Differentiating Black and Hispanic: outcome differences of segregated communities and police shootings in the USA, 2015–2020

Timothy F. Leslie1*, Cara L. Frankenfeld2 and Angela J. Hattery3

Abstract

Background: Police shootings are unevenly spatially distributed, with substantive spikes throughout the USA. While minorities are disproportionately the victims of police force, social or structural factors associated with this distribution are not well understood. The objective of this work was to evaluate police shootings in relation to victim race or ethnicity and residential segregation and racial diversity.

Methods: Validated crowdsourced data from the Washington Post’s Fatal Force (2015–2020) were linked with census tract-level data from the American Community Survey. Residential minority dissimilarity, interaction, and a racial and ethnic diversity metric were calculated in order to assess the potentially variant importance of evenness in distribution, exposure likelihood, and general representation. Logistic and multinomial regression was used to model associations between segregation and diversity, adjusted for other ecological characteristics. Analyses were stratified by victim race or ethnicity (Black, Asian, or Hispanic).

Results: Across all races combined, the odds of a police shooting in a particular census tract were associated with non-Hispanic Black dissimilarity (OR = 0.98, 95% CI 0.97, 0.99) and racial and ethnic diversity (1.046, 95% CI 1.044, 1.060). Areas with higher racial diversity had a higher likelihood of having a police shooting event with Black victims (OR = 1.092, 95% CI 1.104, 1.120) or Asian victims (OR = 1.188, 1.051, 1.343) than less diverse areas. Higher non-Hispanic Black interaction was associated with a lower likelihood of having a police shooting event with Black victims (OR = 0.914, 95% CI 0.833, 0.946) than lower interaction areas. Higher Hispanic dissimilarity was associated with a lower likelihood of having a police shooting event with a Hispanic victim (OR = 0.398, 95% CI 0.324, 0.489) than lower dissimilarity areas.

Conclusions: The variant effects of residential segregation are only seen when victims are analyzed separately by race. There appears to be a protective effect for Hispanic populations in Hispanic communities, while the reverse is true of Black individuals. We urge law enforcement responsible for locations with segregated communities to monitor individual interactions that police have with residents as well as the patterns of frequency and context of those interactions.

Keywords: Segregation, Police, Shootings, Racial

Background

The US death by firearm assault rate is more than 10 times higher than the combined number of deaths for the next 4 highest countries by Gross Domestic Product combined (Marczak et al. 2016). Police shootings, in particular, are being regarded as a public health issue due...
to their increase in occurrence over the past 30 years, as well as a continued disparity in racialized occurrences (GBD 2021). The probability of being fatally shot while Black and unarmed in the USA is 3.49 times more likely than if we are White and unarmed (Ross 2015). Injuries due to police intervention have been found to be 4.9 times higher for Black individuals compared to White individuals (Feldman et al. 2019). These differences remained despite increasing public scrutiny and growing voices for the concern over the determinants of the inequities or their potential solutions.

Characteristics of the environment have long been understood to influence perceptions and behavior during a police encounter (Kania and Mackey 1977; Fye 1980, 1988). Hemenway et al. (2019) found that states with higher household gun ownership prevalence have higher rates of police shootings. Kivisto (2017) found that stricter firearm legislation was associated with lower rates of fatal police shootings. Communities with higher population of minorities experience more fatal police shootings if the population has a higher number of Black residents, although predominantly Hispanic areas did not have the same trends (Snyder 2013). Fatal police shootings are more likely to occur in large metropolitan counties with low median incomes, higher proportion of Black residents, and higher levels of financial inequality (Ross 2015).

In addition to differing prevalences of demographic and socioeconomic factors, the contrast and separation between communities—termed residential segregation—are an additional factor in police behavior (Wright et al. 2021). At the state level, increases in a racism index were found to be a significant driver in the disparity between fatal police shootings of unarmed White and Black individuals, with the association being driven primarily by the residential segregation component of the index (Mesic et al. 2018). These social forces may be mediated through social segregation resulting from the separation of populations along different sociodemographic axes, including race, which can occur through self-selection (Bishop 2009), but may be more determined by structural factors. Structural factors include racial segregation in housing that resulted in segregated neighborhoods and produced a variety of negative outcomes for Blacks in the USA (Massey et al. 1998). Blacks with income levels corresponding to middle class are significantly less likely to live in middle-class neighborhoods than their White counterparts, but instead are more likely to live in low-income neighborhoods, which are characterized by higher crime rates, lower resourced schools, and fewer economic opportunities. Conversely, Whites are far more likely to live in neighborhoods that are both racially and economically homogenous and have better resourced schools, more economic opportunities, and lower crime (O’Hanlon 2017; Reardon et al. 2015). Research focused on racial segregation in Alabama and Mississippi also revealed that the impact of residential segregation was far more profound for Blacks than for Whites: Whites in counties with a higher proportion of Black individuals did not experience lower well-being than Whites in counties with a lower proportion of Black individuals, but the converse was true for Blacks as they, on average, experienced higher levels of well-being when they did not live in majority Black counties (Hattery and Smith 2007).

