Higher crime clearance (Blanes i Vidal and Kirchmaier 2018)

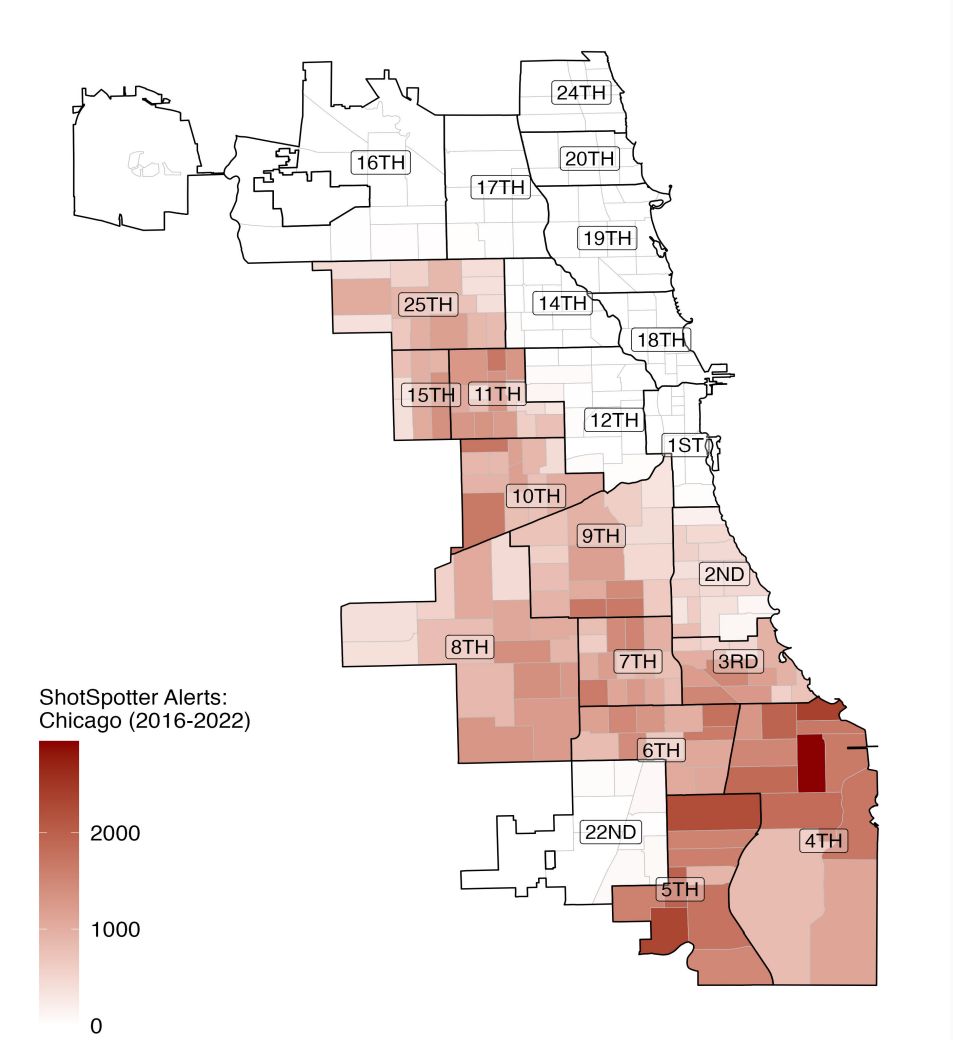
ShotSpotter in Chicago:

