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Association between race, shooting hot spots, and the surge in gun violence during the COVID-19 pandemic in Philadelphia, New York and Los Angeles

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ABSTRACT

Gun violence rates increased in U.S. cities in 2020 and into 2021. Gun violence rates in U.S. cities is typically concentrated in racially segregated neighborhoods with higher poverty levels. However, poverty levels and demographics alone do not explain the high concentration of violence or its relative change over time. In this paper, we examine the extent to which the increase in shooting victimization in Philadelphia, New York, and Los Angeles during the 2020–2021 pandemic was concentrated in gun violence hot spots, and how the increase impacted race and ethnic disparities in shooting victimization rates. We find that 36% (Philadelphia), 47% (New York), and 55% (Los Angeles) of the increase in shootings observed during the period 2020–2021 occurred in the top decile of census block groups, by aggregate number of shootings, and that the race/ethnicity of victims in these gun violence hot spots were disproportionately Black and Hispanic. We discuss the implications of these findings as they relate to racial disparities in victimization and place-based efforts to reduce gun violence.

1. Introduction

Gun violence is spatially concentrated within cities in the U.S. in the most socially disadvantaged communities (Braga et al., 2010). Black and Hispanic men suffer higher rates of gun violence compared to other minority populations (Puzzanchera et al., 2022). The racial inequality in gun violence victimization rates are also associated with areas of concentrated disadvantage, reflecting higher spatial concentrations of poverty, unemployment, joblessness, family disruption, and geographic isolation linked to the enduring legacy of system racism in racial residential segregation and urban disinvestment (Sampson et al., 2018; Diez Roux and Mair, 2010). However, poverty levels and demographics alone do not explain the high concentration of gun violence observed in certain small geographies. Even within the poorest neighborhoods the majority of blocks have no shootings in a given year (Braga et al., 2010). The rates of gun violence increased significantly during the 2020–2021 pandemic and the increase was concentrated in neighborhoods with higher poverty levels (Schleimer et al., 2021). These findings suggest that during epidemic periods of gun violence it is important to examine the subset of places with the most potential volatility in generating violence.

In this paper, we examine the extent to which the surge in shooting victimization during the pandemic in Philadelphia, New York, and Los Angeles occurred in concentrated gun violence "hot spots," and whether the relationship between gun violence in places was disparate by race and ethnicity. In this descriptive analysis we quantify the variability of shootings by place before (2016–2019) and during the pandemic (2020–2021) and how it varies by race and ethnicity of victims. In particular, we delineate how the intensity of gun violence in particular places impacted the racial and ethnic disparity in gun violence victimization rates. This analysis provides an important step for thinking about prevention approaches to reduce the burden of gun violence in cities.

2. Data and methods

We analyze open source data on shooting events from Philadelphia,[1] Los Angeles,[23] and New York.[4] Each event is associated with a date and

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[1] https://www.opendataphilly.org/dataset/shooting-victims.
[2] https://data.lacity.org/Public-Safety/Crime-Data-from-2010-to-2019/63jg-8b9z.
[3] https://data.lacity.org/Public-Safety/Crime-Data-from-2020-to-Present/2nrs-mtv8.
[4] https://data.cityofnewyork.us/Public-Safety/NYPD-Shooting-Incident-Data-Historic-/833y-fsy8.

