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Community-level Shooting Dynamics During COVID-19 in Philadelphia

Temple University
College of Liberal Arts

Criminal Justice

NICOLE J. JOHNSON AND CATERINA G. ROMAN

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ABSTRACT

The current study explores how Philadelphia neighborhoods differed in their experience of gun violence throughout the pandemic, while also testing characteristics that predicted neighborhood differences in shooting levels and changes after COVID-19 onset.

We analyzed bi-monthly changes in the rate of shooting victims across Philadelphia Census tracts (i.e., neighborhoods) between January 2017 and June 2021. We found that the average Philadelphia neighborhood experienced shootings at a faster rate after March/April 2020 than before, though the rate slowed toward the end of the time series. In addition, when looking at the period after COVID onset, neighborhoods differed in their rate of change in shootings – some were faster than average, and some were slower than average. But contrary to expectations, neighborhoods that had higher levels of disadvantage did not experience an increasing rate of shootings post-March 2020, even though they entered COVID (March/April 2020) with significantly higher rates of shootings.

Two factors emerged as being significantly associated with increased rates of shootings post-March 2020: (1) high rates of drug arrests and
(2) high rates of police stops. Importantly, the measure of high rates of drug arrests was not associated with neighborhood differences in the pre-COVID time period. There are a number of implications that can be drawn from these findings. Briefly, this study demonstrates the importance of understanding whether there are unique factors that impact the susceptibility to exogenous shocks like the COVID-19 pandemic. The increasing risk of being in a neighborhood with an active drug market during the pandemic suggests efforts related to disrupting drug organizations, or otherwise curbing violence stemming from drug markets, may go a long way towards quelling citywide increases in gun violence.

Background

COVID-19 has had wide-reaching effects on many aspects of daily life for people around the globe. Not only has the virus itself sickened and killed millions, the mitigation strategies enacted by governments [1], from the local level upward, have disrupted governmental, economic, and other institutional functioning, and altered social and behavioral dynamics, including crime, at an unprecedented scale [2].

However, studies exploring the impacts of the pandemic on violent crime have suggested mixed results. One study found that Philadelphia was one of 6 cities examined that experienced at least a 35% decline in overall crime but the same study found that while robbery, aggravated assault, and simple assault declined post-pandemic on average in 25 US cities, homicides and shootings did not [3]. As the pandemic was in full swing, some Philadelphia trauma centers were seeing a larger share of gun violence victims than before the stay-at-home orders were enacted [4]. With the exception of one study of Chicago community areas [5], most research on the effect of COVID-19 on crime has focused on city-level trends, ignoring what might be learned from examining neighborhood differences within cities.

The current study explores how Philadelphia neighborhoods differed in their experience of gun violence throughout the pandemic, while also testing characteristics that predicted neighborhood differences in shooting levels and changes after COVID-19 onset. Community-level features chosen for inclusion in statistical models were informed by sociological and criminological theories including social disorganization theory, the routine activities approach, crime pattern theory, and the incivilities thesis [6-9].

The study sought to answer five related research questions:

1. What was the typical change in shootings before and after the onset of the COVID-19 pandemic and how do changes in the two periods compare to each other?
2. Did neighborhoods differ in shootings at the onset of (i.e., before) COVID-19?
3. If neighborhoods differ from each other in shootings at the start of the pandemic, which neighborhood factors best predict this variation?
4. Did neighborhoods differ in their rate of change in shootings before and after the COVID-19 pandemic began?
5. If neighborhoods differ in their rate of change post-pandemic onset compared to before the pandemic, which neighborhood factors best predict this variability?

METHODS AND DATA

Methods: Units and Data

Our analysis of changes in gun violence focused on a sample of 373 Census tracts in Philadelphia, PA. The average size of a Philadelphia Census tract is roughly 0.35 square miles, with an average residential population of 4,220 people. We aggregated tract-level shootings to bimonthly units due to the rarity of shootings. Our measure of shootings comprises administrative police incident data from the Philadelphia Police Department defined as shootings victims (excluding police-involved shootings). These data were obtained from OpendataPhilly.org.