Segregation has been linked in disparities in mortality in sum and across a number of chronic illnesses (Frankenfeld et al. 2022), including heart disease (Williams and Collins 2001), cancer diagnosis and treatment (Dai 2010; Menon et al. 2020), diabetes (Gittner et al. 2017), infant mortality (Hattery and Smith 2007), incidence or prevalence of drug overdose deaths (Frankenfeld and Leslie 2019), and domestic violence (Miles-Doan 1998). Some types of segregation have been linked to increased assaults (Krieger et al. 2017), school bullying (Fu et al. 2013), homicides (Frankenfeld and Leslie 2021), and firearms violence (Beard et al. 2017) in a region. As a result of structural racism and legally enforced segregation practices like redlining and housing covenants, as well as personal bias among realtors and home sellers, many communities in the USA from the block to the county remain highly segregated by race (Massey 1990, 2015; Sampson and Sharkey 2008; Jacoby et al. 2018; Arcaya et al. 2018).

Many police departments that are in the news for cases of police killings or police brutality have a force that had a substantially different racial makeup compared to the population they policed (Jetelina et al. 2017). Racial bias in neighborhood police encounters has been documented as a cause for action by scholars in a number of social science fields (Hall et al. 2016; Gilbert and Ray 2016; Vitale 2017). Concerns over police violence have reached the point that government documents such as driving manuals now provide instructional guidance on what drivers should do during traffic stops to reduce the likelihood of being shot (ADOT 2018), while calls to “defund the police” have led to serious inquiry into the breadth of

---

1 Consistent with the scholarly literature on race and policing, we use the terms “Black” and “White” to denote people’s racial identities as well as the demographic makeup of institutions (police departments) and communities or neighborhoods. We utilize capitalization throughout the document to emphasize the person-centric nature of these terms (nouns) as opposed to colors (adjectives). See the statement from the Associated Press. “The Associated Press style is now to capitalize Black in a racial, ethnic, or cultural sense, conveying an essential and shared sense of history, identity, and community among people who identify as Black... The lowercase black is a color, not a person.” (AP 2020).
service that police officers undertake and other options that may be employed that limit or constrain traditional police response (Lum et al. 2021; Jacobs et al. 2021). In addition, the importance of understanding the relationship between race and police shootings has been a consistent source of scholarly inquiry (Fyfe 1982; Hemenway et al. 2019). State-level analysis of residential segregation and police shootings has found a strong effect in the Black–White disparity in firearm homicide rate (Knopov et al. 2019). While shootings across the USA have been examined as an occurrence (Ross 2015), our aim is to further the ongoing narrative both with and within police departments with regards to community race relations.

Segregation can be measured and calculated in a number of different ways (Massey et al. 1998), and each of the ways yields different information about the nature and magnitude of segregation. We utilize multiple residential segregation measures to evaluate associations with population outcomes to capture each of these particular outcomes. Racialized decision-making could be expressed more strongly in places that have uneven population distributions of a particular minority. Within the scholarly of racial inquiry and police behavior, we build upon the commonly used metric of dissimilarity, which examines the evenness or variance in minority population distribution and has been used elsewhere (e.g., Siegel et al. 2021’s application focused on Black populations). Alternatively, racist behavior might be derived by the expectations of a racial majority meeting a racial minority. We operationalize this through the metric of interaction, a measure of the likelihood of a majority member encountering a minority member. Finally, uneven outcomes could be a function of the relative ethnic diversity (or lack thereof) within a region. We implement a group-based metric in order to assess the importance of the presence of a wider number of minority types. Additionally, we consider Hispanic and Asian populations in both our “victims” and “segregation” calculations with the aim to identify whether there are particular elements of segregation, whether in measurement or racial specificity, that are connected to higher rates of fatal police shootings. This breadth provides a broader understanding of the potential mechanisms by which the geographic environment may be an important contributor to population health, including the occurrence racial and ethnic differences in police shootings.