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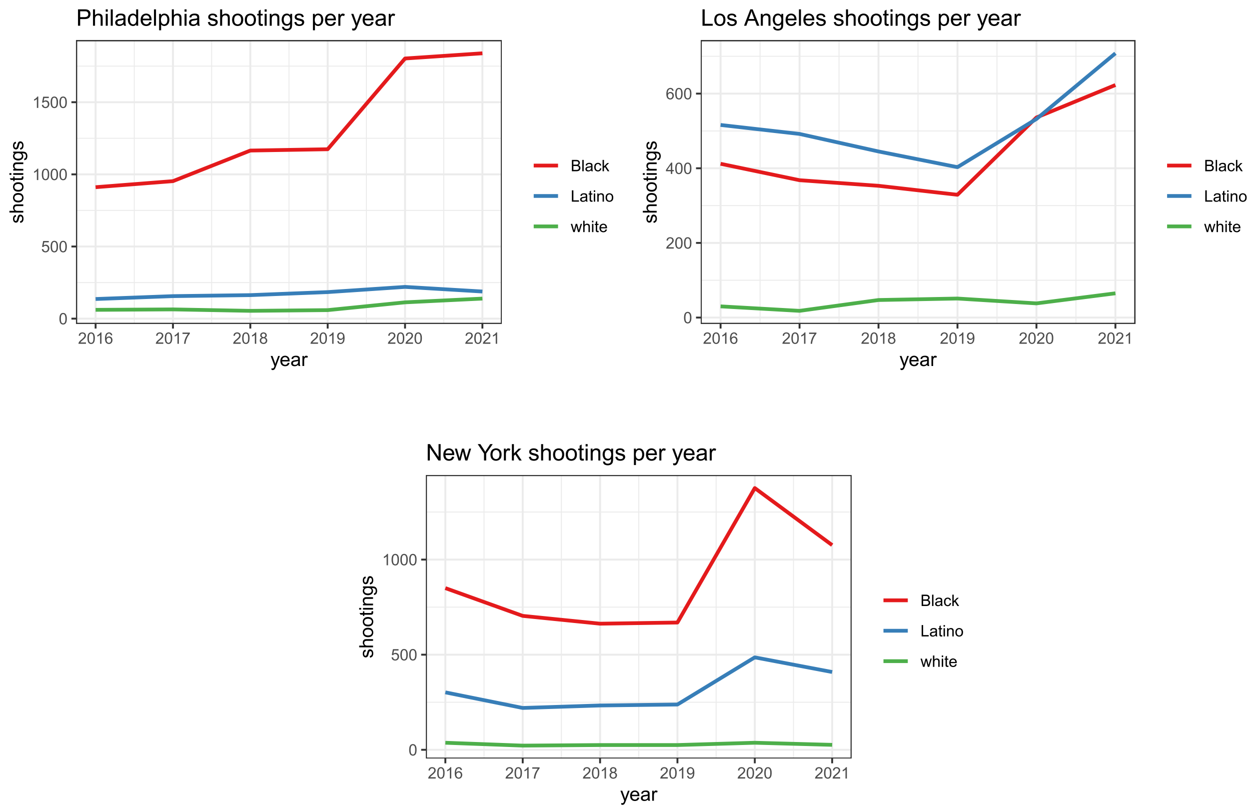

Fig. 1. Race/ethnicity distribution of shooting victims by year. Chi square test for independence of shooting counts by race/ethnicity vs time period (pre/post pandemic) significant at $p=10^{-6}$ level in Philadelphia, marginally significant at the p=.01 level in Los Angeles, and marginally significant at p=.02 level in New York.

Table 1
Race/ethnicity fraction of the population (ACS 2015–2019) and shooting victims in 2016–2019 and 2020–2021.

city	pop. white	vic. white 16–19	vic. white 20–21	pop. Black	vic. Black 16–19	vic. Black 20–21	pop. Hisp.	vic. Hisp. 16–19	vic. Hisp. 20–21
Phil.	0.34	0.05	0.06	0.41	0.82	0.84	0.15	0.13	0.09
L.A.	0.26	0.04	0.04	0.08	0.41	0.44	0.48	0.52	0.48
N.Y.	0.32	0.03	0.02	0.22	0.70	0.71	0.29	0.24	0.26

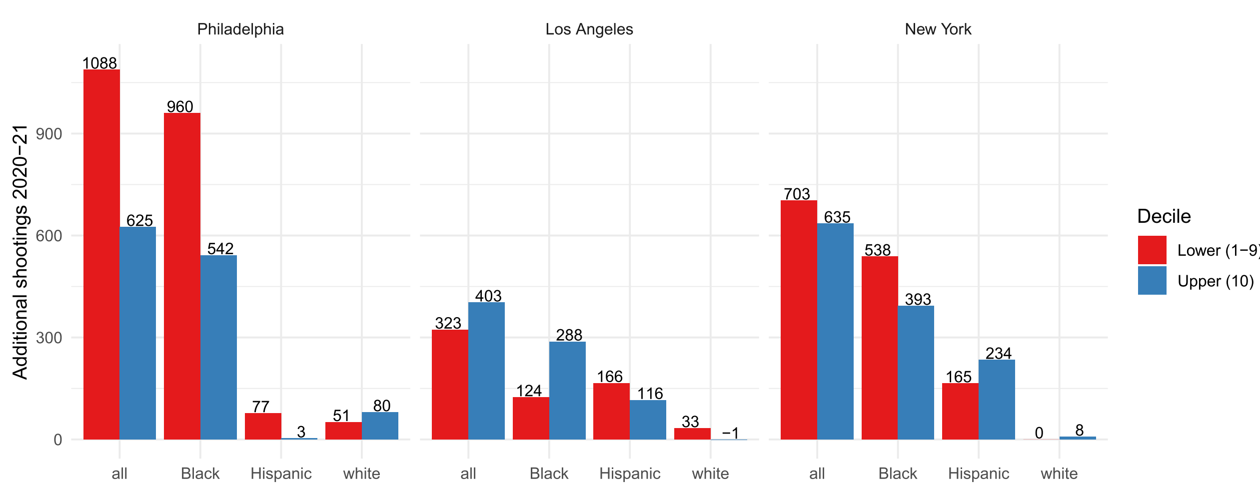

Fig. 2. Additional shootings during 2021–22 relative to the expected number of shootings predicted by a Poisson regression with pandemic indicator variable set to false. Deciles determined by counts of aggregate shootings in census block groups during 2016–2019.