The study time period extends from January 2017 through June 2021, resulting in 27 bimonthly time points. The outcome of interest is defined as the number of shooting victims per bimonthly period. A series of Census tract-level factors informed by the theories noted earlier were included in the models to predict levels of, and changes in, tract-level shooting rates.

Table 1 describes each of these key factors ("predictors") in addition to the shootings and time variables used in the models.

For almost all of the factors used in the models, years of research suggest that there are important associations between these factors and neighborhood levels of violence. The important structural characteristics included in this study are economic deprivation ("concentrated disadvantage"), residential turnover (i.e., instability) and a factor that measures likely immigrant population (which research shows is a protective factor against violence).

A measure of racially-segregated neighborhoods is included, as research on urban crime has demonstrated that racially segregated neighborhoods, particularly majority Black neighborhoods, may incur higher rates of violent crime as a result of city-wide stratification of other neighborhood conditions, such as poverty [10].

This stratification of poor neighborhood conditions may link to higher violent crime in minority neighborhoods as a result of cultural adaptations, or social isolation preventing effective local community influence to informally control crime [11]. The measure is defined as Census tracts with more than 70% of its population comprised of residents who are Black.

The effect on gun violence of being a neighborhood with high drug activity or near neighborhoods with high drug activity was captured by two measures derived from arrest data from 2017-2019, as described in Table 1. We purposely used pre-COVID onset arrest data so the measure would not be biased because of the police department's COVID-19 policies to limit many types of low-level arrests. To capture the potential impact of blighted environmental factors on gun violence, a measure of Philly311 service calls is included (available via OpenDataPhilly.org). The top five most-received quality of life call types were included as an aggregate measure in analyses: graffiti removal, abandoned vehicles, vacant lot clean up, vacant house calls, and streetlight outages.

Because policies dictating policing levels were introduced during COVID, and existing research indicates a relationship between police presence and levels of crime, we included a measure of "police stops" which include pedestrian and car stops officially recorded by the Philadelphia Police Department.

Other factors examined in the study include measures that capture spatial concentrations of disadvantage ("surrounding disadvantage," also referred to by some as the spatial lag of disadvantage), spatial concentration of gun violence (i.e., the spatial lag of gun violence), and time-based variables that help model the structural form of the rate of change in gun violence over time.

All Census data were derived according to the 2014-2018 American Community Survey 5-year estimates for Philadelphia.

TABLE 1 - VARIABLE DESCRIPTIONS

VARIABLES	DESCRIPTION	N	MEAN (ST.D)
LEVEL 1 – TIME POINTS			
Gun violence	Count of shootings victims per Census tract per bimonthly period	10,071	.707 (1.42)
Timepre	Pre-COVID linear time slope	10,071	-7.04 (6.48)
Timepost	Post-COVID linear time slope	10,071	1.04 (2.03)
Timepost - quadratic	Post-COVID quadratic time slope	10,071	5.19 (12.10)
Police stops	Standardized count of police investigatory stops in each tract per bimonthly period	10,071	0 (1)
Temporal lag of gun violence	Time (T) minus 1, lag of shooting victims	9,698	.69 (1.40)
Surrounding gun violence (spatial lag)	Standardized average count of shooting victims in adjacent Census tracts	10,071	0 (1)
LEVEL 2 – CENSUS TRACTS			
Concentrated disadvantage	Standardized composite index of 4 Census tract-level variables: percentage of population in poverty, percentage of female-headed households, percentage unemployed, percentage of households receiving public assistance.	370	0 (1)
Percentage of renters	Percentage of renter-occupied households	372	0 (1)
Foreign born	Standardized average of percentage of foreign born and percentage of population who speak language other than English	373	0 (1)
Predominantly Black population	Census tracts where greater than (>)70% of population is Black, non-Hispanic	373	.28 (.45)
High drug activity Census tract	Census tracts with greater than (>) 90th percentile drug arrest rate for 2017-2019	373	.10 (.30)
Philly311 call rate	Standardized pooled Philly311 call rate, 2017-June 2021	373	0 (1)
Surrounding concentrated disadvantage (spatial lag)	Standardized average of concentrated disadvantage score in adjacent Census tracts	373	0 (1)
Distance to drug markets	Total distance in miles between each tract and all high drug activity Census tracts	373	0 (1)
Total population	Total residential population	373	4220.61 (1687.59)