**Methods**

**Fatal force data**

The Washington Post logs fatal shootings by on-duty police officers in the USA and makes the data publicly accessible as the Fatal Force database (Washington Post 2021). The database utilizes news accounts, social media postings, and police reports as sources of information (Washington Post 2016) and has been found to be consistent with other open-source police shootings databases (Comer and Ingram 2022). Data have been collected and reported from 2015, and, for this analysis, data from January 2015 through December 2020 were utilized. Data were geocoded to census tracts using the latitude and longitude information provided in the database. In the Fatal Force Data, race and ethnicity are classified in a single variable (White, Black, Asian, Hispanic, Native American, or other). Given that Hispanic often supersedes race in this categorization, the presumption is that White, Black, and Asian are non-Hispanic groups, and we use non-Hispanic classifications in the geographic data (described in the next section). However, when referring to the victims, we use the classifications as stated in the data, and the number of fatal shooting events in each census tract was calculated by for race and ethnic groups: Hispanic, White, Black, Asian, and other.

**US population and geographic characteristics data**

Data about the US population overall and by census tracts were obtained from the US Census for relevant characteristics. For overall population and populations by year, resident population data were obtained from the Monthly Population Estimates for the USA: April 1, 2010, to December 1, 2020 (table: NA-EST2019-01). Estimates for July 1 for the years 2015–2020 were used for each year, and the average across these values was used for the overall population. For age and gender groups, stratified data were obtained from the Annual Estimates of the Resident Population for Selected Age Groups by Sex for the USA: April 1, 2010, to July 1, 2019 (table: NC-EST2019-AGESEX). Data for resident population were aggregated by age-groups (5–19, 20–34, 35–49, and 50+ years) and gender (male and female) and averaged across years 2010 to 2019. Race and ethnicity resident population data were obtained from the Annual Estimates of the Resident Population by Sex, Race, and Hispanic Origin for the USA: April 1, 2010, to July 1, 2019 (table: NC-EST2019-SR11H). Census data were aggregated by race and ethnicity (Hispanic, non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, non-Hispanic Native American, and non-Hispanic Other).

**Segregation calculations**

In order to calculate residential segregation characteristics by race and ethnicity for census tracts, block group-level American Community Survey five-year estimates data (2015–2019) were obtained (table B03002). We follow Massey and Denton (1988) as well as Oka and Wong (2014) in our residential segregation metric selection. For residential segregation, dissimilarity and interaction...
were used in this analysis. Non-Hispanic White population was used as the majority population for the calculations. While in some areas, the majority may not be non-Hispanic White individuals, the calculations account for this in the use of absolute values. We incorporate multiple segregation metrics as they capture distinct elements (Harris and Johnston 2018). Dissimilarity provides a measure of evenness, and interaction is a measure of exposure that looks at the likelihood the minority and majority groups occupy the same area. The variables included in the calculations are the minority population of area i \( (x_i) \), the total population of area i \( (t_i) \), the ratio of \( x_i \) to \( t_i \) \( (p_i) \), the majority population of area i \( (y_i) \), the sum of all \( x_i \) \( (X) \), the sum of all \( t_i \) \( (T) \), and the ratio of \( X \) to \( T \) \( (P) \). Segregation measures were calculated for Hispanic, Black, and Asian as minority populations. The theoretical range for these values is from 0 to 1, with 1 indicating complete dissimilarity or complete interaction.

The interaction calculation

\[
\sum_{i=1}^{n} \left[ \left( \frac{x_i}{T} \right) \left( \frac{y_i}{1 - P} \right) \right]
\]

The dissimilarity calculation

\[
\sum_{i=1}^{n} \left[ t_i(p_i - P) \right] / [2TP(1 - P)]
\]

Diversity is a composition characteristic of the geographic unit and was calculated as the negative of the summation of the percentage of mutually exclusive groups multiplied by its natural logarithm. The mutually exclusive groups for racial diversity were non-Hispanic White, non-Hispanic Black, non-Hispanic American Indian or Alaska Native, non-Hispanic Asian, non-Hispanic Native Hawaii or Pacific Islander, non-Hispanic other, and Hispanic. This measure incorporates the effect of multiple minority groups rather than focusing on measures specific to a particular group. The theoretical range for this value is 0 to 1, with 1 indicating the highest diversity.