Staggered Rollout

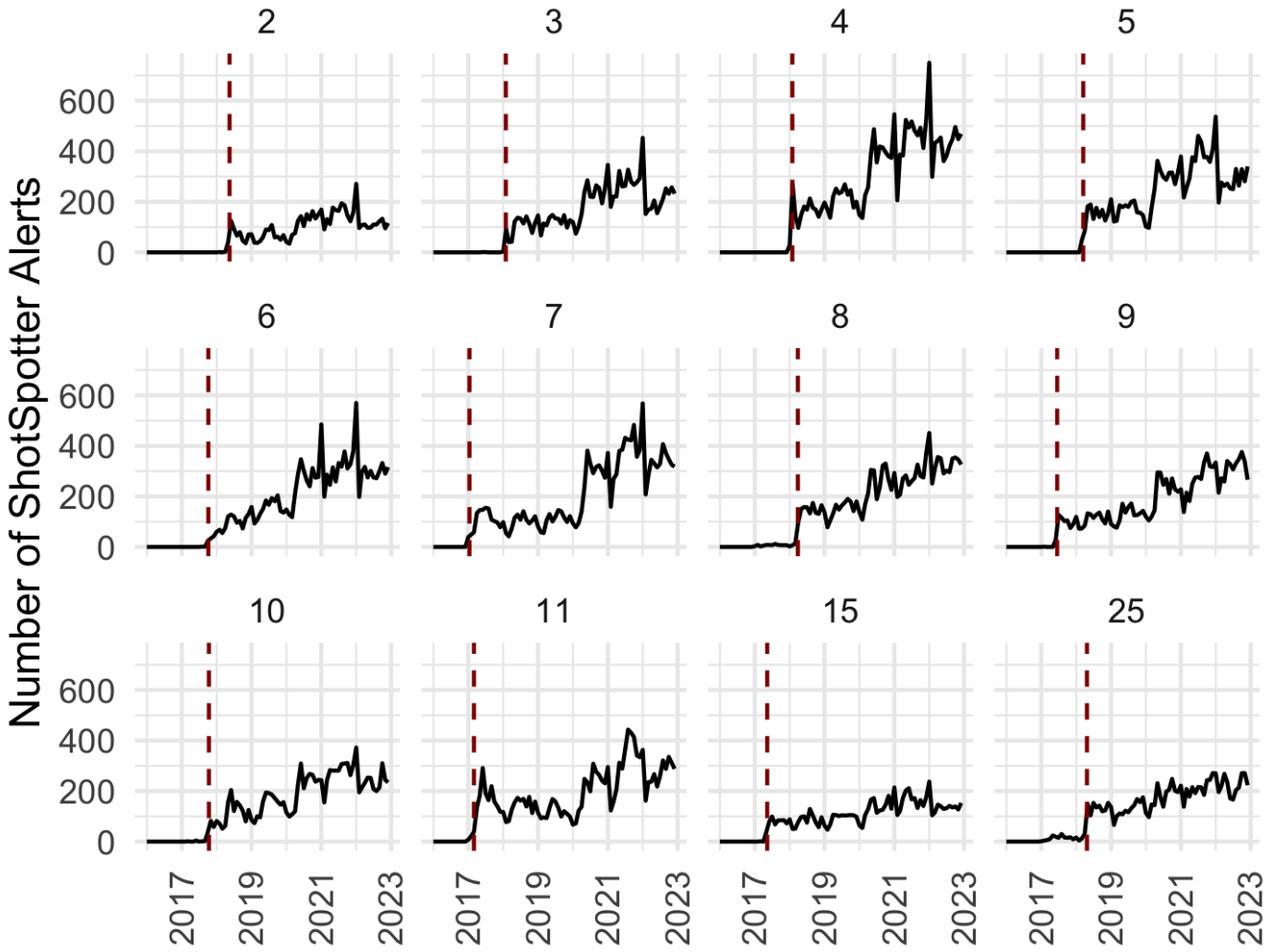
- 12 of 22 police districts in 2017-2018

High Priority

- Priority 1 (immediate dispatch)
  - Active shooter, domestic disturbance
  - ~5% of all Priority 1 dispatches
- Same operating procedure as 911
  - No specialized response team



ShotSpotter Alert Trends/Averages:



District	Mean Shots
2	3.509
3	6.072
4	10.731
5	8.243
6	7.097
7	6.926
8	7.578
9	6.372
10	6.244
11	6.611
15	3.833
25	5.823

Estimation Strategy:

Specification (OLS):

$$Y_{d,t} = \beta ShotSpotterEnacted_{d,t} + \gamma_d + \delta_t + \lambda \mathbb{X}_{d,t} + \epsilon_{d,t}$$