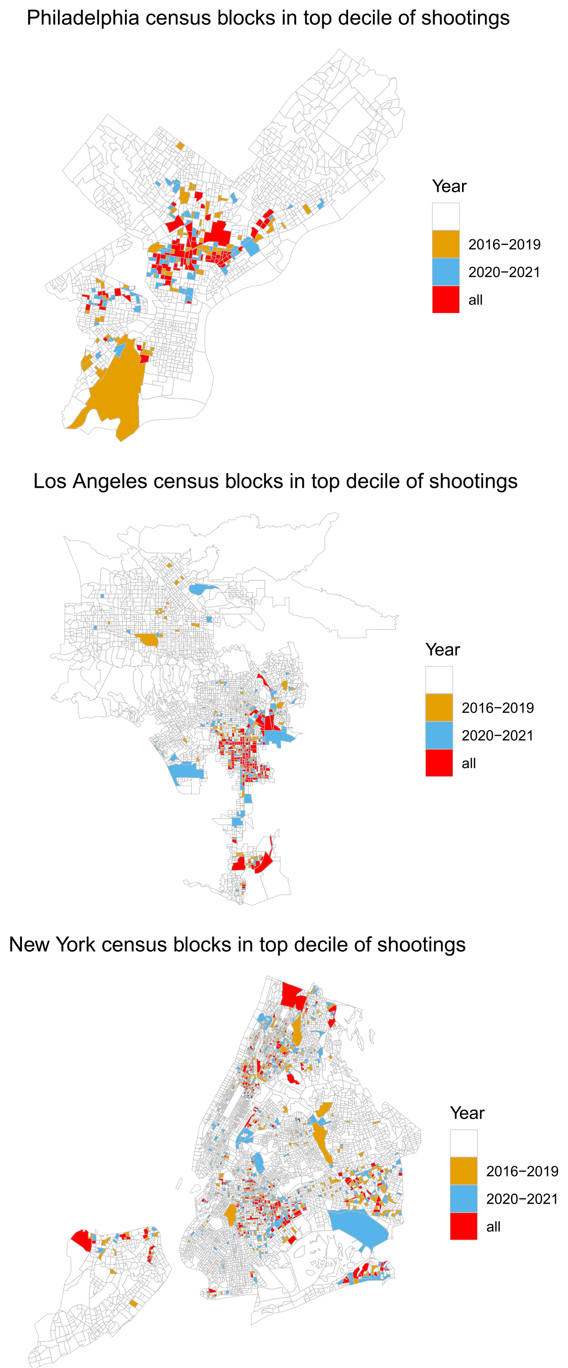

Fig. 3. Top decile of census blocks ranked by aggregate shootings over 2016–2019 (orange) and 2020–2021 (blue). Census blocks that appear in the top decile for both periods shown in red (51% overlap in Philadelphia, 54% in Los Angeles, and 64% in New York).

time, along with the latitude and longitude of the location. Events without a location were removed from the analysis (652 events were removed from Philadelphia). Overall the data consists of 6,200 events in Los Angeles, 7,568 events in New York, and 9,409 events in Philadelphia across 2016–2021. Data also contains the race/ethnicity and age of the shooting victim. We focus on Black, Hispanic/Latino and white individuals due to small sample sizes of other racial/ethnic groups in the data. We merge shooting event data with American Community Survey (2015–2019) data on race/ethnicity, percent of income below the poverty line and percent unemployed at the census block group level. The block group is the lowest level of population enumeration in the census that provides demographic estimates.

We use two methods to assess the association of race, crime concentration, and the increase in gun violence during the pandemic. In the first approach, we rank census block groups by aggregate shooting incident counts during the pre-pandemic period 2016–2019. We define "hot spot" census block groups to be those in the top decile (10%) of block groups. We then fit Poisson regressions on yearly shooting incident counts per block group, disaggregated by race/ethnicity, with indicator variables for pre-pandemic shooting decile and time period (2016–2019 vs. 2020–2021). In the second approach, we measure inequality in the distribution of shootings using a Poisson-Gamma estimate of the spatial gini index of shootings in census block groups that corrects for small sample size (Mohler et al., 2019). We compare the gini index disaggregated by race/ethnicity in the pre/post pandemic time periods.

3. Results

Fig. 1 displays the trend in shootings by race and ethnicity over time in Philadelphia, Los Angeles and New York. There is a clear increase in shootings in 2020–2021 that was greatest for Black victims, followed by Hispanic and white victims.

