

A Spatial and Community-Level Examination of Gun Violence: Accounting for Racial Composition and Structural Inequality in Micro-Place Research

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Abstract

We offer a spatial and community-level investigation of firearm injury risk surrounding Wilmington communities in New Castle County, Delaware, to better understand gun violence, existing disparities, and potential prevention. We geocoded 689 shooting incidents (2019–2024) from two independent databases. Community characteristics were derived from ACS (2019–2023) for 409 census block groups in New Castle County. Utilizing Moran's I and LISA, we assessed spatial autocorrelation. Circular buffers (250 m) around each shooting location were dissolved into exposure zone polygons, in addition to estimating regression models that also account for spatial dependence. The firearm injury rate varied greatly by community type, where predominantly Black communities experienced 32 times higher shootings than majority-white areas. Strong spatial clustering was observed, with 79% of shooting incidents occurring in 10% of block groups. Circular buffer analysis also revealed that micro-places of gun violence were disproportionately minority and impoverished. Regression analyses further support racial composition as one of the strongest predictors of gun violence, net of controls. Overall, the firearm injury risk in Wilmington is concentrated in communities characterized by racial composition and economic disadvantage. Place-based injury prevention is key, with gun violence policies acknowledging larger structural inequalities.

INTRODUCTION

Gun violence disproportionately impacts Black Americans living in economically marginalized urban communities¹, significantly increasing their risk for injury and death. In fact, one study found gun violence is a primary cause of death for Black young people in urban communities.² In 2022, the homicide rate among Black individuals was 29.0 per 100,000, nearly four times the national average of 7.7 per 100,000.³ Furthermore, 87.4% of these homicides involved firearms, underscoring the prevalence of gun violence in low-income Black communities. Clearly, gun violence is an important health issue in urban spaces, and it is a largely preventable public health problem. While gun violence has received considerable attention, the majority of studies can be classified into two groups: (1) qualitative studies, such as interviews with residents who have experienced gun violence within their communities and ethnographic work,^{1,4,5} and (2) quantitative research examining violence within communities defined by census tracts.^{6–8} These strategies are important but can fail to account for the structural features of communities that create the greatest risk for injury/death and/or acknowledge that gun violence occurs in smaller, micro places rather than communities (census tracts) more generally.

The current research considers these two important issues when offering a spatial and community-level investigation of gun violence in Wilmington, DE. Wilmington, DE, has been labeled “Murder Town USA” and one of the “most dangerous small cities in America.”^{5,9} In an era of increasing gun violence in urban communities, this study offers a systematic look at the spatial patterns in, and levels of exposure to gun violence within micro places. Moreover, we incorporate the community context by estimating how

firearm injury rates vary by community type. Below, we briefly review previous literature on gun violence and the importance of investigating micro places.

Research on Gun Violence

Because Black Americans are overrepresented among the economically disadvantaged in the United States, they face higher exposure to violence.¹⁰ Shakoor and Chalmers¹¹ also found higher rates of witnessing violent events among lower-income minority youth. Living in urban and high-crime areas has been found to increase the risk of exposure to violence.^{12,13} For example, separate from individual risk factors, racial composition (percent Black population) significantly increases the risk of injury or death for Black residents more than for White residents.⁷ Qualitative research on gun violence in disadvantaged communities is extensive. For example, many Black individuals have shared their personal experiences with police contact, stating they feel targeted and experience poor treatment at the hands of police officials.^{5,14} Moreover, in face-to-face interviews with 50 young Black men, residents of high-crime neighborhoods in Brooklyn and the Bronx reported feelings of “hopelessness” or powerlessness in their communities when engaging with police officers,^{15,16} making it difficult to report injury or victimization to the police. Importantly, research indicates that poor police-community relationships can reduce residents’ willingness to report crimes or cooperate with police.¹⁷ As a result, gun carrying may increase as a form of self-protection.^{18,19}

