The Effect of ShotSpotter Technology on Police Response Times

Mini Conference

Michael Topper and Toshio Ferrazares
University of California, Santa Barbara
6/9/2023

Motivation:

State of Crime in the US:

- Gun violence has increased relative to pre-Covid
- Calls to defund the police
- More mistrust of the police
- Higher police officer churn

Motivation:

State of Crime in the US:

- Gun violence has increased relative to pre-Covid
- Calls to defund the police
- More mistrust of the police
- Higher police officer churn

Attempted Solution:

- ShotSpotter Technology
  - Gunshot dectection
- Widespread (150+ cities)
- Costly (~9 million a year)

Motivation:

State of Crime in the US:

- Gun violence has increased relative to pre-Covid
- Calls to defund the police
- More mistrust of the police
- Higher police officer churn

Attempted Solution:

- ShotSpotter Technology
  - Gunshot dectection
- Widespread (150+ cities)
- Costly (~9 million a year)

Research Question:

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

- Priority 1: 911 Call-to-dispatch
- Priority 1: 911 Call-to-on-scene

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)

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)

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)
- Enhance community trust

Summary of Paper:

Summary of Paper:

Setting:

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

Data:

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

Summary of Paper:

Setting:

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

Data:

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

Empirical Strategy:

- Staggered difference-in-difference
  - Aggregate to daily level
- Variation: ShotSpotter rollouts across police districts

Main Results:

- Longer dispatch/arrival times:
  - +2.5 minutes in call-to-dispatch
  - +3 minutes in call-to-on-scene
- Lower arrest rates
  - 5% decrease in arrests made

Contribution:

First economics study to provide causal analysis on ShotSpotter

Contribution:

First economics study to provide causal analysis on ShotSpotter

Related Literature:

ShotSpotter Specific

Police Technology

Rapid Response

Gun Control

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:
  - No violent crime effect, mixed response time results (Mares and Blackburn 2021)
  - Lower hospital travel time (Goldenberg et al. 2019)
  - Lowered response times (Mazerolle et al. 1998)

Contribution:

First economics study to provide causal analysis on ShotSpotter

Related Literature:

ShotSpotter Specific

Police Technology

Rapid Response

Gun Control

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:

First economics study to provide causal analysis on ShotSpotter

Related Literature:

ShotSpotter Specific

Police Technology

Rapid Response

Gun Control

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)

Contribution:

First economics study to provide causal analysis on ShotSpotter

Related Literature:

ShotSpotter Specific

Police Technology

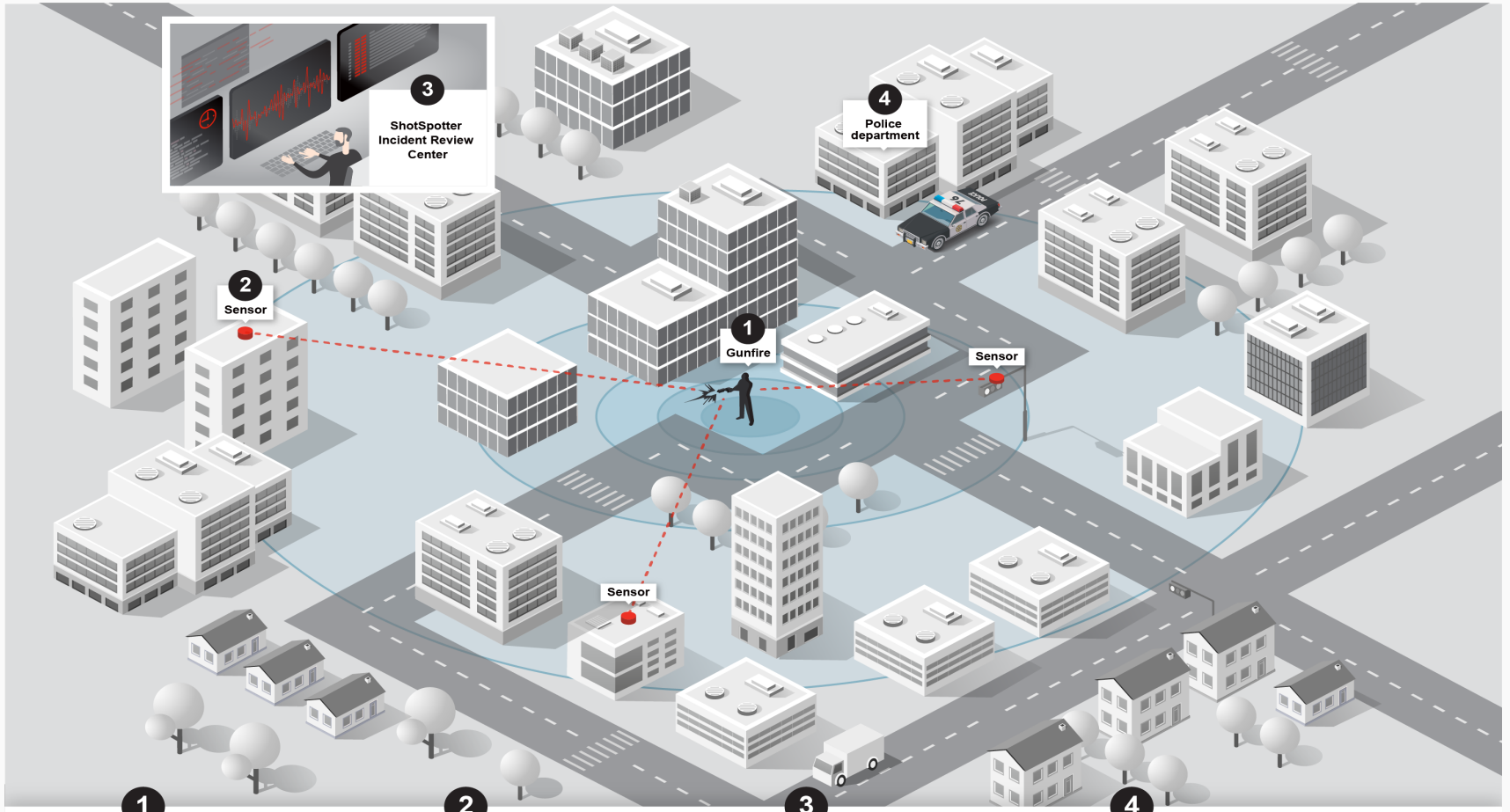
Rapid Response

Gun Control

We find evidence of lower gun victomization, linked directly to a police operating procedure.

- Alternative Studies:
  - Gun-access policies (Colmer and Doleac 2022)
  - Direct, personal intervention (Bhatt et al. 2023)

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.

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
- Priority 2 (rapid dispatch)
  - Suspicious person, car accident
- Priority 3 (routine dispatch)
  - Noise disturbance, parking violation

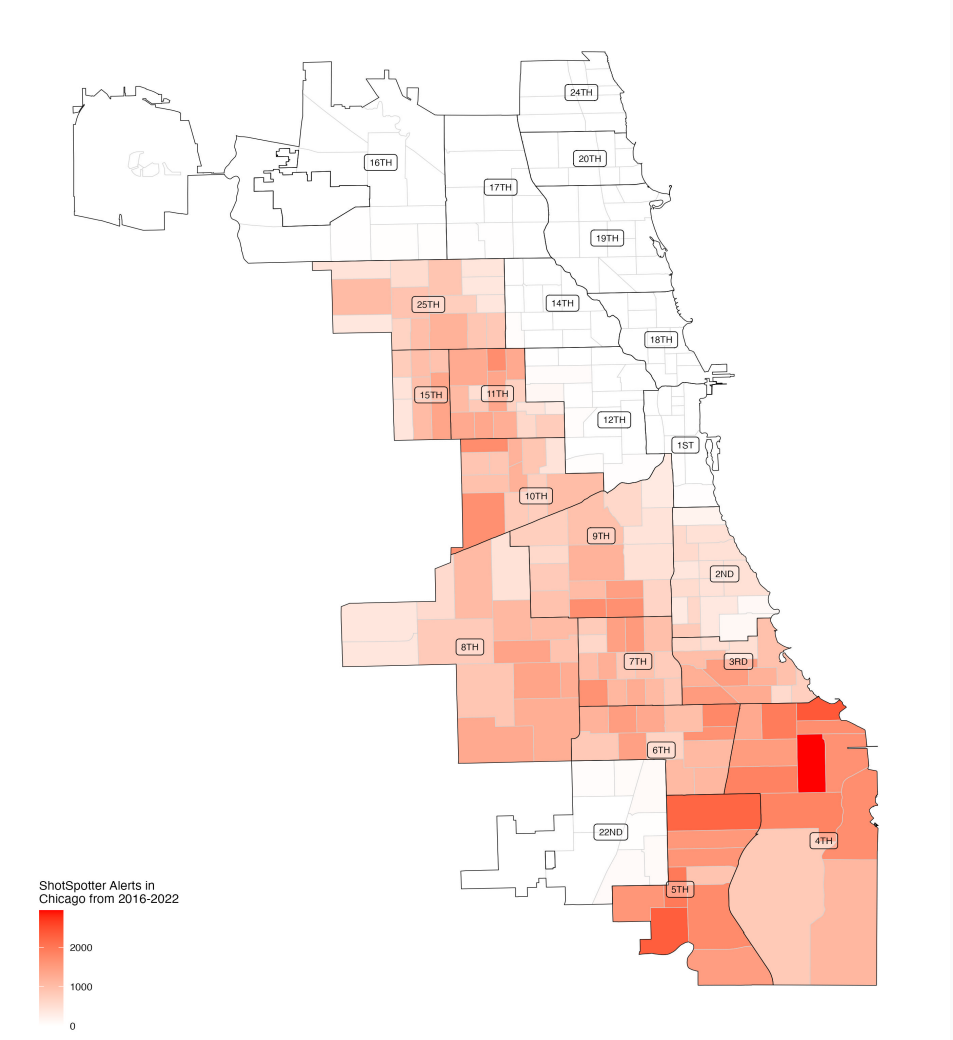
ShotSpotter in Chicago:

Staggered Rollout

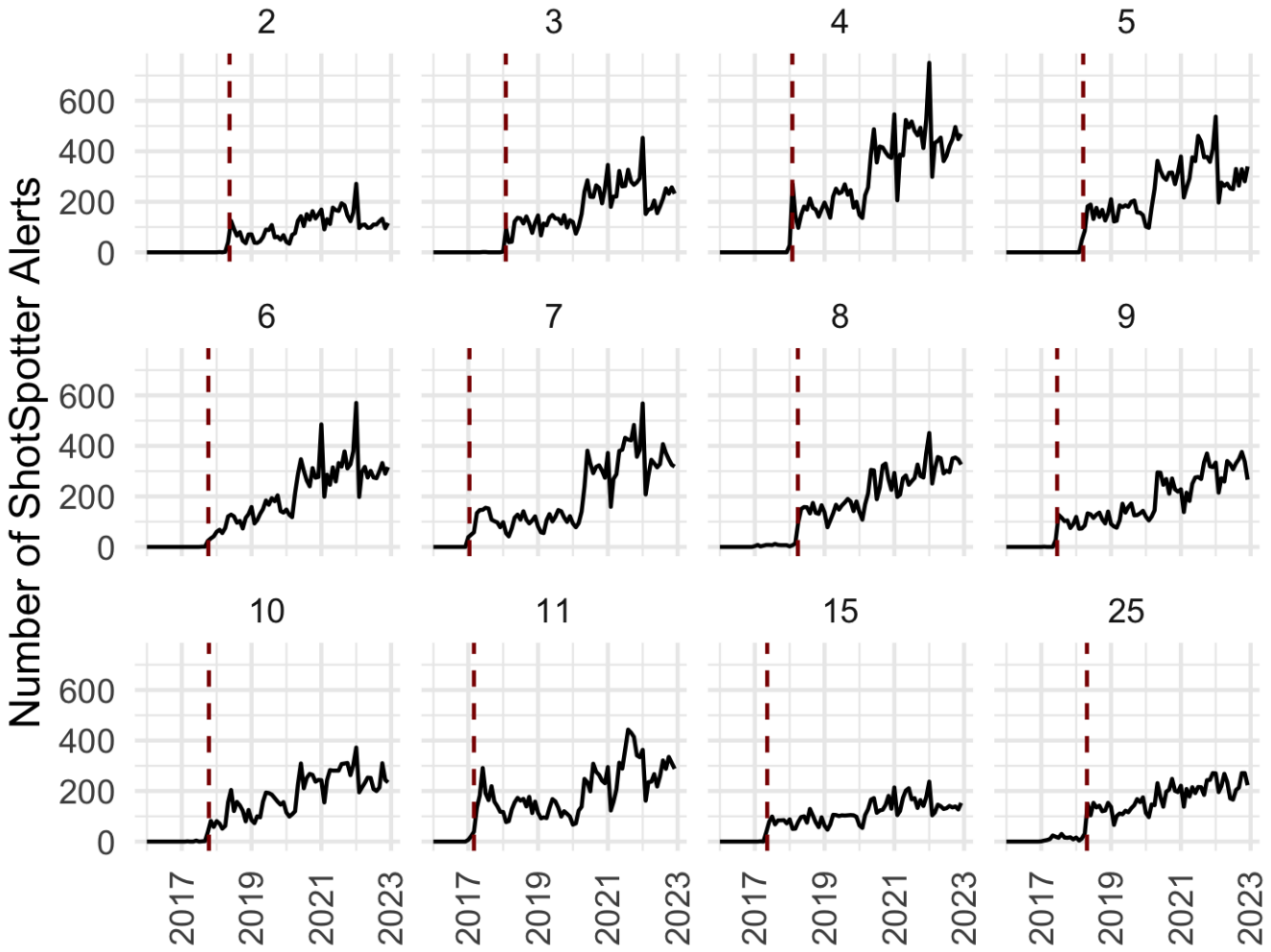
- 12 of 22 police districts in 2017-2018