Table 1 shows the distribution of shooting victim race/ethnicity relative to the general population during the pre (2016–2019) an post (2020–2021) pandemic time periods. Victimization rate per population was highest for Black individuals and second highest for Hispanic individuals. For example, in New York, 70% of shooting victims were Black, despite comprising 22% of the population. In contrast, 3% of shooting victims were white, relative to representing 32% of the population. Victimization among Hispanic individuals more closely mirrors the population. These trends were consistent before and during the COVID-19 pandemic. The patterns of increase also does not change substantially by age, which is consistent with research that shows criminal offending and victimization by age tends to be similar across time periods (Farrington, 1986; Lauritsen and Rezey, 2013) (see Appendix for age trends across time periods).

Next we examine the extent to which the increase in gun violence observed during the pandemic was concentrated in gun violence "hot spots". Fig. 2 displays excess shootings during 2020–2021 relative to the expected shootings from the Poisson regression (with pandemic indicator set to equal zero) in gun violence hot spots vs. lower decile census block groups. Here we observe that the gun violence increase was disproportionately concentrated in hot spots. For example, in Los Angeles there were 288 additional shootings (compared to 2016–2019 levels) where the victim was Black in the top decile, compared to 124 additional shootings where the victims was Black across deciles 1–9. Gun violence was also disproportionately concentrated in the top decile of census block groups in Philadelphia and New York, where 36% (Philadelphia) and 47% (New York) of the increase in shootings observed during the period 2020–2021 occurred in the top decile of census block groups. Further details of the Poisson regression are contained in the Appendix.

Fig. 3 shows a map the location of gun violence hot spots as defined by the top decile of census block groups during the pre- and post-pandemic periods. There was significant overlap of block groups in the top decile across 2016–2019 and 2020–2021, representing a 51% overlap in Philadelphia, 54% in Los Angeles, and 64% in New York. In 2020–2021, the top decile of census block groups accounted for 44% of shootings in Philadelphia, 57% of shootings in Los Angeles and 74% of shootings in New York. These shooting hot spots had greater concentrations of Black and Hispanic individuals and disproportionately more victims of the same race and ethnicity (Table 2). Table 3 displays the demographic distribution of victims in the lowest 9 deciles of census block groups ranked by shootings. The fraction of the population identifying as white is larger in these census block groups compared to the top decile. However, the fraction of shooting victims was largely Black and Hispanic.

Table 2
Demographics of shooting victims vs. population in gun violence hot spots. First two columns contain the fraction of shootings in the top decile of census blocks (ranked by shootings) in 2016–2019 and 2020–2021. Remaining columns contain demographics of the population and shooting victims in the top decile of census blocks ranked by aggregate shootings in that time period (closest ACS range of 2015–2019 was used).

city	frac. top decile 16–19	frac. top decile 20–21	frac. pop. white 15–19	frac. vict. white 16–19	frac. vict. white 20–21	frac. pop Black 15–19	frac. vict. Black 16–19	frac. vict. Black 20–21	frac. pop. Hisp. 15–19	frac. vict. Hisp. 16–19	frac. vict. Hisp. 20–21
Phil.	0.44	0.44	0.09	0.04	0.06	0.59	0.78	0.83	0.27	0.18	0.11
L.A.	0.50	0.57	0.04	0.02	0.02	0.20	0.54	0.56	0.71	0.42	0.38
N.Y.	0.66	0.74	0.08	0.02	0.02	0.44	0.73	0.71	0.39	0.23	0.25

Consistent with prior research, poverty and economic disadvantage alone do not explain the concentration of shootings during the pandemic. To illustrate this point further, we measure inequality in the distribution of shootings using a Poisson-Gamma estimate of the spatial gini index of shootings. The gini index ranges from 0 (total equality) to 1 (total inequality). In 2020–2021, the gini index of shootings was 0.6, 0.7 and 0.8 in Philadelphia, Los Angeles and New York respectively. For comparison, we also ranked census block groups by poverty and unemployment indices and computed the gini index of shootings. While the poverty index explains some percentage of the concentration of shootings (gini index of 0.3-0.5 across cities), there remains a significant concentration of shootings unexplained by poverty across time and cities. It is important to note that poverty likely changed in dynamic ways with the COVID pandemic that we cannot capture with census measures.