Importance of Micro-Places

Equally important are studies that illustrate that community characteristics also increase exposure to gun violence and potential risk of injury or death. However, scholars have found that census tracts can mask important variations in levels of crime and violence.²⁰ As a result, studies have moved to examining micro places and/or hot spots of crime.^{20–22} Although still novel, extensive work is being conducted to empirically validate crime concentration in micro places.²³ This line of research is promising, as scholars have statistically revealed the “law of crime concentration,” or clustering of violence in smaller segments or micro places, such as parks.²² For example, Rowlands and Love²⁴ found that gun violence in four cities is often localized to economically marginalized communities, with 4% of city blocks bearing 50% of gun-related crimes. Given this, there has been a shift from neighborhood-level (census tract) to micro-place-specific analyses, particularly when examining more nuanced incidents like gun violence.

Yet there are reservations about this line of research, in that micro-place research tends to ignore the structural inequalities and racial hierarchies that shape crime patterns.^{25,26} Thus, scholars are calling for research that examines crime concentration in micro places while also considering how racial composition and economic disadvantage contribute to those patterns. The current study addresses this call by examining the spatial concentration of gun violence at the census block-group level while also

accounting for the role of, and variation in, racial and economic characteristics of communities. In doing so, we examine the spatial distribution and community-level factors associated with firearm injury risk in communities surrounding Wilmington, Delaware. Wilmington itself adds to the significance of this research. That is, it is a mid-size US city located in the Northeast, which is a unique location for investigation since the majority of micro-place studies focus on large US cities (eg, Boston, Chicago, Kansas City).

METHODS

We examine firearm injuries or shooting incidents in areas and communities surrounding Wilmington and New Castle County, Delaware between 2019 and 2024. There are two primary sources of data detailing the number and types of firearm injuries/shootings in Wilmington that are publicly available. First, the *Center for Structural Equity* (CFSE), through the multi-year effort of Executive Director Chambers, has generated a data file containing the details of 1,823 shootings that occurred from 2011 to 2025, focusing on predominantly marginalized Black communities in Wilmington (e.g., Northside, Eastside, Hilltop and West Center City).¹ These records are compiled by CFSE violence-response workers from community reports and follow-up contact with victims and families. This data file offers extensive information on the characteristics of victim(s), potential offender(s), motive or circumstance of the incident, specific address/location, and other pertinent details. The unit of record is the victim: each row describes one person. The second dataset draws on Wilmington police accounts of gun violence and firearm injuries, which is made publicly available by the *News Journal* (Delaware newspaper). Dr David Chen, MD/PhD of Internal Medicine at Christiana Care Hospital, in consultation with staff at the *News Journal*, has generated these data. These data include 1,471 incidents that occurred between 2017 to 2024 and the details of those incidents, such as characteristics of victim(s) and detailed police narrative or description of the incident. This data was geocoded by one of the authors. Importantly, both datasets were carefully examined for accuracy to avoid geocoding errors and duplication of shooting incidents, resulting in a final sample of 689 total shooting incidents between 2019 and 2024. In the multivariate analyses, the dependent variable is the firearm injury rate per 1,000 population in the OLS models and the incident count, with a population offset, in the negative binomial model.

In addition to firearm injury data, we incorporate census data (via 2019–2023 American Community Survey (ACS) 5-Year estimates) for 412 census block groups in New Castle County, Delaware, into this research; three block groups with fewer than 200 residents were excluded, leaving a final total of 409. Specifically, using census data, we generate 14 community-level indicators commonly utilized in studies of violence, capturing racial composition, economic conditions, and several social characteristics. Some of the core indicators include percent (non-Hispanic) black, percent Hispanic, poverty rate, unemployment rate, and percentage of female-headed households. Other indicators and controls included: percentage of males 15–34, percentage with no high school diploma, housing vacancy rate, percent renter-occupied, percentage moved recently, percentage on public assistance, and the percentage living alone, together with log median household income and log population density.