Analytic Strategy

Due to the count distribution of the outcome variable, mixed effects negative binomial regression models, nesting time within neighborhoods, were specified for the current analyses. This method allowed us to estimate the underlying pathway of shootings before and after the onset of the pandemic, while allowing for an exploration of variability among the individual pathways of each neighborhood.

A two-rate model was specified, where separate linear time slopes were used to characterize the pre-COVID ("timepre") and post-COVID-onset ("timepost") periods.

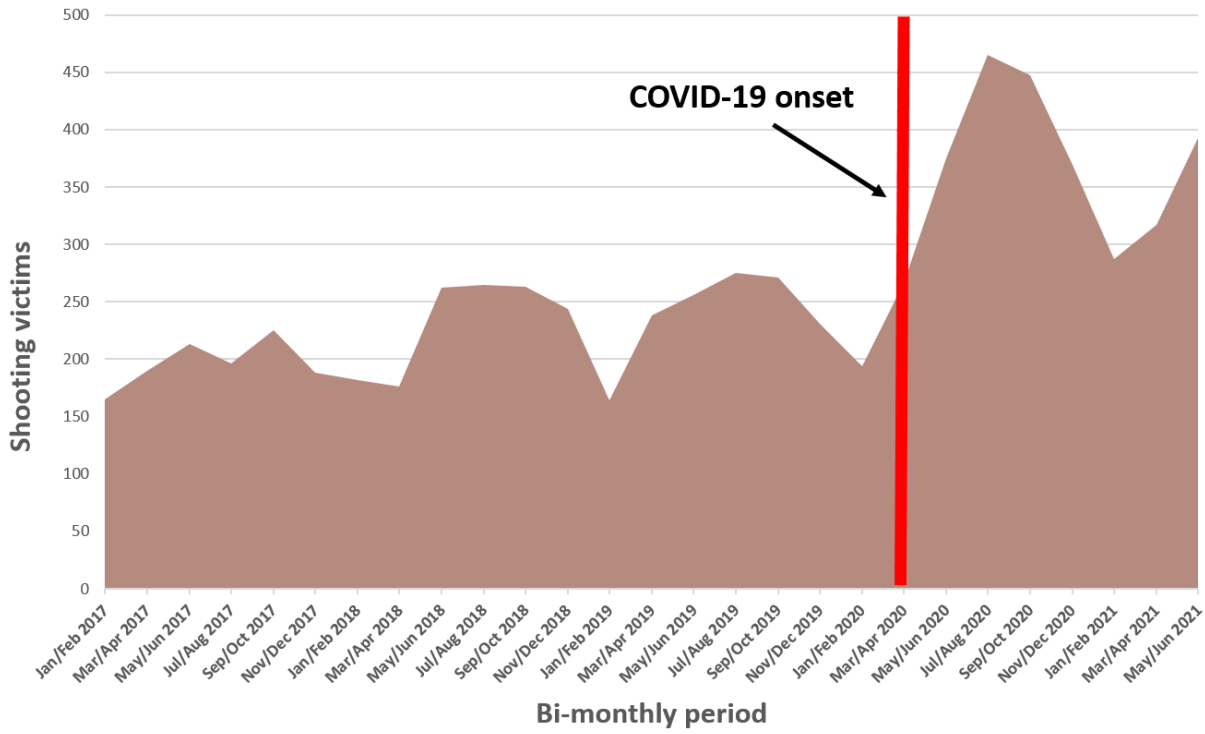
Further, a quadratic timepost slope ("timepost - quadratic") was also included in the models to account for any departures from a linear change post-COVID. Graphically, a quadratic function is represented by a parabola (a curve).