4. Discussion

While gun violence surged in Philadelphia, New York, and Los Angeles in 2020–2021, much of this surge was confined to a small fraction of places. These findings should not be a surprise. Research going back more than a century consistently demonstrates that crime is spatially concentrated into a small share of city blocks (Brantingham et al., 1976; Sherman et al., 1989; Weisburd, 2015; Mohler et al., 2019). We observed a concentration by census block groups, but recognize that the concentration of shootings is even greater at more micro units like street segments or addresses. It is well-known that crime and gun violence coincide with other chronic social problems such as poverty and negative health

Table 3
Demographics of shooting victims vs. population in lower risk deciles. First two columns contain the fraction of shootings in the lowest 9 deciles of census blocks (ranked by shootings) in 2016–2019 and 2020–2021. Remaining columns contain demographics of the population and shooting victims in the lowest 9 deciles of census blocks ranked by aggregate shootings in that time period.

city	frac. lower deciles 16–19	frac. lower deciles 20–21	frac. pop. white 15–19	frac. vict. white 16–19	frac. vict. white 20–21	frac. pop Black 15–19	frac. vict. Black 16–19	frac. vict. Black 20–21	frac. pop. Hisp. 15–19	frac. vict. Hisp. 16–19	frac. vict. Hisp. 20–21
Phil.	0.56	0.56	0.38	0.05	0.05	0.39	0.86	0.86	0.13	0.08	0.08
L.A.	0.50	0.43	0.32	0.06	0.07	0.08	0.27	0.28	0.45	0.62	0.60
N.Y.	0.34	0.26	0.35	0.04	0.01	0.19	0.66	0.69	0.28	0.27	0.28

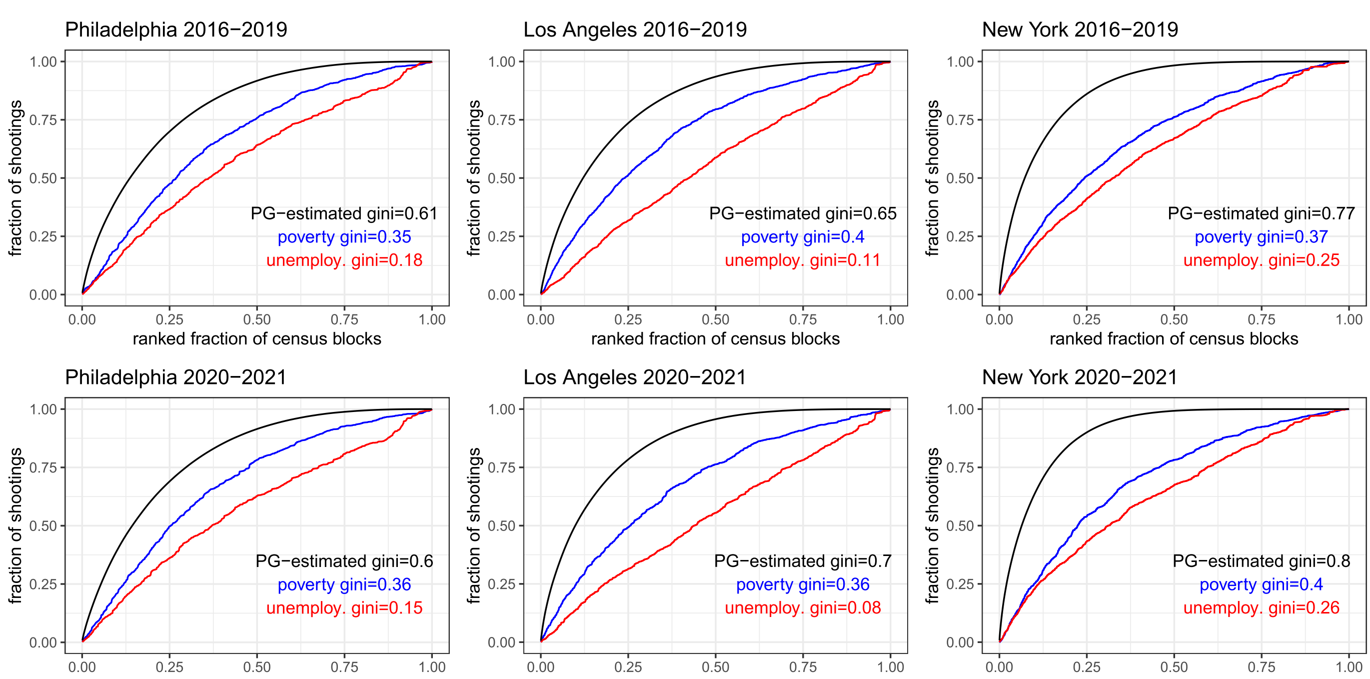

Fig. 4. Gini index of shootings in census blocks from 2016–2019 and 2020–2021. Poisson-Gamma small sample gini estimate of shootings in census block groups ranked by shootings (black). Gini index of shootings in census block groups ranked by poverty index (blue) and unemployment index (red).

outcomes (Weisburd and White, 2019), producing "concentrated disadvantage" that is often correlated with race (Sampson et al., 1997). What we demonstrate here is that the concentration of gun violence victimization by race-ethnicity is multiplicative, or compounding when gun violence rates surged during the pandemic. The top census block groups of gun violence in Philadelphia, Los Angeles, and New York, already have a disproportionate number of Black and Hispanic residents, relative to those cities as a whole, exposing minorities to a higher baseline risk of victimization. Yet, even within these "hot spots," Black and Hispanic residents experience a disproportionate risk of victimization relative to white residents *in those same hot spots*. Gun violence is first spatially concentrated and then demographically concentrated, reflecting enduring legacies of racial inequalities in American society (Sampson et al., 2018). For example, in Philadelphia in 2020–2021, a resident of a top decile hot spot was 6.6 times more likely to be Black than white (see Table 2). Compared to the city as a whole, we expect there to be more Black victimization because there are more Black individuals living in top gun violence hot spots. Yet the victims of shootings in those same top decile hot spots were actually 13.8 times more likely to be Black than white, more than two-times greater than expected based on spatial concentration of residential populations alone (see Fig. 4).