Finally, before moving to the analyses, we used census block group percentages of the population (e.g., non-Hispanic White, non-Hispanic Black, and Hispanic of any race) to create *community types*. *Predominantly Black* neighborhoods are those where at least 50% of the block identified as non-Hispanic Black; *predominantly White* communities used the same 50% threshold. *Hispanic concentrated areas* are census blocks with more than 25% of persons of Hispanic origin that are neither majority Black nor White communities. We further identified *mixed/other* as the remainder of the neighborhoods.

Analysis

Statistical analysis focused on capturing the spatial distribution and community-level factors of firearm injury risk. First, we assessed spatial autocorrelation using Global Moran's I and LISA cluster analysis on block group rates. Second, we conducted circular buffer analysis to identify gun violence micro places and describe the population living near shootings and/or with the highest levels of violence risk or exposure. Buffers of 250 meters were drawn around each geocoded shooting location, and overlapping buffers were dissolved into contiguous polygons. The 250-meter radius was selected because it is commonly used in micro-place research.²⁰ Moreover, Zhang et al²⁷, in their study of neighborhood robbery, reported that a 250-meter radius (approximately 2 urban blocks) best captures the immediate spatial environment and is consistent with prior place-based criminological research. Next, we used areal weighted interpolation to redistribute census block group characteristics onto these new geographies while preserving population proportionality. Finally, we estimated a series of nested (OLS and negative binomial) regression models to assess which community-level predictors affect firearm injury rates, net of controls.

RESULTS

Key to this research is capturing the spatial and community-level indicators of gun violence in the relatively understudied area of Wilmington, Delaware. That is, our work not only demonstrates the spatial location of firearm injury or death, but we also acknowledge the variation in the racial and economic context of Wilmington communities as well. To start, we offer a look at firearm injury rates across community types.

Table 1 presents the firearm injury rate across the community types. When compared to majority-White areas, with a rate of 0.17 incidents per 1,000, the predominantly Black areas experience firearm injuries 32 times higher. Stated another way, 65% of all gun violence incidents occurred in majority Black block groups. Statistical tests confirmed these differences (One-way ANOVA confirmed significant group differences ($F = 32.55$, $p < 0.001$); Welch's t-test for the primary comparison yielded $t = 5.23$, $p < 0.001$).

Table 1
Firearm Injury Rates by Community Type.

Community Type	Block Groups	Population	Shooting Incidents	Rate (per 1,000)	95% CI	CFSE alone	News Journal alone
Predominantly Black	69	84,821	450	5.31	[4.82, 5.81]	4.34	4.53
Predominantly White	234	325,305	54	0.17	[0.12, 0.22]	0.08	0.12
High Hispanic	36	45,605	70	1.53	[1.18, 1.93]	1.03	1.56
Mixed/Other	70	117,245	115	0.98	[0.80, 1.18]	0.77	0.84
Total	409	572,976	689	1.20	-	0.92	1.03
Black : White ratio	NA		NA	32.0	[24.1, 42.4]	56.5	37.8
Single-source columns give the rate per 1,000 counting every incident that source holds. Ratio CI from the log-rate-ratio standard error.							

Figure 1 provides a diagram of the disparities in firearm injuries by community type. Here, while the overall firearm injury rate was 1.20 per 1,000, the predominantly Black areas experienced a rate of 5.31 incidents per 1,000, suggesting that gun violence is 4.4 times higher in these areas. Overall, we find that the racial composition of the community greatly influences the exposure to gun violence in Wilmington DE, and surrounding areas.

**** Table 1 & Fig. 1 about here ****

Spatial concentration: In addition to revealing significant variation in gun violence across community types, we examine the likelihood that gun violence is concentrated in small segments or micro places, a pattern referred to as the “law of crime concentration.”²² As shown in Fig. 2, LISA identified 40 hot spots largely concentrated in Wilmington’s North, East, and West Center City segments, which represent the most economically marginalized and racially isolated areas in the county.⁵ More specifically, the top 10% of block groups accounted for 78.7% of all firearm injury incidents from 2019–2024 (Global Moran’s I = 0.547, $z = 20.0$, $P < .001$). In comparison, Braga et al²⁸ reported that less than 3% of Boston’s street segments generated more than 50% of gun assault incidents from 1980 to 2008. Overall, our study produces similar findings of the concentration of gun violence in micro places within Wilmington, DE, even though Wilmington is a much smaller US city than cities commonly studied (eg, Boston, Chicago).