High Priority

- Priority 1 (immediate dispatch)
  - Active shooter, domestic disturbance
  - ~5% of all Priority 1 dispatches
- Priority 2 (rapid dispatch)
  - Suspicious person, car accident
- Priority 3 (routine dispatch)
  - Noise disturbance, parking violation



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):

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

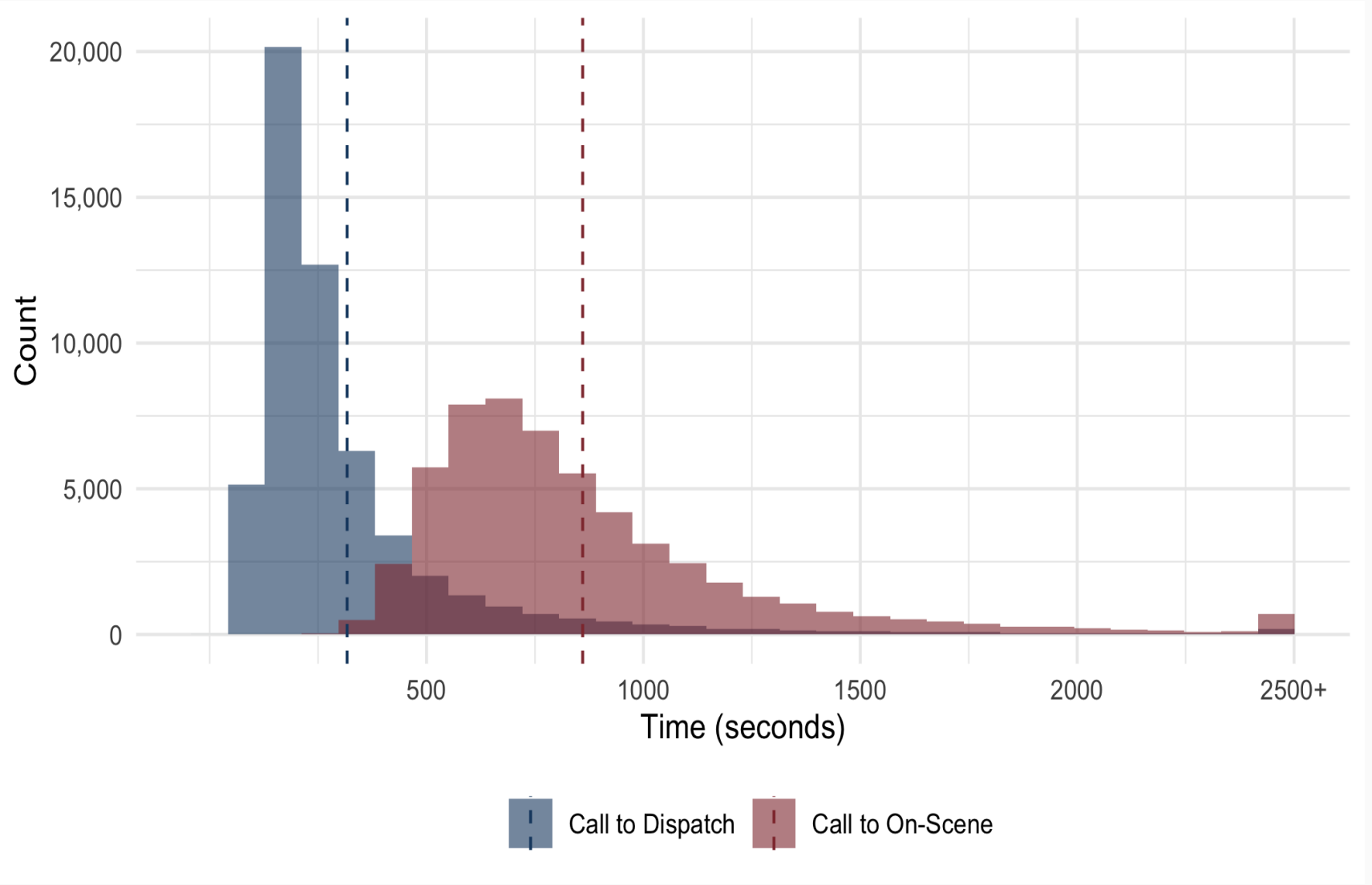
Estimation Strategy:

Specification (OLS):

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

- $Y_{d,t}$ is an outcome of average **daily** time (in seconds) in police district d in time t
  - 911 Call-to-Dispatch
  - 911 Call-to-On-Scene
- $ShotSpotter_{d,t}$ 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

Distribution of Outcome Variables:



Main Results:

Effect on Call-to-Dispatch | Effect on Call-to-On-Scene | Effect on Arrest Rate

	Priority 1			Priority 2	Priority 3
	(1)	(2)	(3)	(4)	(5)
ShotSpotter Activated	142.944***	145.065***	143.342***	150.284**	136.856
	(50.035)	(47.147)	(47.086)	(56.958)	(84.475)
Border Activated			11.959	15.664	87.982*
			(29.343)	(38.531)	(48.981)
Mean of Dependent Variable	321.128	321.128	321.128	435.705	1134.520
Observations	55792	55792	55792	55791	55792
FE: Day-by-Month-by-Year	X	X	X	X	X
FE: District	X	X	X	X	X

Note:

* p < 0.1, ** p < 0.05, *** p < 0.01

Main Results:

Effect on Call-to-Dispatch | **Effect on Call-to-On-Scene** | Effect on Arrest Rate

	Priority 1			Priority 2	Priority 3
	(1)	(2)	(3)	(4)	(5)
ShotSpotter Activated	201.154***	199.123***	197.026***	246.724***	155.646
	(58.395)	(57.157)	(57.101)	(70.981)	(99.956)
Border Activated			14.564	66.127*	98.844
			(32.708)	(33.988)	(62.111)
Mean of Dependent Variable	872.166	872.166	872.166	1123.717	2130.285
Observations	55791	55791	55791	55676	55764
FE: Day-by-Month-by-Year	X	X	X	X	X
FE: District	X	X	X	X	X

Note:

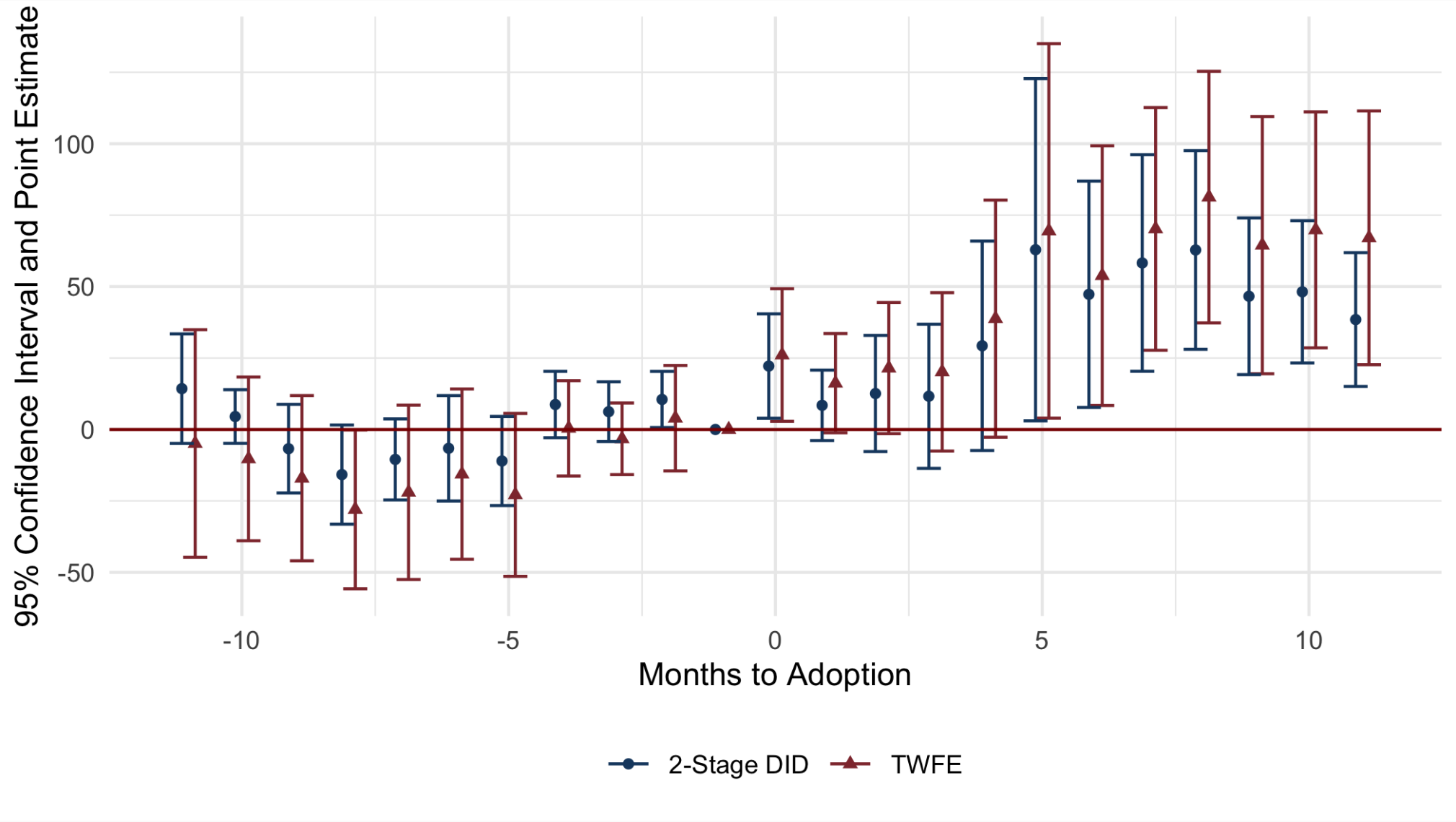
* p < 0.1, ** p < 0.05, *** p < 0.01

Main Results:

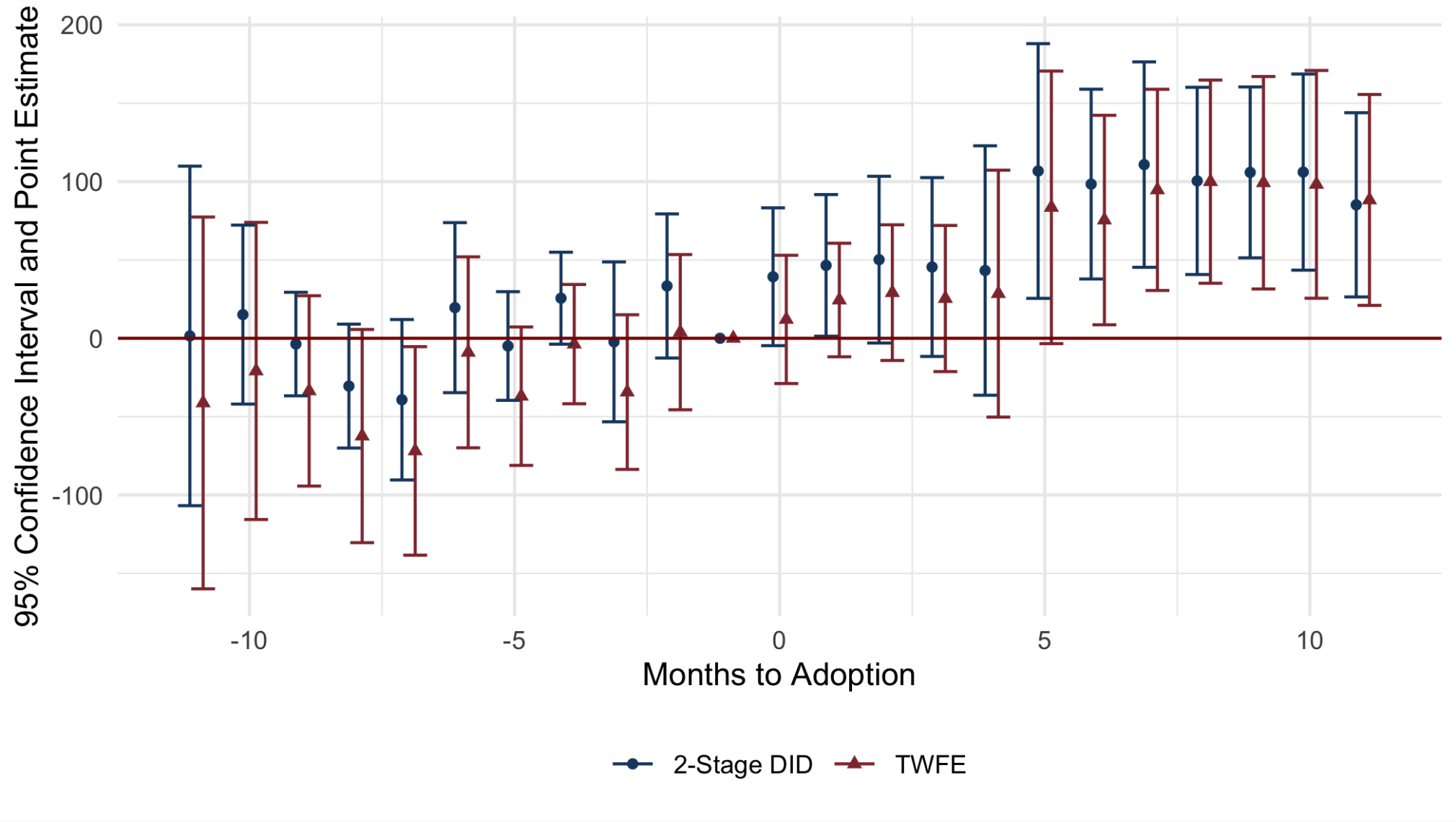
Effect on Call-to-Dispatch | Effect on Call-to-On-Scene | **Effect on Arrest Rate**