There are no agreed-upon geographic characteristic covariates for segregation analyses, and we used the Social Vulnerability Index (SVI) as a guide for relevant geographic-level social characteristics. The Agency for Toxic Substances & Disease Registry SVI is a tool created to identify and map communities that will most likely need support before, during, and after a hazardous event (Flanagan et al. 2011). Census tract-level data were downloaded for SVI 2018 (utilizing American Community Survey 5-year estimates from 2014 to 2018), and values for SVI themes were used as covariates in this analysis. SVI themes include socioeconomic status; household composition and disability; minority status and language; and housing type and transportation. Socioeconomic status theme incorporates data about percentage below poverty, percentage unemployed, percentage with no high school diploma, and mean income. Household composition and disability theme incorporates data about percentage individuals of age 65 and older and age 17 or younger, percentage of population older than age 5 with a disability, and percentage of single-parent households. Minority status and language theme incorporates data about percentage of minority individuals and percentage that speak English “less than well.” Housing type and transportation theme incorporates information about the percentages of multi-unit structures, mobile homes, crowded housing, households with no vehicle, and group quarters.

Statistical analysis

Frequencies and percentages of fatal police shootings were calculated to describe the population of all shootings in the database from 2015 through 2020 \( (n = 6224) \). Frequencies were used to calculate incidence per 100,000 population using the corresponding relevant population. There were 5183 events that had both locations that could be geocoded to census tract \( (n = 5923) \) as well as had detail on the racial characteristics of the victim \( (n = 5674) \) in order to be included in the analysis to evaluate the associations with geographic characteristics. An examination of the removed fields (events unable to be geocoded) found no identifiable bias with regards to race or other characteristics of the victim.

Segregation, diversity, and SVI themes in raw form are scaled from 0 to 1 and were transformed to 0 to 10 scale for analysis by multiplying the values by 10. Pearson correlations were used to evaluate for potential collinearity between measures of segregation and other social geographic characteristics, and in the absence of strong correlations (Table 1), it was appropriate to include SVI themes as covariates for segregation and diversity. There were few instances of more than two events occurring in a census tract for each race or Hispanic ethnicity, and each census tract was classified as having 0, 1, 2+ events based on race or ethnicity of the victim for White, Black, Asian, and Hispanic. There was an insufficient frequency of events for Native American or other for those groups to be analyzed. Analyses were conducted at the census tract level. Multinominal logistic regression was used to model the odds of event for 1 and 2+ versus 0 events for diversity and each segregation measure. Analyses were also collapsed to evaluate the odds of any event \( (1+ \) versus 0) in relation to diversity and each segregation measure, and logistic regression was used for the analysis. Analyses were adjusted for SVI themes and log total population of the census tract. In order to consider possible differential effects by type of segregation, there
Table 1  Pearson correlation coefficients for relationships between segregation, diversity, and Social Vulnerability Index (SVI) themes

| Geographic characteristic | Dissimilarity, non-Hispanic Black | Dissimilarity, non-Hispanic Asian | Dissimilarity, Hispanic | Interaction, non-Hispanic Black | Interaction, non-Hispanic Asian | Interaction, Hispanic | Racial and ethnic diversity | SVI, Socioeconomic Status | SVI, Household Composition and Disability | SVI, Minority Status and Language | SVI, Housing Type and Transportation |
|---------------------------|-----------------------------------|----------------------------------|-------------------------|---------------------------------|---------------------------------|-----------------------|---------------------------|--------------------------|---------------------------------|---------------------------------|---------------------------------|
| Dissimilarity, non-Hispanic Black | 1.00 | | | | | | | | | | | |
| Dissimilarity, non-Hispanic Asian | 0.20 | 1.00 | | | | | | | | | | |
| Dissimilarity, Hispanic | 0.13 | 0.24 | 1.00 | | | | | | | | | |
| Interaction, non-Hispanic Black | -0.30 | -0.07 | -0.08 | 1.00 | | | | | | | | |
| Interaction, non-Hispanic Asian | -0.04 | -0.38 | -0.11 | 0.33 | 1.00 | | | | | | | |
| Interaction, Hispanic | 0.00 | -0.05 | -0.23 | 0.42 | 0.38 | 1.00 | | | | | | |
| Diversity, Racial and ethnic | -0.35 | -0.33 | -0.16 | -0.05 | -0.02 | -0.14 | 1.00 | | | | | |
| SVI, Socioeconomic status | 0.02 | 0.29 | 0.20 | -0.22 | -0.29 | -0.28 | 0.11 | 1.00 | | | | |
| SVI, Household composition and disability | 0.08 | 0.32 | 0.18 | -0.11 | -0.18 | -0.12 | -0.14 | 0.57 | 1.00 | | | |
| SVI, Minority status and language | -0.12 | -0.12 | -0.05 | -0.26 | -0.21 | -0.35 | 0.62 | 0.41 | 0.00 | 1.00 | | |
| SVI, Housing type and transportation | -0.09 | 0.05 | 0.03 | -0.15 | -0.17 | -0.22 | 0.19 | 0.52 | 0.27 | 0.32 | 1.00 | |
are a number of comparisons made and used in statistical hypothesis testing. Due to the debated issues with applying multiple comparisons testing (Perneger 1998; Nakagawa 2004; Gelman et al. 2012), such measures have not been applied. However, aligned with recommendations from others (Nakagawa 2004), effect estimates and confidence intervals have been provided so that readers consider this issue in their interpretations of the results. Analyses were conducted using Stata (version 15, StataCorp, USA).