**** Fig. 2 about here ****

Characteristics of micro places

The circular buffer analysis provides additional detail about the segments or micro places where gun violence is occurring in Wilmington, DE, particularly as it relates to racial and economic characteristics. To perform these analyses, circular buffers (250 m) around each shooting location were dissolved into 145 contiguous polygons covering 4.4% of county area. Areal weighted interpolation was used to redistribute census characteristics onto these new units. Table 2 offers a comparison of the community characteristics inside and outside of these buffer zones. We find that, inside spatial buffers where the majority of gun violence occurs, Black racial composition is 52.4%, the poverty rate more than doubles (21.5% vs. 9.1%), the median income is substantially lower than areas outside the buffer (\$66,673 vs \$105,791, and the percentage of female-headed households is approximately two times higher (41.2% v 19.6%). Importantly, in a series of sensitivity analyses, the direction of these differences held at every radius from 50 m to 1 km, though their size did not. For example, Black residents were 2.5 times overrepresented within 50 m of a shooting, 2.1 times within 250 m, and 1.1 times within 1 km.

Table 2
Inside vs Outside the 250 m buffer

Measure	Inside Buffer	Outside Buffer
Estimated Population	73,819 (12.9%)	499,157 (87.1%)
% Non-Hispanic Black	52.4%	20.5%
% Below Poverty	21.5%	9.1%
Median Household Income	\$66,673	\$105,791
% Female-Headed HH	41.2%	19.6%
% Vacant Housing	9.5%	4.2%

**** Table 2 about here ****

The above findings provide strong evidence of the spatial concentration of firearm injuries in Wilmington DE. Wilmington provides a unique and new location for investigation, expanding micro-place research beyond the focus on large U.S. cities like Boston and Chicago. That is, the fact that it is a much smaller city in terms of population size (73,176 residents according to 2024 U.S. Census Bureau), evidence that gun violence is highly spatially concentrated in smaller segments lends support for micro-place research across city sizes. Our findings also reveal that incidents of gun violence vary across community types, particularly in regard to racial composition and economic conditions. Building off spatial analyses, we now turn to the multivariate regression results.

Regression analysis

In Table 3 we take our analysis a step further by offering nested OLS regression and negative binomial models that estimate the impact of racial composition and economic indicators on the firearm injury rate, net controls. Model 1 includes seven core demographic and economic community-level predictors,

including % (non-Hispanic) Black, % Hispanic, poverty rate, unemployment rate, and the presence of female-headed households. Model 2 displays the full OLS regression model, accounting for a larger list of possible community-level predictors, such as housing vacancy rate, % renter-occupied units, and residential instability. As shown here, while economic conditions, such as poverty and median income levels, vacant units, and lower educational attainment all had a direct impact on firearm injury rates, racial composition (percent Black) remains significantly associated with firearm injury rates.