The pre-COVID time period was characterized by modeling the trend over 20 time points (i.e., bimonthly periods), and the post-COVID onset time period was characterized by modeling the trend over 7 time points.

DEFINITIONS

- **Gun violence/shootings** - Criminal shooting victims (fatal and nonfatal, non-officer-involved) from the Philadelphia Police Department (available from OpenDataPhilly.org).
- **Concentrated disadvantage** – A standardized composite measure describing the extent of households in poverty, female-headed households with children, households receiving public assistance, and unemployment rate in Census tracts.
- **High drug activity tracts** – Census tracts exceeding the 90th percentile in pooled 2017-2019 drug arrest rates
- **Surrounding disadvantage** – The average level of concentrated disadvantage in adjacent Census tracts (those touching the sides and corners of a focal tract). "Spatial lag"
- **Surrounding gun violence** – The average number of shootings occurring in adjacent Census tracts (those touching the sides and corners of a focal tract). "Spatial lag"

TREND IN SHOOTING VICTIMS



Results

The graph above details the trend in shootings aggregated across Philadelphia Census tracts at each time point. March/April 2020 experienced 266 shootings, an increase of 37% from the bimonthly period immediately preceding it (January/February 2020), and 12% more shootings than the same period in 2019. The peak average number of shootings during COVID occurred during the July/August 2020 period, with 465 shootings. This is nearly 70% higher than the number of shootings in the same period of 2019. The remaining paragraphs in this section discuss the answers to the five research questions posed on page 3.

RQ1: What was the typical change in shootings before and after the onset of the COVID-19 pandemic and how do changes in the two periods compare to each other?

Before pandemic onset (up to Mar/Apr 2020), the rate of change (increase in shootings) was 2% over the "bimonthly" periods, but after the onset of the pandemic (from Mar/Apr 2020-May/Jun 2021), the rate of change for the average neighborhood was 22%. Although the post pandemic change rate was increasing, the rate of change slowed down considerably toward the end of the time series.

STATISTICAL MODEL

The **mixed effects negative binomial model** conceptualizes the processes examined as a multilevel model, where the variable "time" is a level 1 variable (as well as the dependent variable, gun violence) and neighborhoods (i.e., Census tracts) are level 2. In these types of models, time is coded 0, 1, 2, 3, etc.. The "intercept" is the predicted value when time is 0.
In this study, the intercept (time 0) was set to March/April 2020 (COVID-19 onset) for both time slopes.

Because we believe neighborhood variation is substantively important, each neighborhood has their own intercept and slope (i.e., rate of change), expressed as random effects at level 2. By coding the intercept set to COVID-19 onset, the main effects in study models can be interpreted as predicting the shooting rate at the beginning of and immediately following the onset of COVID-19. The "random effect" is the random variation in the average shootings among (between) neighborhoods.

2. Did neighborhoods differ in shootings at the onset of COVID-19?

There was significant variation between neighborhoods in their level of shootings before the pandemic began. The community level factors explained a large portion of the variation between neighborhoods.

3. If neighborhoods differ from each other in shootings at the start of the pandemic, which neighborhood factors best predict this variation?

The statistically significant factors that predicted higher rates of shootings before the city entered lockdown due to the pandemic included: high levels of concentrated disadvantage and surrounding disadvantage, majority Black population, closer in distance to high drug activity neighborhoods, higher rates of police stops, and high levels of surrounding gun violence. Being a high drug activity tract was not significantly associated with a higher rate of shootings before COVID onset.

4. Did neighborhoods differ in their rate of change in shootings before and after the COVID-19 pandemic began?

There was greater variability in neighborhood shooting pathways after the onset of COVID-19. Neighborhoods greatly differed in their rate of change in shootings after COVID began -- some were faster than average, and some were slower than average. The map on page 11 highlights these stark differences.

The Census tracts shaded darkest red are those with the largest deviation above the average rate of change for tracts post-COVID onset.

5. If neighborhoods differ in their rate of change post-pandemic onset compared to before the pandemic, which neighborhood factors best predict this variability?