**Results**

There were 5949 fatal shootings involving police officers documented in the database from January 2015 through December 2020 (Table 2). The overall annual incidence of fatal shootings was 0.31 per 100,000 population. Annual incidence of approximately 1000 was similar across the years included. Fatal shootings were more common in Mountain, East and West South Central, and Pacific Census regions, and less common in New England and Middle Atlantic. Incidence was highest in young adults and males. Higher incidence was observed in Black and Native American residents than other race and ethnic groups.

In relation to events regardless of race or ethnicity of the victim, non-Hispanic Black dissimilarity was inversely associated with an event in that census tract and racial and ethnic diversity was positively associated with an event occurring in the tract (Table 3). For White victims, dissimilarity for any type (non-Hispanic Black, Hispanic, or non-Hispanic Asian) was inversely associated, and interaction of any type and diversity was positively associated, with an event involving a White victim occurring in the census tract. For Black victims, Hispanic and non-Hispanic Asian dissimilarity and diversity were positively associated and interaction of any type and diversity was positively associated, with an event involving a Black victim occurring in the census tract. For Hispanic victims, Hispanic and non-Hispanic Asian dissimilarity and diversity were inversely associated and non-Hispanic Asian interaction was positively associated with an event involving a Hispanic victim occurring in the census tract. For Asian victims, Hispanic and non-Hispanic Asian dissimilarity was inversely associated and diversity was positively associated with an event involving an Asian victim occurring in the tract. There was some evidence of stronger associations when events were disaggregated from any to 1 and 2+ for any race or ethnicity victim and diversity, non-Hispanic Asian interaction and diversity for White victims, Hispanic dissimilarity and interaction for Black victims, and Hispanic dissimilarity and diversity for Hispanic victims.

### Table 2 Characteristics of fatal police shootings and annual incidence for selected population groups from 2015 to 2020