	Priority 1	Priority 2	Priority 3
	(1)	(2)	(3)
ShotSpotter Activated	-0.008***	0.003	0.007**
	(0.002)	(0.004)	(0.003)
Mean of Dependent Variable	0.148	0.143	0.128
Observations	55792	55791	55792
FE: Day-by-Month-by-Year	X	X	X
FE: District	X	X	X
Note:			
* p < 0.1, ** p < 0.05, *** p < 0.01			

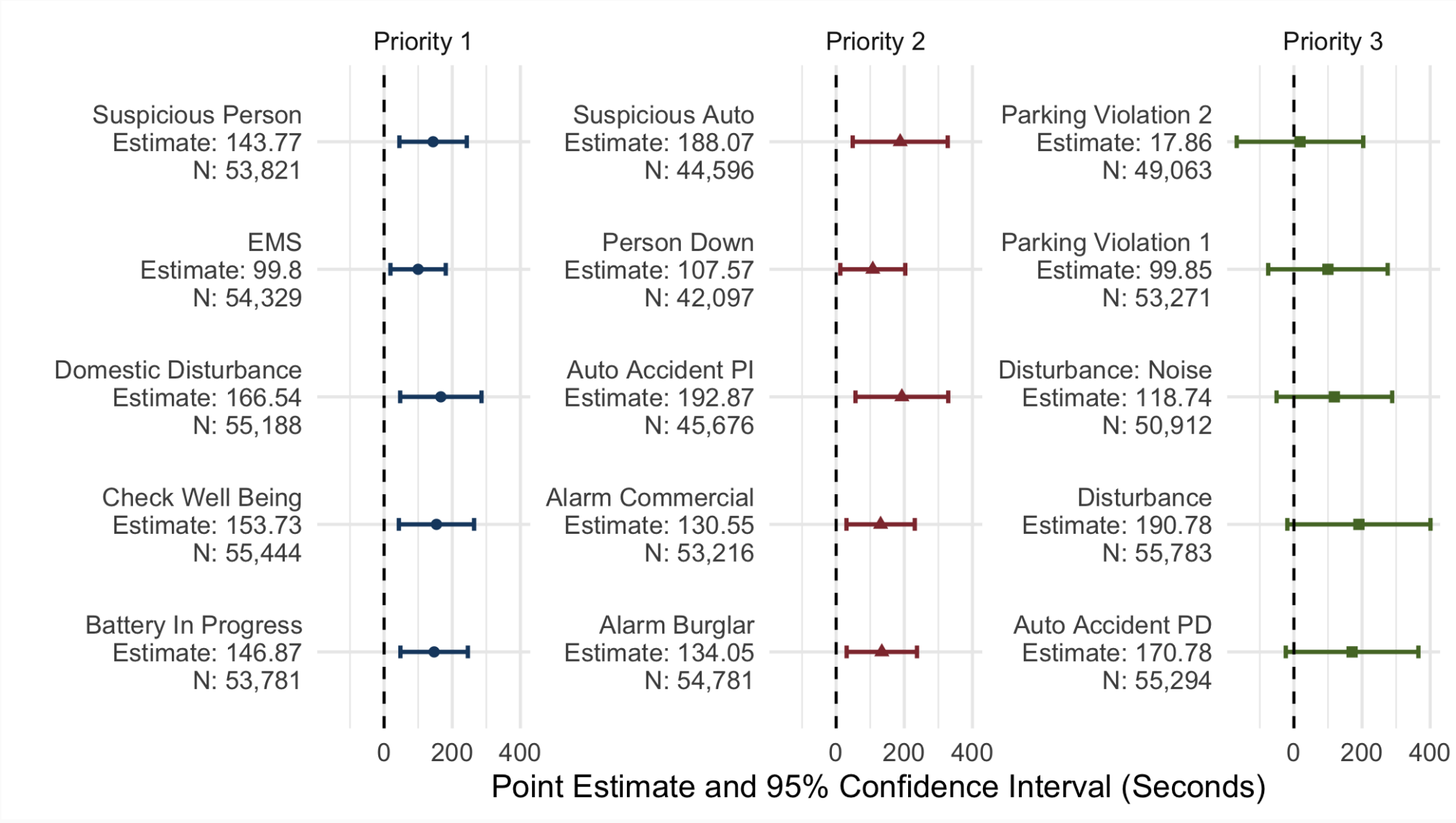
Dynamic Effects: Call to Dispatch (Priority 1)