Inexplicably, *empirical facts* like those reported above, are often lost (or ignored) when researchers, the media or the public stop to consider what to do about gun violence in these "hot spots" (Brittain, 2022). Since gun violence is concentrated in space, it makes sense that police and other public safety resources should be concentrated in those areas where gun violence is the most prevalent, especially during a period of surging gun violence (Sherman et al., 1989; Weisburd, 2015). Place-based approaches in hot spots that disrupt the routine activities of individuals at risk for committing acts of gun violence include more direct deployment of police to these areas, more effective management of problematic bars, and restrictions on time when alcohol is sold at alcohol outlets (Sherman et al., 1989; Lum et al., 2022; Haberman and Ratcliffe, 2015).

The concentration of gun violence *within hot spots* suggests there should be a more focused effort at the delivery of police and public safety services in collaboration with community members in economically disadvantaged minority neighborhoods to reduce gun violence hot spots. Braga and Weisburd (2010) suggest that addressing community problems is especially important in "minority neighborhoods where residents have long suffered from elevated crime problems and historically poor police service" (p. 5). In addition to place-based efforts that focus on disrupting routine social activities that lead to gun violence, more effort should be directed towards making structural improvements to the environments of gun violence hot spots. Research evidence shows that changing environmental aspects of places where gun violence concentrates helps to reduce serious crime and gun violence without simply displacing it to nearby areas (MacDonald et al., 2019). Such changes include cleaning up vacant lots, remediating abandoned housing, and improving street lighting.

These recommendations would not be contested if we were talking about the delivery of resources that provide public safety benefits to disadvantaged communities suffering from higher rates of gun violence. Targeted delivery would be hardly controversial because the focus is the provision of benefits with few obvious downside risks. The difference with targeting efforts to reduce gun violence in hot spots is that most short-term prevention tactics are blunt, retrospective, focused on offenders, and prone to abuse of civil liberties. Here there are potential real costs that coincide with the potential benefits (Manski and Nagin, 2017). And those costs and benefits are often hard to link causally. Police activity in gun violence hot spots that focuses on actual criminal behavior of individuals instead of loose heuristics of suspicion can help reduce gun violence in the short-term while minimizing racial disparities in who is stopped and questioned by the police (MacDonald et al., 2016).

The results presented here suggest that we really need to consider the problem in two parts: (1) Where and among whom is gun violence most concentrated? and (2) What are the most effective, fair and just tools that can be brought to bear preventing firearm victimization? A place-based problem solving approach that engages the police, municipal services, and community-based organizations to identify gun violence hot spots, and target for preventative interventions that communities desire, would be a particularly useful approach to attempt. Place-based approaches to addressing public safety offer some guidance for how to reduce gun violence in hot spots and racial disparities in shooting victimization.

CRediT authorship contribution statement

John MacDonald: Conceptualization, Methodology, Formal analysis, Visualization, Writing - original draft, Writing - review & editing. **George Mohler:** Methodology, Formal analysis, Conceptualization, Data curation, Visualization, Writing - original draft, Writing - review & editing. **P. Jeffrey Brantingham:** Conceptualization, Methodology, Visualization, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix

Tables 4–6 include estimates from a Poisson regression model[5] with robust standard errors clustered at block group level. Regressions are run separately for each racial/ethnic group and include indicator predictor variables for decile and time period. Tables 4–6 show the number of shootings per year in the top decile compared to bottom deciles overall and by race/ethnic group in Philadelphia, New York and Los Angeles. We compare the estimated number of shootings in 2020–2021 using only the location that were in pre-pandemic (2016–2019) top decile with those in the actual top decile. The results show that the estimated number of shootings increases proportionally more in the top decile of 2020–2021, and that this increase is being driven by a higher rate of victimization for Black and Hispanic individuals. For example, there were an estimated 653 Black shooting victims per year in the top decile of Philadelphia in 2020–21 compared to 385 per year in 2016–2019. Relying on the locations in the top decile of 2016–2019

[5] We compared Poisson and negative binomial models. Both models yielded similar predictions (correlation > 99.7%, mean absolute error < .05) and we used the simpler model.

would predict 497 Black shooting victims.