In the last set of models, five factors were used to test for interaction effects with the pre-COVID slope, post COVID slope, and post COVID slope-quadratic. These factors were: (1) concentrated disadvantage, (2) majority Black neighborhood, (3) high drug market activity, (4) Philly311 service call rate, and (5) police activity.

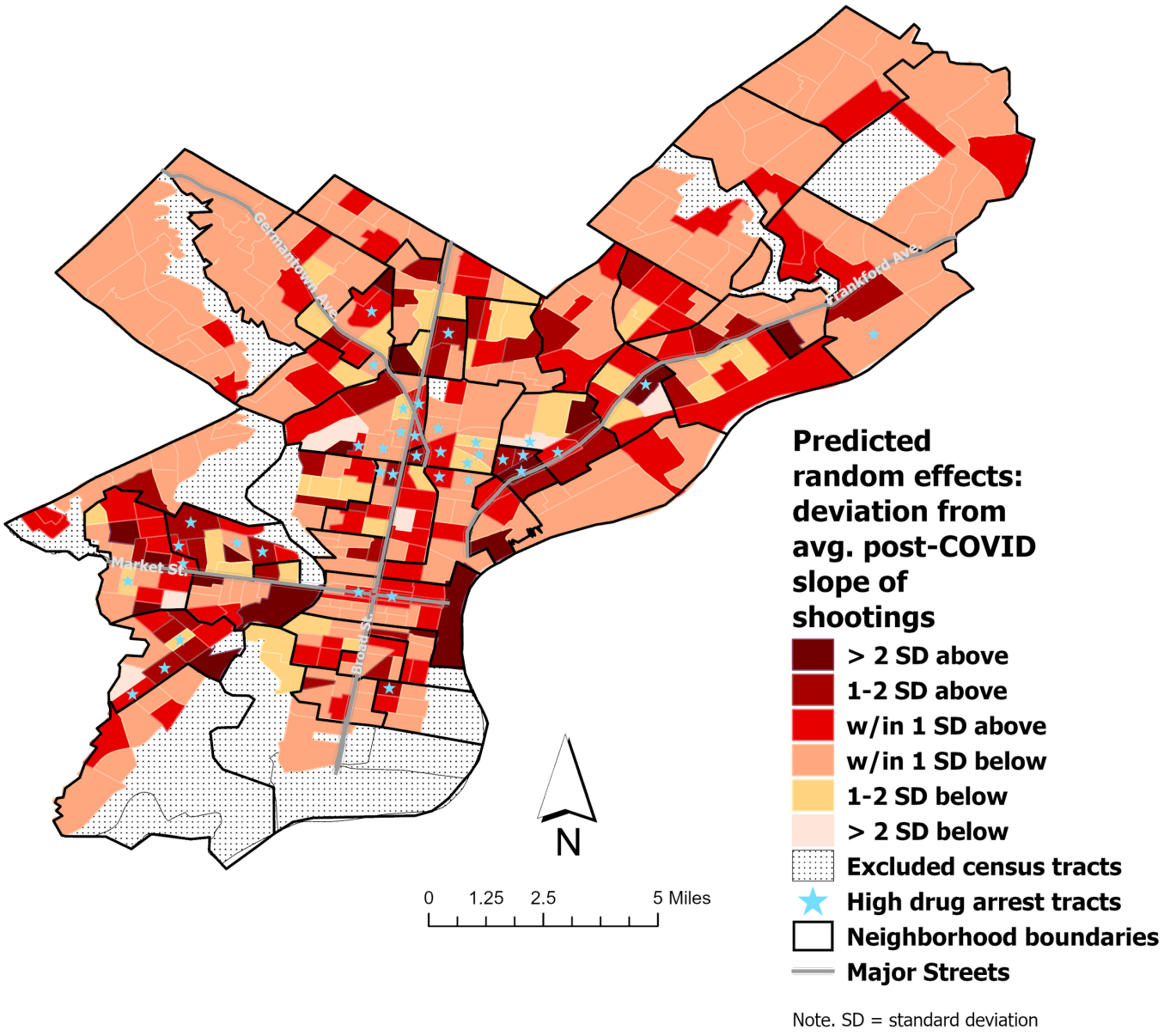
Of these five factors tested, two factors emerged as having significant interactions with the rate of change in shootings. First, in the post-COVID onset period, neighborhoods with high drug activity increased in shootings faster after COVID compared to tracts without high drug activity. Panel A in the graph on page 12 illustrates the effect on shootings of the interaction between time and drug activity. High drug activity was not a salient factor in the pre-COVID period.