Table 3
Firearm Injury at the Community Level, 2019–2024

Variable	Model 1	Model 2	Model 3	Model 4
% NH Black	0.105*** (0.014)	0.083*** (0.013)	1.032*** (0.005)	—
% Hispanic	-0.009 (0.021)	-0.070** (0.023)	1.005 (0.009)	—
% Poverty	0.075** (0.025)	0.031 (0.023)	1.021* (0.009)	0.032 (0.023)
Unemployment Rate	0.008 (0.042)	-0.010 (0.037)	0.988 (0.013)	—
% Female-Headed HH	0.009 (0.018)	0.007 (0.016)	1.015** (0.006)	0.024 (0.016)
ln(Median Income)	0.882 (0.847)	1.950* (0.833)	1.162 (0.368)	0.916 (0.741)
ln(Pop Density)	0.544* (0.265)	0.445 (0.240)	1.366** (0.102)	—
% Male 15–34	—	-0.058 (0.033)	1.007 (0.015)	—
% No HS Diploma	—	0.156*** (0.033)	1.011 (0.013)	0.127*** (0.032)
% Vacant Housing	—	0.344*** (0.036)	1.065*** (0.015)	0.354*** (0.038)
% Renter-Occupied	—	-0.006 (0.013)	1.002 (0.005)	—
% Moved Recently	—	-0.035 (0.035)	1.001 (0.016)	-0.075* (0.032)
% Public Assistance	—	0.059 (0.052)	1.022 (0.019)	—
% Living Alone	—	0.033 (0.018)	1.016* (0.007)	—
Predominantly Black (ref = White)	—	—	—	4.601*** (0.805)
High Hispanic	—	—	—	-1.619 (1.030)
Mixed/Other	—	—	—	1.088 (0.706)
R ² (Adj R ²)	0.288 (0.276)	0.472 (0.453)	—	0.411 (0.398)
AIC	2537.6	2429.9	931.7	2464.2
Estimated α	—	—	1.49	—

*Models 1, 2, 4: OLS on the rate per 1,000. Model 3: negative binomial on the count with population offset and MLE dispersion; entries are incidence rate ratios with SE of log(IRR). ** p < 0.001, * p < 0.01, * p < 0.05.*

Variable	Model 1	Model 2	Model 3	Model 4
Max VIF		2.70		
N	409	409	409	409
<i>Models 1, 2, 4: OLS on the rate per 1,000. Model 3: negative binomial on the count with population offset and MLE dispersion; entries are incidence rate ratios with SE of log(IRR). ** p < 0.001, * p < 0.01, * p < 0.05.</i>				

**** Table 3 about here ****

Model 3 replicates these results using a different estimation procedure. In this model, a negative binomial GLM model of shooting counts serves as the dependent variable, with a population offset and maximum-likelihood-estimated dispersion parameter. Here, the findings are largely consistent with the other models presented here, highlighting the role of economic conditions, vacancy rates, and racial composition (% Black population) as significant predictors of gun violence: each percentage point of Black population is associated with 3.2% more incidents. That is, the negative binomial model (Model 3) confirmed key findings in a count framework. Finally, in Model 4, categorical OLS regression replaces racial composition with dummy variables for the community types offered earlier in this paper (e.g., majority Black, High Hispanic, Mixed/Other; reference = Majority White), along with controls. This categorical model shows that, holding poverty, education, vacancy, and residential instability constant, majority Black block groups experienced 4.6 additional firearm injuries per 1,000 compared to majority white areas ($p < 0.001$).

Last, we test for the robustness of the findings reported here. In the Appendix, we perform four sensitivity analyses to assess the sensitivity of our key results that include: (1) re-estimation using each incident source alone (CFSE only; News Journal only), to assess whether the findings depend on the coverage of a single source; (2) extension of the shooting data to the full 2011–2024 period, to verify findings were not driven by the restriction to the ACS reference period; (3) re-estimation counting CFSE victim records rather than incidents, as in the earlier version of this analysis; and (4) re-estimation excluding the 624 CFSE records whose coordinates could not be verified against an address. Across all four sets of models, the spatial concentration of gun violence (Moran's I of 0.52–0.58) and the direction of the racial disparity are supported.

DISCUSSIONS AND POLICY IMPLICATIONS

In a book titled *Murder Town, USA*, Payne and colleagues⁵ offer an ethnography of the prevalence and struggles with gun violence in some of Wilmington's most economically marginalized and predominantly Black communities. The story portrayed in *Murder Town, USA* shows that racial isolation and strained community-police relations contribute to rising levels of gun violence within these neighborhoods.⁵ Moreover, and often missed in previous research, Payne and colleagues demonstrate high levels of

resiliency among Black residents as they face structural inequality, as well as evidence of residents' passion for outreach as they strive toward building stronger, safer communities.