| Characteristics | n   | %    | US Census Population Estimates* | per 100,000 population |
|----------------|-----|------|----------------------------------|------------------------|
| All, 2015–2020 | 5949| 100.0| 325,561,090                     | 0.305                  |
| Year           |     |      |                                  |                        |
| 2015           | 993 | 16.7 | 320,635,163                     | 0.310                  |
| 2016           | 960 | 16.1 | 322,941,311                     | 0.297                  |
| 2017           | 986 | 16.6 | 324,985,539                     | 0.303                  |
| 2018           | 990 | 16.6 | 326,687,501                     | 0.303                  |
| 2019           | 999 | 16.8 | 328,239,523                     | 0.304                  |
| 2020           | 1021| 17.2 | 329,877,505                     | 0.310                  |
| Region         |     |      |                                  |                        |
| New England    | 112 | 1.9  | 14,790,786                      | 0.126                  |
| Middle Atlantic| 299 | 5.0  | 41,242,349                      | 0.121                  |
| South Atlantic | 1138| 19.1 | 64,531,706                      | 0.294                  |
| East South Central | 441 | 7.4  | 19,019,070                      | 0.386                  |
| West South Central | 909 | 15.3 | 39,857,459                      | 0.380                  |
| East North Central | 585 | 9.5  | 46,847,718                      | 0.208                  |
| West North Central | 361 | 6.1  | 21,260,389                      | 0.283                  |
| Mountain       | 883 | 14.8 | 24,171,762                      | 0.609                  |
| Pacific        | 1221| 20.5 | 52,976,569                      | 0.384                  |
| Age            |     |      |                                  |                        |
| 6–19           | 299 | 5.0  | 62,137,807                      | 0.080                  |
| 20–34          | 2486| 41.8 | 67,216,130                      | 0.616                  |
| 35–49          | 1878| 31.6 | 61,642,990                      | 0.508                  |
| 50–91          | 1038| 17.4 | 113,886,790                     | 0.152                  |
| Unknown        | 248 | 4.2  |                                  |                        |
| Gender         |     |      |                                  |                        |
| Male           | 5688| 95.6 | 159,893,431                     | 0.593                  |
| Female         | 260 | 4.4  | 164,804,376                     | 0.026                  |
| Unknown        | 1   | 0.0  |                                  |                        |
| Race and ethnicity |     |      |                                  |                        |
| White          | 2774| 46.6 | 197,655,170                     | 0.234                  |
| Black          | 1444| 24.3 | 40,534,100                      | 0.594                  |
| Asian          | 103 | 1.7  | 18,109,812                      | 0.095                  |
| Native American | 84  | 1.4  | 2,403,978                       | 0.582                  |
| Hispanic       | 1018| 17.1 | 58,498,253                      | 0.290                  |
| Other          | 47  | 0.8  | 7,496,494                       | 0.104                  |
| Unknown        | 479 | 8.1  |                                  |                        |
| Manner of death|     |      |                                  |                        |
| Shot           | 5649| 95.0 |                                  |                        |
| Shot and Tasered | 300 | 5.0  |                                  |                        |
| Threat         |     |      |                                  |                        |
| Attack         | 3866| 65.0 |                                  |                        |
| Other          | 1891| 31.8 |                                  |                        |
| Undetermined   | 192 | 3.2  |                                  |                        |
| Signs of mental illness | |      |                                  |                        |
| No             | 4555| 76.6 |                                  |                        |
| Yes            | 1394| 23.4 |                                  |                        |
Dissimilarity, interaction, and diversity had independent associations with events when mutually adjusted (Table 4). For Black victims, non-Hispanic Black interaction was inversely associated and diversity was positively associated with an event in the tract. For Hispanic victims, Hispanic dissimilarity was inversely associated with an event in the tract. For Asian victims, diversity was positively associated with an event in the tract. For both Black and Hispanic victims, all SVI themes were positively associated with an event occurring in the tract. For Asian victims, minority status and language and housing type and transportation SVI themes were positively associated with an event occurring in the tract.

Discussion

Our results evidence an association with racial residential segregation on policing behavior beyond correlations with other tract socioeconomic characteristics. Explanations for this policing difference have been a consistent topic of interdisciplinary scholarship. The overpolicing of minority communities has been well documented (Perry 2006; Weitzer 2017). For example, racial residential segregation and the subsequent effects on police shootings are consistent with research on differential applications of racial profiling biases in campaigns such as “stop and frisk” (Hattery and Smith 2021). Furthermore, when Blacks live in racially mixed regions their risk for being shot by the police is lower than when they live in segregated regions. Our results confirm the findings of Hattery and Smith (2007) that noted that Blacks living in the Deep South had better well-being outcomes when they lived in integrated counties compared to those living in segregated counties. As the population of officers that have fired their service weapon on the job is approximately 27% (Morin and Mercer 2017), the relationship between community geography and demography with risk for Blacks being shot by police is an affirmation of structural racism, regardless of individual level prejudice. We found that the dissimilarity metric used commonly in the literature is the least effective residential segregation metric in differentiating differences in police shootings ratings (Siegel et al. 2019; Gaynor et al. 2021). Instead, the strength and consistency of measures of interaction and ethnic diversity suggest that racialized behavior is driven more through engagement and presence than through evenness (or a lack thereof), perhaps mediated through a process of racial incongruence (Gaston et al. 2021). This differentiation suggests a much broader set of regions that would benefit from interventions.