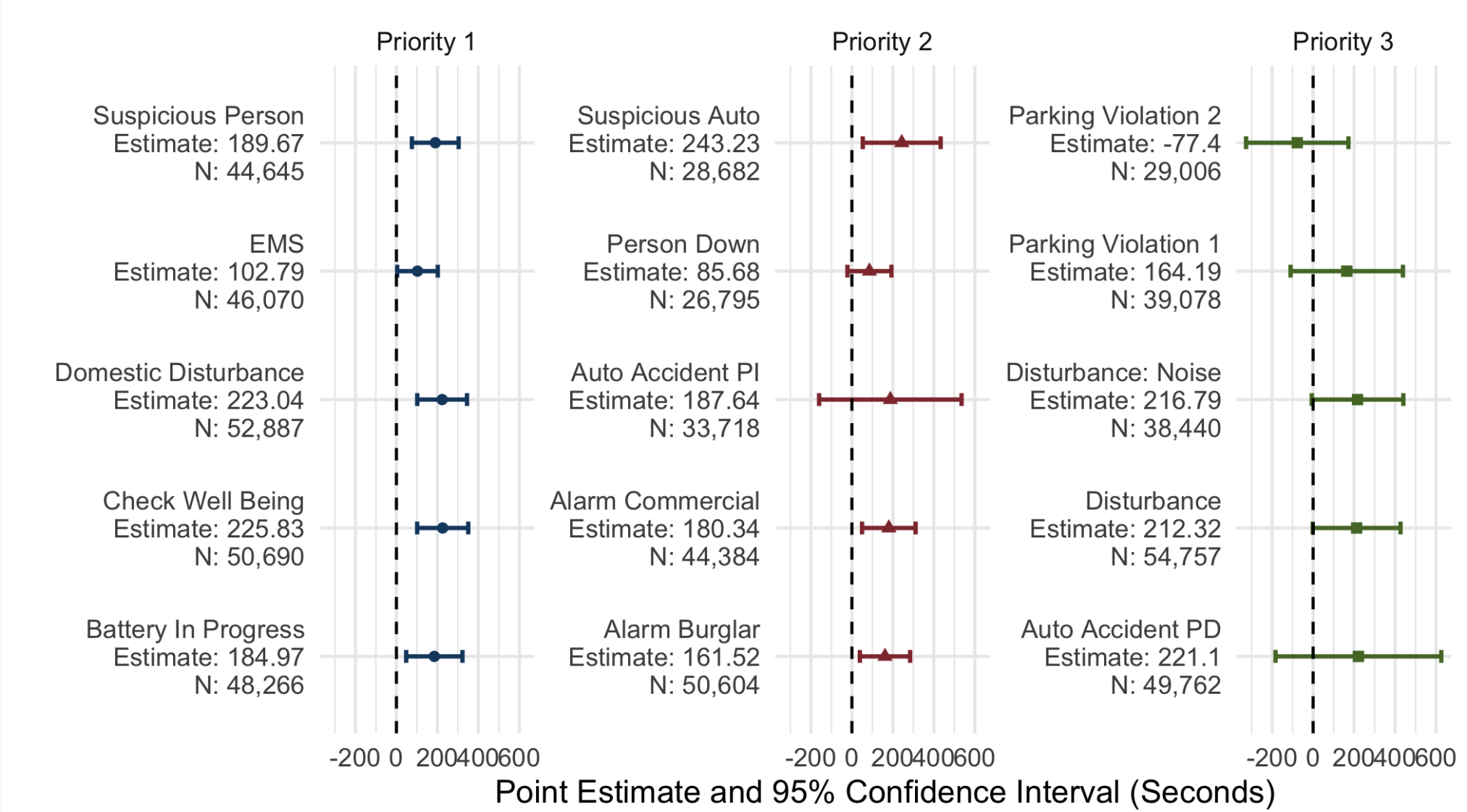
Dynamic Effects: Call to On-Scene (Priority 1)



Call to Dispatch Times (seconds): Top 5



Call to On-Scene Times (seconds): Top 5



Other Analysis:

Other Analysis:

Robustness:

- TWFE Robust Estimators
- Alternative Variation: Alerts
  - 1 additional alert = +18 seconds to dispatch
- Sample Selection:
  - Remove 2020 (Covid)
  - Remove never-treated

Other Analysis:

Robustness:

- TWFE Robust Estimators
- Alternative Variation: Alerts
  - 1 additional alert = +18 seconds to dispatch
- Sample Selection:
  - Remove 2020 (Covid)
  - Remove never-treated

Heterogeneity:

- Break-downs by:
  - Officer Hours
  - Weekdays/Weekends
  - Night/day (in progress)

Conclusion:

Main Takeaways:

- First causal policy analysis of ShotSpotter:
  - Unintended Consequences:
    - Higher Dispatch/On-Scene Times for Priority 1 (2.5/3.0 minutes)
    - Lower Arrest Rates for Priority 1 (5% decrease)
  - Intended Consequence
    - Lower Gun Victimization
- For further research:
  - Cost-benefit analysis
  - Other suggestions?