We offer the first spatial and community-level study of gun violence in Wilmington, DE, and surrounding areas. While there are several micro-place studies on gun violence, typically in some of the largest US cities, less is known about spatial patterns in gun violence in mid-size US cities like Wilmington. In our estimation efforts, we move beyond the spatial concentration of gun violence to also account for race and economic conditions within those areas. Scholars have recently criticized micro-place research for not acknowledging the larger racial and economic disparities of communities when investigating gun violence.²⁵ To accomplish this, we estimate the influence of racial composition, economic disadvantage, and other social indicators on gun violence, as well as examine variation in gun violence across different types of communities. In closing, we highlight some of the key findings from this study and potential policy implications of this research.

First, racial composition is the most powerful community-level predictor of firearm injury risk. Racial composition (measured as % Black residents) spatially concentrates incidents of firearm injuries, significantly increasing exposure to, and experiences with, gun violence. Similarly, Semenza et al²⁹, in a nationally representative study, found that 41% of Black people reported a friend or family member being shot, and another 38% reported witnessing or hearing about shootings in their neighborhood. Like other studies that find the importance of racial composition to gun violence, we too argue it is indicative of the presence of structural racism and inequality, limiting access to resources and reducing institutional investments. These conditions, in turn, shape crime and increase the risk of violence. In this way, the strong relationship between racial composition and gun violence reflects the enduring impact of racial inequality in American cities today. Creating policies that reduce racial disparities in the most economically marginalized communities, such as antidiscrimination housing enforcement, investment in underresourced neighborhoods, and affordable housing mobility programs, are examples of strategies that may reduce racial disparities in gun violence.

Second, holding education, vacancy, and residential instability constant, the majority-Black block groups experienced 4.6 additional injuries per 1,000 compared with majority-White areas. Historical disinvestment, differential policing, and diminished institutional resources in Black communities likely contribute to this gap.³⁰ Generating programs that improve opportunities, such as workforce training initiatives, targeted job creation programs, and youth employment programs, can go a long way toward reducing violence. Moreover, housing mobility initiatives have reported long-term benefits in education, employment, and health outcomes,^{31,32} which could indirectly reduce gun violence in majority-Black communities.

Third, the risk of firearm injury is highly spatially concentrated. We find that 79% of shooting incidents occur in 10% of block groups, which is highly consistent with Rowlands and Love's analysis²⁴ and the broader law of crime concentration.²² Moreover, the circular buffer analysis reveals that micro places of firearm injuries cover just 4.4% of the county (and around 13% of its total population), with Black

residents being 2.13 times overrepresented in these areas. In earlier sections, we referenced research showing that Black residents often fail to report injuries or victimization to police¹⁵ and may lack trust in police or feel police are not there to protect them,¹⁸ contributing to gun-carrying behavior for self-protection.

Thus, another area of potential prevention is improving community-police relations. The police's ability to resolve conflicts and decrease retaliation risks can be an effective avenue toward gun violence prevention. This is, however, strongly affected by police relationships with community members. For example, in communities where residents trust police, clearance rates of shootings are much higher. Brunson³³ discussed how focused deterrence, when combined with community leaders and service providers, may improve police-community relations. Systematic review evidence also supports focused deterrence as a violence-reduction strategy.³⁴ Importantly, the success of these strategies is largely dependent on focusing deterrence in specific locations or micro places.³⁵ Given that these interventions have been effective in rigorous evaluations,^{36,37} there is reason to believe these strategies could also be effective in smaller cities like Wilmington, DE.