Estimation Strategy:

Specification (OLS):

$$Y_{d,t} = \beta ShotSpotterEnacted_{d,t} + \gamma_d + \delta_t + \lambda \mathbb{X}_{d,t} + \epsilon_{d,t}$$

- $Y_{d,t}$ is an outcome of average **daily** time (in seconds) in police district d in time t
  - Priority 1 911 Call-to-Dispatch/911 Call-to-On-Scene
- $ShotSpotterEnacted_{d,t}$ is the binary treatment
- γ_d is a police district-specific fixed effect
- δ_t is a day-by-month-by-year fixed effect
- $\mathbb{X}_{d,t}$ is a vector of controls:
  - Officer hours, number of 911 calls (by priority)
- Standard errors clustered by police district
- β interpretation: average change in average daily response time

Main Results:

Call-to-Dispatch | Call-to-On-Scene | Arrest Rate | Gun Victimization

			Officer Hours > Median	<= Median
	(1)	(2)	(3)	(4)
ShotSpotter Activated	63.147***	71.915***	26.509**	91.126***
	(20.824)	(21.646)	(11.608)	(29.647)
Mean of Dependent Variable	263.941	263.941	215.487	312.299
Observations	55,792	55,792	27,868	27,924
FE: Day-by-Month-by-Year	X	X	X	X
FE: District	X	X	X	X
Gardner (2021) Robust		X		
Note:				
* p < 0.1, ** p < 0.05, *** p < 0.01				

Main Results:

Call-to-Dispatch | **Call-to-On-Scene** | Arrest Rate | Gun Victimization

			Officer Hours > Median	<= Median
	(1)	(2)	(3)	(4)
ShotSpotter Activated	108.269***	124.887***	60.480***	143.476***
	(24.346)	(25.306)	(19.850)	(32.508)
Mean of Dependent Variable	769.284	769.284	710.531	827.917
Observations	55,791	55,791	27,867	27,924
FE: Day-by-Month-by-Year	X	X	X	X
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Call-to-Dispatch | Call-to-On-Scene | **Arrest Rate** | Gun Victimization