Additionally, we investigated whether ecological drivers were more present in racially specific situations. Areas with high urbanization, poor housing security, and a lack of racial diversity have higher rates of Black victim police shootings. Areas with lower racial diversity have a much lower rate of police shootings of Hispanic victims. Hispanic communities have been found to have significantly different relationships with the police compared to Black Americans (Ong and Jenks 2004). Communities where individuals identify as White despite having Hispanic origins report higher community unity, have higher socioeconomic status, a better grasp of the English language, are native born, and are more likely to assimilate with the White population (South et al. 2005a, b). Our results may be evidence of a continued “Hispanic Paradox” (Frazinizi et al. 2001; Chunane and Wright 2021). The difference in effects between Blacks and Hispanics is frequently noted across the residential segregation literature, showing up in studies on breast cancer (Priutt et al. 2015), cardiometabolic risk (Mayne et al. 2019), in addition to those on policing (Holmes et al. 2018; Feldman et al. 2019; Zhao et al. 2019). These different outcomes from the same residential characteristics suggest that it is the interaction of location and race or ethnicity that modifies some element of police officer behavior (Mears et al. 2017). However, our results could also be a function of reporting bias in our underlying dataset. In particular, crowdsourced data may be challenged in differentiating between individuals who identify or appear as White but might have Hispanic origins.

There are some limitations that should be considered in the interpretation of this analysis. The magnitude of segregation in any given location is the outcome of complex processes taking place at multiple scales (Fowler 2018), and our chosen level of census tracts may suffer from an incomplete understanding of the spatial mechanisms of segregation. The dataset on police shootings provides no detail on the race or ethnicity of the police officer, which limits our ability to test the effect of racial or ethnic differences or officer–victim discordance with segregation on the shooting outcome. Results specific to fatal shootings by police might not be applicable to all uses of force, especially those that in non-fatal injuries. Finally, the information on arrest or policing rates beneath the county level is highly uneven.

Our results are also limited in degree of missingness of race and ethnicity information for the victim. It is possible that there is an overrepresentation of particular racial groups that are more likely to be mentioned, but it is not possible to determine the direction of bias. Analyzing this behavior at the tract level also has the effect of

| Table 2 (continued) |
|----------------------|
| Estimates for all and by year represent 2015–2020; estimates for region, age, gender, race, and ethnicity are averages of 2015–2019 estimates based on currently available data |
### Table 3: Association between any event in a census tract for measures of segregation and diversity by race and Hispanic ethnicity, adjusted for social vulnerability index themes and log population