This research, however, is not without limitations. Micro-place research has been criticized for focusing on very small geographic units that decontextualize the community or structural characteristics needed to understand crime.³⁸ While we incorporate community characteristics and variation across neighborhood types in our work, concerns remain about the meaning and measurement issues surrounding micro-place research.³⁹ Other concerns about micro-place research include not being able to take into account that crime and/or locations can shift over time, the tendency to focus on the location of incidents rather than the victims and offenders of gun violence, and overall data availability and quality issues.^{17,22}

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FOOTNOTES

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Figures

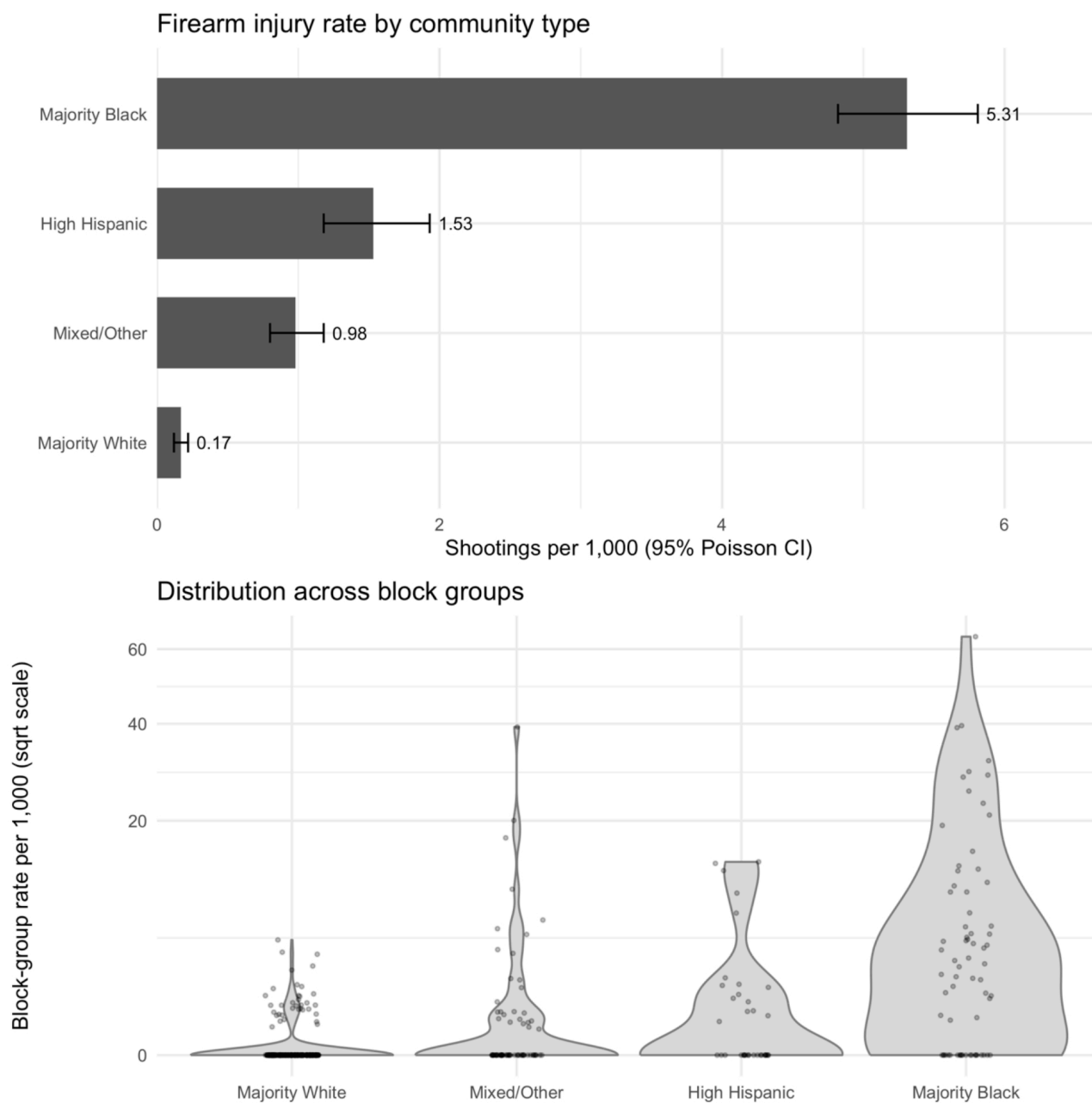


Figure 1

Legend not included with this version.