		Arrest Rate by Most Frequent Arrest Calls				
	Arrest Rate	Domestic Battery	Domestic Disturbance	Robbery	EMS	Battery
	(1)	(2)	(3)	(4)	(5)	(6)
ShotSpotter Activated	-0.007***	-0.016**	-0.003	-0.018*	-0.006	-0.010**
	(0.002)	(0.007)	(0.005)	(0.009)	(0.005)	(0.004)
Mean of Dependent Variable	0.147	0.348	0.134	0.668	0.155	0.153
Observations	55,792	49,999	55,177	29,405	54,290	53,747
FE: Day-by-Month-by-Year	X	X	X	X	X	X
FE: District	X	X	X	X	X	X
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	Gun-Related Victimization			
	All	Homicide	Robbery	Battery
	(1)	(2)	(3)	(4)
ShotSpotter Activated	-0.066**	-0.012*	-0.007**	-0.047*
	(0.031)	(0.006)	(0.003)	(0.026)
Mean of Dependent Variable	0.363	0.073	0.015	0.276
Observations	55792	55792	55792	55792
FE: Day-by-Month-by-Year	X	X	X	X
FE: District	X	X	X	X
Note:				
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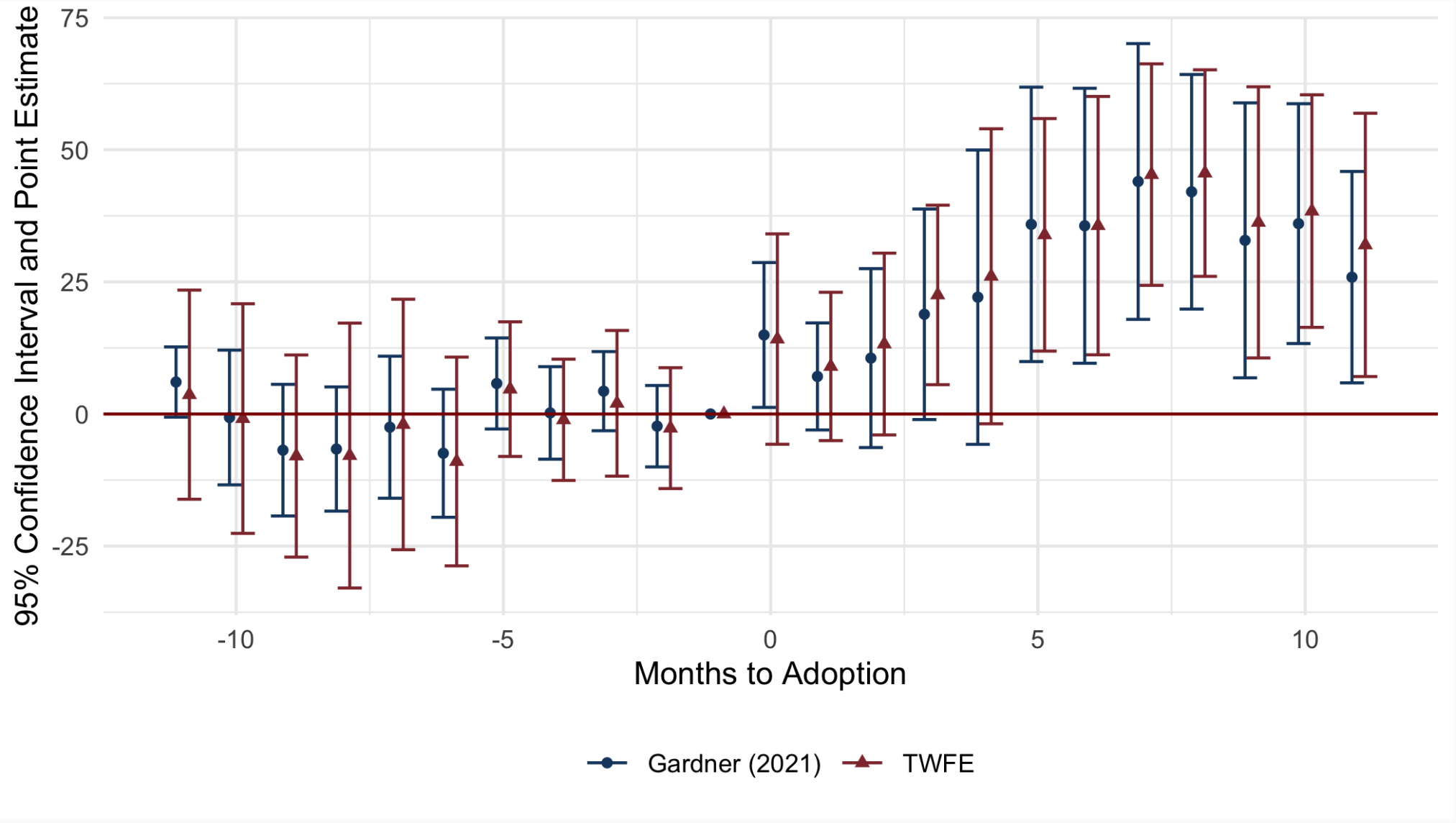
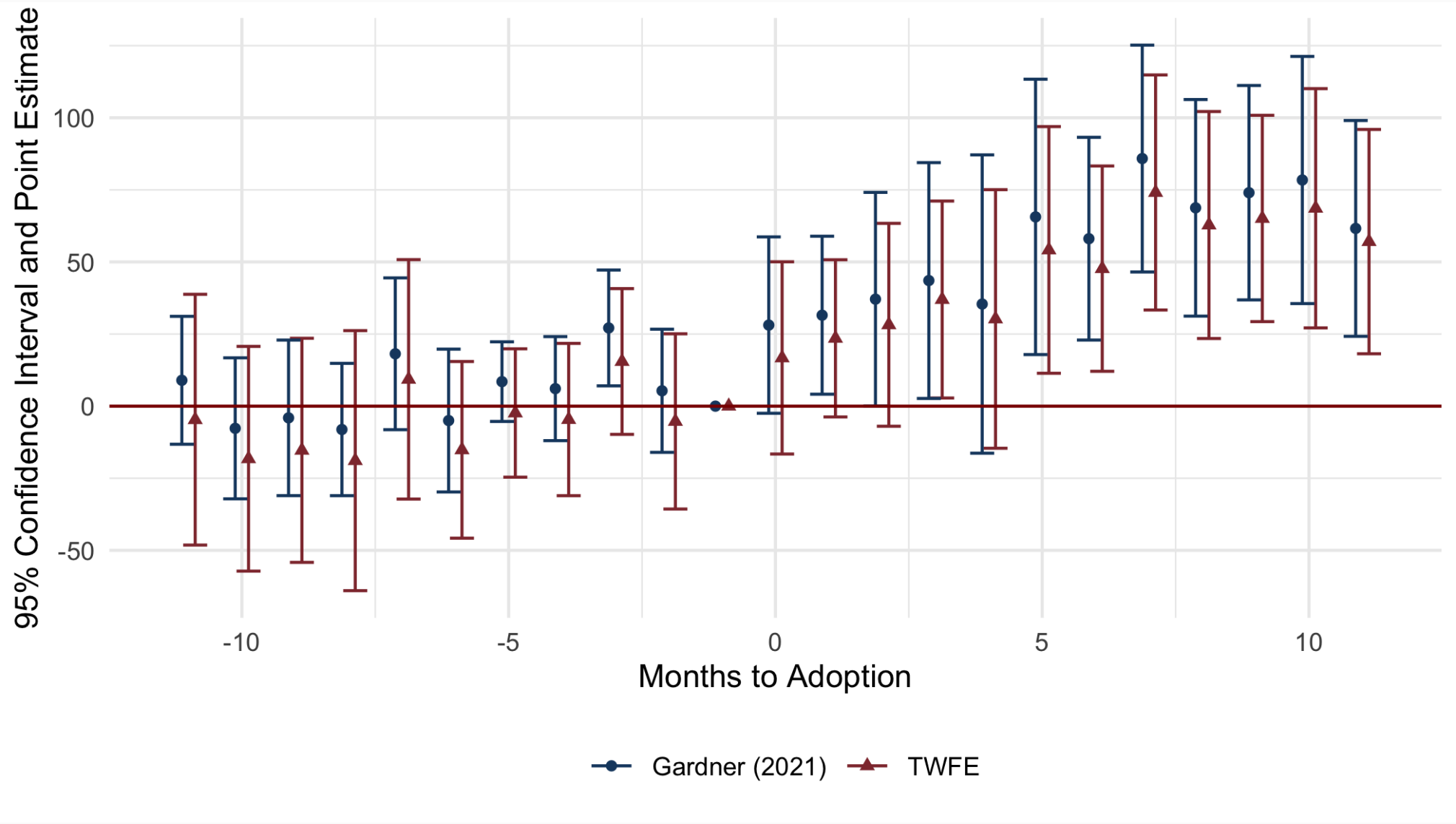
Dynamic Effects: Call to Dispatch