Second, neighborhoods with more police stops both increased in shootings faster before COVID and after COVID onset compared to tracts with an average number of stops (see graph panel B). This is consistent with the idea that more police resources are allocated to those areas with the most violence.

Indeed, this is the logic underlying hot spots policing, where areas that have relatively higher crime are targeted by relatively more proactive policing activity. However, it would be reasonable to suspect that events surrounding the murders of George Floyd in late May 2020 and Walter Wallace in Philadelphia in October 2020 may have corresponded to changes in shootings as well; some police practitioners and researchers have suggested that after periods of social unrest related to police violence, police purposely reduce proactive policing efforts to avoid the intense scrutiny of the public. This reduction in police activity following social unrest is known as the "Ferguson effect," and was first discussed after the killing of Michael Brown in Ferguson, Missouri in 2014. Neighborhood-level police activity also tends to change during protests as officers are called away from their typical beats to police areas where the protests are occurring.

But in the current study, neighborhoods that had more police investigative stops had more shootings in the same period. This indicates that violent neighborhoods that already had relatively higher levels of police attention at the start of the pandemic maintained their levels of police activity, and police activity increased in neighborhoods where gun violence increased. This suggests that a "Ferguson" effect did not occur. However, it is important to note that this study was not designed to unpack the dynamics around the protests; the bimonthly temporal unit limits drawing concrete conclusions here.

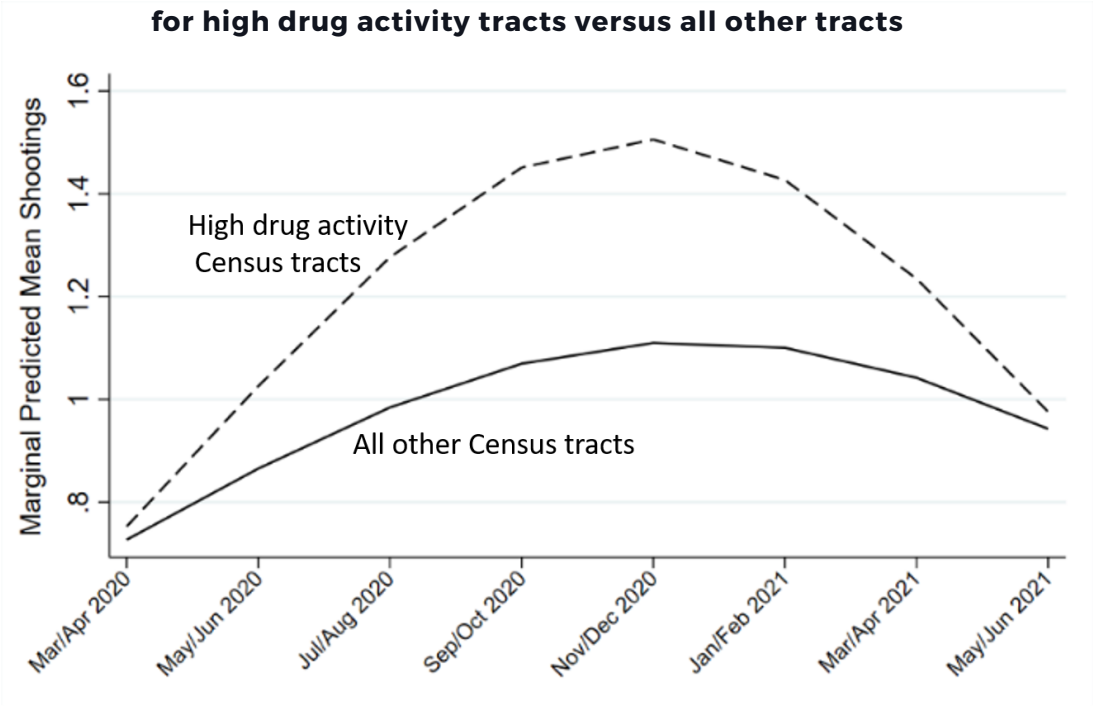
Philadelphia neighborhoods differed in their rate of change in shootings after COVID began - some were faster than average, and some were slower than average