The mean age of shooting victims was 29 in Philadelphia, 31 in Los Angeles, and 25–44 in New York (the most frequent age category of victims) (Fig. 5). The age distribution of victims from 2016–2019 vs 2020–2021 is consistent across racial/ethnic groups and shows only a small increase in the average age for Hispanic victims.

Table 4
Results from Poisson regression of yearly shootings vs. decile at the census block level in Philadelphia.

	Margin	Lower_5	Upper_5	N=	Predicted	P_5	P_95	Additional
Total								
Lower deciles 16–19	0.83488	0.787024	0.882736	938	1566.235	1476	1656	
Upper decile 16–19	4.788061	4.454141	5.121981	104	996	926	1065	
Lower deciles 20–21	1.414659	1.33142	1.497899	938	2654	2498	2810	1088
Upper decile 20–21	7.792977	7.070027	8.515927	104	1621	1471	1771	625
Black								
Lower deciles 16–19	0.719102	0.673263	0.764941	938	1349	1263	1435	
Upper decile 16–19	3.674315	3.372741	3.975888	104	764	702	827	
Lower deciles 20–21	1.230723	1.150554	1.310892	938	2309	2158	2459	960
Upper decile 20–21	6.278402	5.69961	6.857193	104	1306	1186	1426	542
Hispanic								
Lower deciles 16–19	0.071209	0.05809	0.084328	938	134	109	158	
Upper decile 16–19	0.928229	0.621298	1.235161	104	193	129	257	
Lower deciles 20–21	0.112127	0.090786	0.133468	938	210	170	250	77
Upper decile 20–21	0.944198	0.603697	1.284698	104	196	126	267	3
white	_margin	_ci_lb	_ci_ub					
Lower deciles 16–19	0.043912	0.036572	0.051253	938	82	69	96	
Upper decile 16–19	0.181945	0.120827	0.243063	104	38	25	51	
Lower deciles 20–21	0.071047	0.057332	0.084763	938	133	108	159	51
Upper decile 20–21	0.56428	0.362755	0.765805	104	117	75	159	80

Table 5
Results from Poisson regression of yearly shootings vs. decile at the census block level in New York.

	Margin	Lower_5	Upper_5	N=	Predicted	P_5	P_95	Additional
Total								
Lower deciles 16–19	0.298222	0.286689	0.309755	2055	1226	1178	1273	
Upper decile 16–19	2.393512	2.273108	2.513916	228	1091	1037	1146	
Lower deciles 20–21	0.469146	0.447418	0.490874	2055	1928	1839	2017	702
Upper decile 20–21	3.785654	3.554001	4.017307	228	1726	1621	1832	635
Black								
Lower deciles 16–19	0.211837	0.201129	0.222546	2055	871	827	915	
Upper decile 16–19	1.792315	1.68351	1.90112	228	817	768	867	
Lower deciles 20–21	0.342781	0.323764	0.361798	2055	1409	1331	1487	538
Upper decile 20–21	2.654753	2.456387	2.853119	228	1211	1120	1301	393
Hispanic								
Lower deciles 16–19	0.0769	0.07036	0.083441	2055	316	289	343	
Upper decile 16–19	0.554822	0.447301	0.662343	228	253	204	302	
Lower deciles 20–21	0.117042	0.106025	0.128059	2055	481	436	526	165
Upper decile 20–21	1.068282	0.909726	1.226838	228	487	415	559	234
white								
Lower deciles 16–19	0.009328	0.007068	0.011589	2055	38	29	48	
Upper decile 16–19	0.045843	0.024276	0.067411	228	21	11	31	
Lower deciles 20–21	0.00921	0.005876	0.012544	2055	38	24	52	0
Upper decile 20–21	0.062393	0.033907	0.090879	228	28	15	41	8

Table 6
Results from Poisson regression of yearly shootings vs. decile at the census block level in Los Angeles.

	Margin	Lower_5	Upper_5	N=	Predicted	P_5	P_95	Additional
Total								
Lower deciles 16–19	0.405226	0.387546	0.422907	1381	1119	1070	1168	
Upper decile 16–19	2.233522	2.126894	2.34015	153	683	651	716	
Lower deciles 20–21	0.520985	0.493366	0.548604	1381	1439	1363	1515	320
Upper decile 20–21	3.53879	3.290528	3.787053	153	1083	1007	1159	399
Black								
Lower deciles 16–19	0.14223	0.12896	0.1555	1381	393	356	429	
Upper decile 16–19	1.24551	1.101642	1.389377	153	381	337	425	
Lower deciles 20–21	0.186988	0.167797	0.206179	1381	516	463	569	124
Upper decile 20–21	2.187203	1.923504	2.450902	153	669	589	750	288
Hispanic								

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Table 6 (*continued*)