Dynamic Effects: Call to On-Scene



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Robustness:

- Sample Selection:
  - Remove 2020 (Covid)
  - Add in outliers
  - Remove shots fired calls
  - Remove never-treated
- Leave-one-out

Heterogeneity:

- Priority 2 (rapid dispatch)
- Priority 3 (routine dispatch)
  - Similar results (trickle-down effect)

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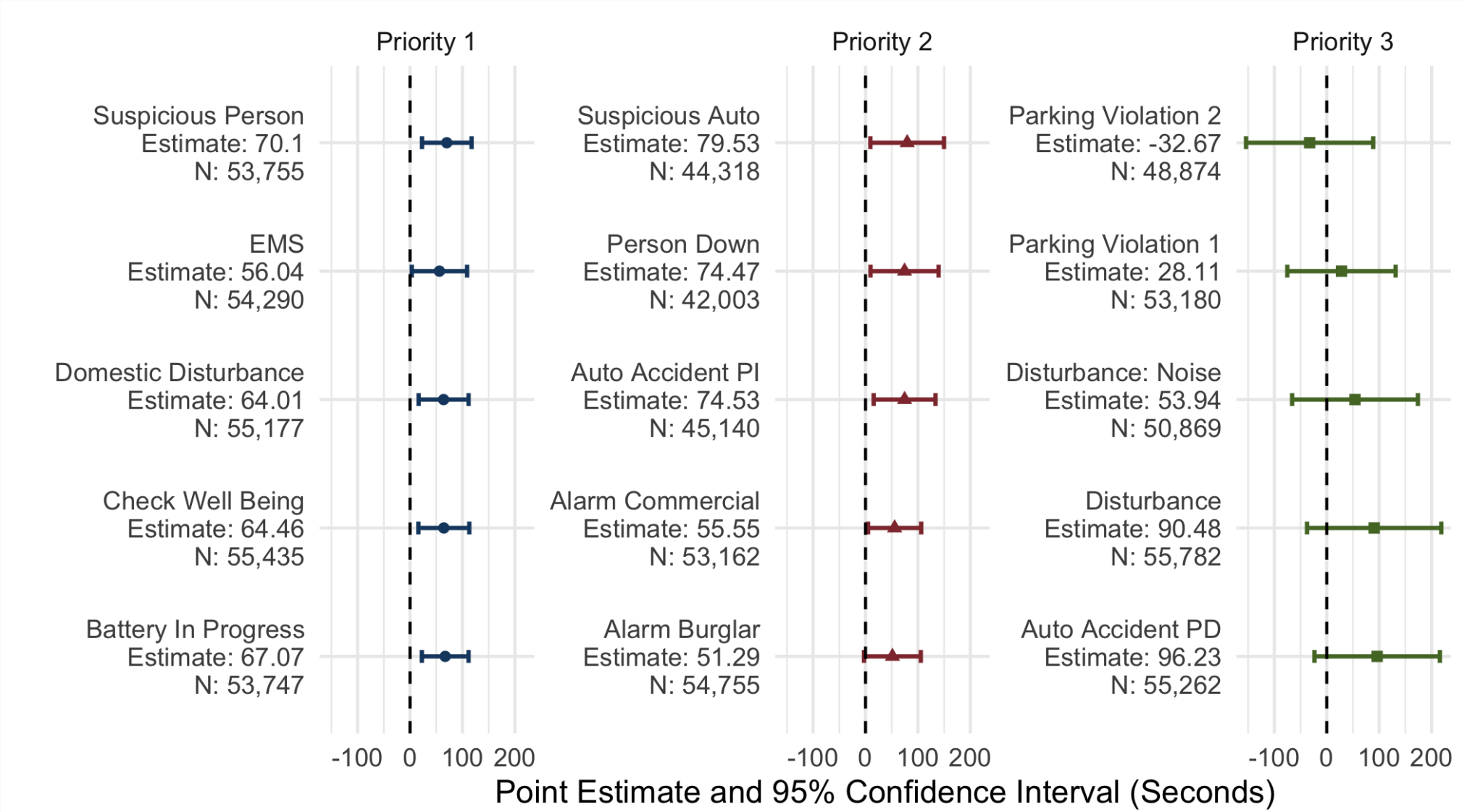
Intensive Margin:

- Alternative Variation: Alerts
  - (RHS): Gunshot alert $\rightarrow$ random event
  - 1 additional alert = +6/+10 seconds to dispatch/on-scene

Cost-Benefit Analysis

- In progress

Call to Dispatch Times (seconds): Top 5



Conclusion:

Main Takeaways:

- An in-depth analysis on consequences of ShotSpotter:
  - Unintended Consequences:
    - Higher priority 1 response times
      - Call-to-Dispatch (+1 minute/ 23% increase)
      - Call-to-On-Scene (+2 minutes/ 14% increase)
    - Lower arrest rates for priority 1 (5% decrease)
  - Intended Consequence
    - Lower gun victimization (16% decrease)
- Other recommendations appreciated
- Thank you!