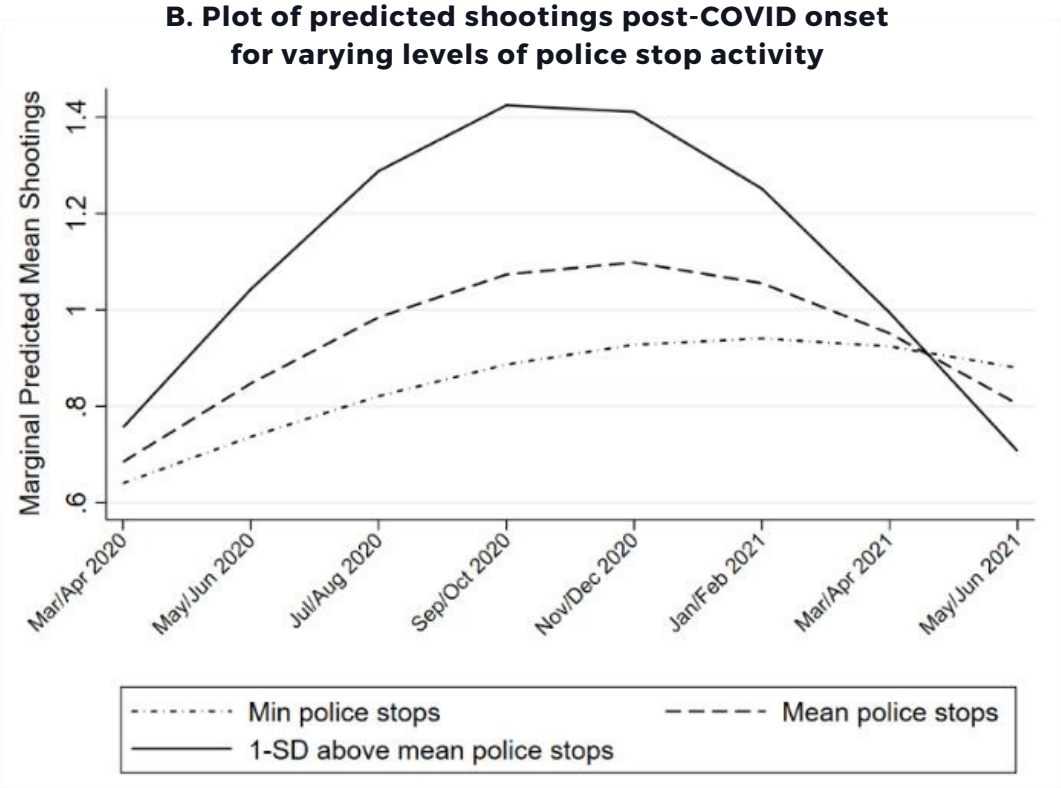
Note. SD = standard deviation

Map shows post-COVID onset time period (March 2020 to June 2021)
Cartographer: N. Johnson

A. Plot of predicted shootings post-COVID onset for high drug activity tracts versus all other tracts



B. Plot of predicted shootings post-COVID onset for varying levels of police stop activity



SD = standard deviation

CONCLUSION

The results of this study revealed that the characteristics of neighborhoods matter with regard to gun violence in Philadelphia. Putting aside for a moment the findings examining how COVID-19 affected shootings, the study found that well-known correlates of violence predicted higher shooting rates. In particular, Philadelphia neighborhoods steeped in disadvantage but also surrounded by deprivation and violence were at higher risk for gun violence. Majority Black neighborhoods were also at higher risk of gun violence, which corresponds to what researchers have found in Philadelphia and elsewhere [10, 12]. However, with regard to COVID-19, none of these established correlates of neighborhood violence affected the rate of shooting changes over time after COVID onset. High drug activity emerged as a key predictor of whether a neighborhood had a more rapid rise in shootings over the course of the pandemic.