	Margin	Lower_5	Upper_5	N=	Predicted	P_5	P_95	Additional
Lower deciles 16–19	0.241857	0.22765	0.256063	1381	668	629	707	
Upper decile 16–19	0.930238	0.822156	1.038319	153	285	252	318	
Lower deciles 20–21	0.301871	0.279872	0.323869	1381	834	773	895	166
Upper decile 20–21	1.307991	1.132958	1.483024	153	400	347	454	116
white								
Lower deciles 16–19	0.019115	0.015395	0.022835	1381	53	43	63	
Upper decile 16–19	0.051194	0.030759	0.07163	153	16	9	22	
Lower deciles 20–21	0.030912	0.024355	0.037469	1381	85	67	103	33
Upper decile 20–21	0.046749	0.016774	0.076725	153	14	5	23	−1

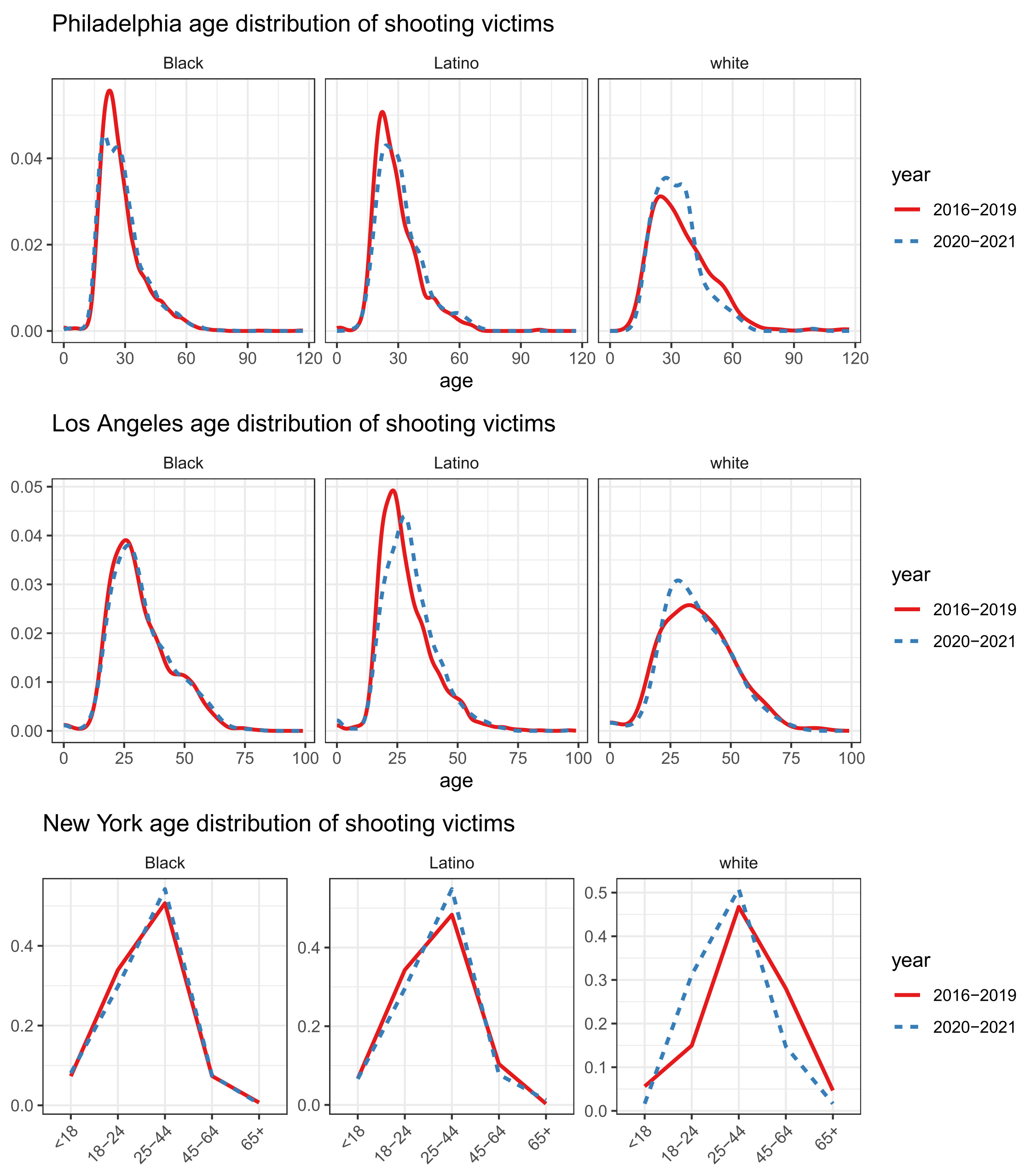

Fig. 5. Age distribution of shooting victims by time period and race/ethnicity. Age data for New York victims was only available in five age bins through Sep. 30 2021.

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