LISA clusters of firearm injury rate
Queen contiguity, 40 hot spots at $p < 0.05$

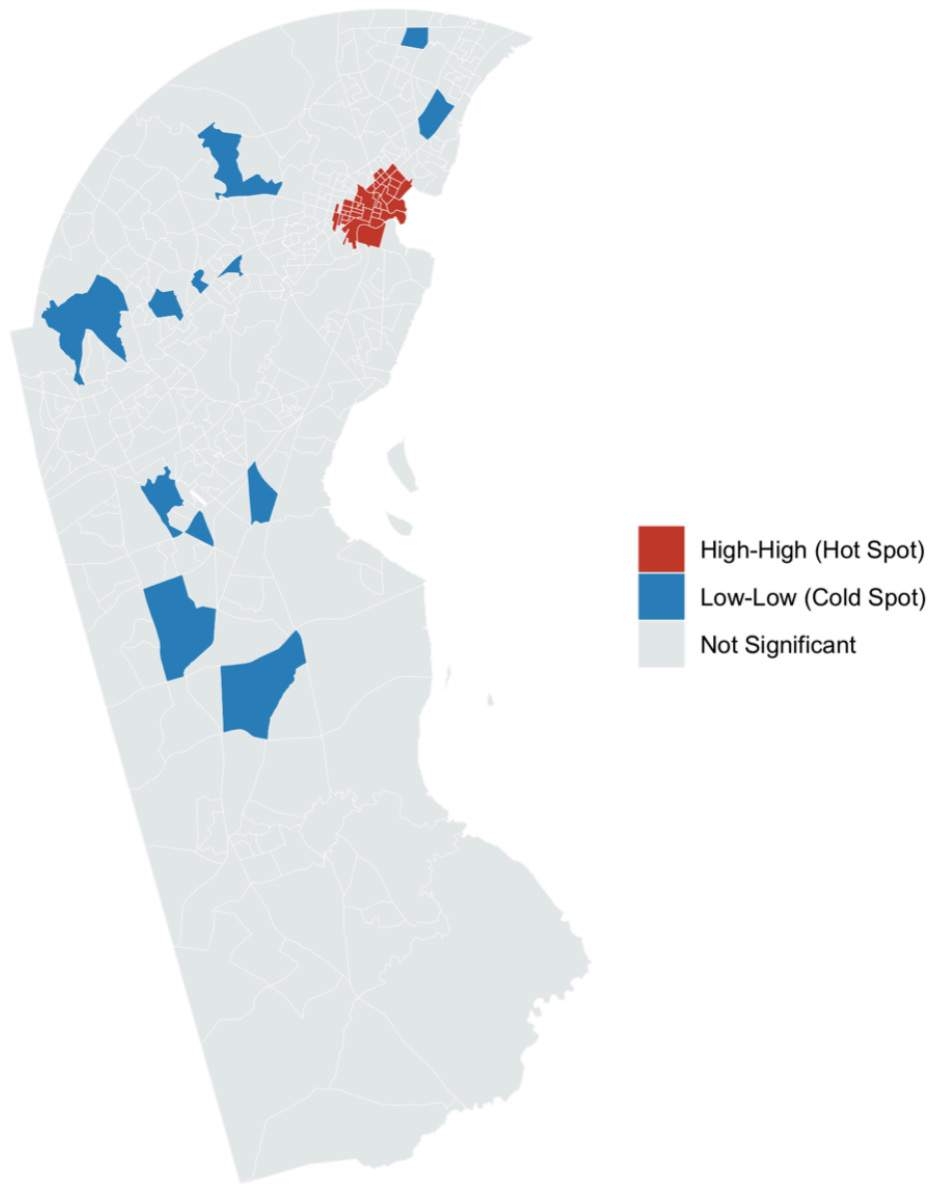


Figure 2

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