A variety of potential explanations could undergird this finding. For one, the pandemic could have altered the perceived likelihood of punishment for drug organizations. The suspension of low-level, nonviolent arrests by the Philadelphia Police Department was widely publicized across news media outlets. The temporary suspension of nonviolent arrests could have emboldened some groups to become more active, thereby increasing their interactions with other sellers as they compete for the same buyers. It may be the general *perception* by drug organizations and new or potential sellers of a decrease in police activity (regardless of actual levels) were motivating criminal behavior.

In addition, widespread job loss and the economic downturn in the licit economy may have pushed some individuals into the illicit narcotics trade, thus further saturating drug markets and also creating competition that resulted in violence. Economic strains might similarly have reduced the number of buyers, further increasing competition among sellers. With fewer potential guardians on the street, and place managers at local businesses curbing the drug trade, the violence potential of some drug organizations could have been exacerbated absent witnesses and other deterrents. Unfortunately, the necessary data (e.g., shooting motives, drug and gang-involvement in shootings, etc.) are currently lacking to examine any of the potential explanations outlined above. Furthermore, data to capture any potential effect of the increase in the general number of guns in circulation or crime guns are not available, let alone at the neighborhood level.

The increasing risk for neighborhoods that have high levels of drug activity suggests that efforts related to disrupting drug organizations, or otherwise curbing violence stemming from drug markets, may go a long way towards quelling citywide increases in gun violence. Drug market risk of violence likely goes hand in hand with the structural factors that set the stage for the attraction and maintenance of illicit markets. Many, but not all, high drug activity Census tracts were located around the north central Philadelphia area of Greater Kensington area, a stark example of the agglomeration economy (i.e., mass collection of markets) of the illicit drug trade. The map on page 12 shows the geographic distribution of these high drug activity tracts. This agglomeration factor could have promoted more violence than if the drug market landscape were more dispersed.

Furthermore, the pandemic likely complicated narcotics policing, prosecution and deterrence through incarceration because of the desire to mitigate the spread of COVID-19.

A clear implication from this study is that city officials should bolster the communities that appear to be particularly susceptible to detrimental outcomes following an exogenous shock such as COVID-19. A directed and strategic combination of efforts from across a range of city agencies is likely required to address both the overall disparities in neighborhood risk of gun violence, and the rapid increases brought on by COVID-19.

The type of investment needed to make a sustainable dent in gun violence goes beyond criminal justice interventions to cross-system investments that provide palpable resources to distressed neighborhoods. This is suggestive of a public health framework that is comprehensive at its core, addressing multiple issues simultaneously for long-term change.

LIMITATIONS: The findings from the regression models can only speak to statistical associations among neighborhood characteristics, rather than the underlying mechanisms linking characteristics to initial levels and evolution of shooting rates over time. In other words, this study cannot conclude causation.

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About the Authors

Nicole Johnson is a doctoral candidate in the Department of Criminal Justice at Temple University. Nicole's research interests span the areas of policing, community criminology, and street gangs. Originally from North Carolina, Nicole received her undergraduate degree in criminology with a minor in Chinese studies from NC State University, and a Master's degree in criminology, law and society from George Mason University. For more on Nicole, see: https://njjohns.github.io/

Caterina Roman has been a professor in the Department of Criminal Justice at Temple University since 2008; before that she was a senior researcher at the Urban Institute in DC. She studies the social, economic, and environmental conditions that give rise to violence and neighborhood inequality. For more on Caterina and links to her papers and research briefs, see https://www.caterinaroman.com/

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Temple University
Department of Criminal Justice
1115 Polett Walk
5th Floor Gladfelter Hall
Philadelphia, PA 19010
www.temple.edu/cj