| Group         | N tracts | Dissimilarity, non-Hispanic Black OR (95% CI) | Dissimilarity, Hispanic OR (95% CI) | Dissimilarity, non-Hispanic Asian OR (95% CI) | Interaction, non-Hispanic Black OR (95% CI) | Interaction, Hispanic OR (95% CI) | Interaction, non-Hispanic Asian OR (95% CI) | Diversity, race, and ethnic diversity OR (95% CI) |
|---------------|----------|--------------------------------------------|-----------------------------------|---------------------------------------------|---------------------------------------------|-----------------------------------|---------------------------------------------|-----------------------------------------------|
|                |          |                                            |                                    |                                             |                                             |                                   |                                             |                                               |
| All           |          |                                            |                                    |                                             |                                             |                                   |                                             |                                               |
| 0             | 68,563   | 1.000 Ref                                  | 1.000 Ref                          | 1.000 Ref                                   | 1.000 Ref                                   | 1.000 Ref                         | 1.000 Ref                                   | 1.000 Ref                                     |
| 1+            | 4766     | 0.984† 0.972, 0.996                        | 0.998 0.981, 1.016                 | 0.999 0.991, 1.007                         | 1.003 0.989, 1.016                         | 1.002 0.987, 1.017                | 1.006 0.993, 1.019                         | 1.042† 1.029, 1.056                         |
| 2+            | 417      | 0.972 0.930, 1.016                        | 0.977 0.913, 1.046                 | 0.981 0.954, 1.008                         | 1.016 0.966, 1.067                         | 1.012 0.957, 1.071                | 1.037 0.991, 1.086                         | 1.109† 1.060, 1.160                         |
| Any (1+)      | 5183     | 0.983† 0.972, 0.994                        | 0.997 0.980, 1.014                 | 0.998 0.990, 1.006                         | 1.004 0.991, 1.017                         | 1.003 0.988, 1.018                | 1.008 0.995, 1.021                         | 1.046† 1.033, 1.060                         |
| White         |          |                                            |                                    |                                             |                                             |                                   |                                             |                                               |
| 0             | 71,224   | 1.000 Ref                                  | 1.000 Ref                          | 1.000 Ref                                   | 1.000 Ref                                   | 1.000 Ref                         | 1.000 Ref                                   | 1.000 Ref                                     |
| 1             | 2410     | 0.978† 0.963, 0.994                        | 0.946† 0.921, 0.973                | 0.979† 0.968, 0.990                         | 1.040† 1.024, 1.056                         | 1.047† 1.029, 1.066                | 1.029† 1.013, 1.045                         | 1.103† 1.082, 1.125                         |
| 2+            | 112      | 0.966 0.891, 1.047                        | 0.924 0.801, 1.065                 | 1.024 0.976, 1.075                         | 1.070 0.995, 1.151                         | 1.038 0.954, 1.131                | 1.081† 1.010, 1.157                         | 1.318† 1.191, 1.458                         |
| Any (1+)      | 2522     | 0.978† 0.963, 0.993                        | 0.945† 0.920, 0.971                | 0.981† 0.970, 0.992                         | 1.041† 1.025, 1.057                         | 1.047† 1.029, 1.066                | 1.031† 1.015, 1.047                         | 1.111† 1.090, 1.132                         |
| Black         |          |                                            |                                    |                                             |                                             |                                   |                                             |                                               |
| 0             | 72,428   | 1.000 Ref                                  | 1.000 Ref                          | 1.000 Ref                                   | 1.000 Ref                                   | 1.000 Ref                         | 1.000 Ref                                   | 1.000 Ref                                     |
| 1             | 1253     | 0.981 0.959, 1.004                        | 1.142† 1.116, 1.169                | 1.048† 1.034, 1.063                         | 0.923† 0.894, 0.954                         | 0.907† 0.876, 0.940                | 0.939† 0.910, 0.969                         | 1.082† 1.056, 1.109                         |
| 2+            | 65       | 0.997 0.898, 1.106                        | 1.223† 1.110, 1.347                | 1.027 0.963, 1.095                         | 0.935 0.802, 1.090                         | 0.760† 0.615, 0.940                | 0.917 0.786, 1.069                         | 1.056 0.950, 1.174                         |
| Any (1+)      | 1318     | 0.982 0.960, 1.004                        | 1.145† 1.120, 1.172                | 1.047† 1.033, 1.062                         | 0.924† 0.895, 0.954                         | 0.902† 0.871, 0.934                | 0.938† 0.910, 0.967                         | 1.081† 1.056, 1.107                         |
| Hispanic      |          |                                            |                                    |                                             |                                             |                                   |                                             |                                               |
| 0             | 72,810   | 1.000 Ref                                  | 1.000 Ref                          | 1.000 Ref                                   | 1.000 Ref                                   | 1.000 Ref                         | 1.000 Ref                                   | 1.000 Ref                                     |
| 1             | 883      | 0.988 0.959, 1.017                        | 0.406† 0.333, 0.495                | 0.966† 0.945, 0.986                         | 0.977 0.933, 1.022                         | 1.042† 1.001, 1.095                | 1.048† 1.007, 1.190                         | 0.970† 0.945, 0.995                         |
| 2+            | 53       | 0.859 0.695, 1.060                        | 0.159† 0.049, 0.519                | 0.966 0.886, 1.053                         | 1.110 0.906, 1.360                         | 1.126 0.886, 1.431                | 1.053 0.867, 1.279                         | 0.907† 0.824, 0.998                         |
| Any (1+)      | 936      | 0.983 0.955, 1.012                        | 0.391† 0.321, 0.476                | 0.966† 0.946, 0.986                         | 0.982 0.939, 1.026                         | 1.046 0.996, 1.098                | 1.048† 1.008, 1.090                         | 0.965† 0.942, 0.990                         |
| Asian*        |          |                                            |                                    |                                             |                                             |                                   |                                             |                                               |
| 0             | 73,649   | 1.000 Ref                                  | 1.000 Ref                          | 1.000 Ref                                   | 1.000 Ref                                   | 1.000 Ref                         | 1.000 Ref                                   | 1.000 Ref                                     |
| Any (1+)      | 97       | 0.953 0.981, 1.130                        | 0.473† 0.257, 0.870                | 0.913† 0.842, 0.991                         | 0.990 0.889, 1.102                         | 0.985 0.869, 1.118                | 1.015 0.915, 1.125                         | 1.211† 1.075, 1.364                         |

*There were too few instances of more than 2+ events for Asian victims to disaggregate to 1 and 2+ for Asian population group

† $p < 0.05$
combining the behaviors of differentiated police forces, and different agencies could drive engagement behaviors (Shane et al. 2017). More precise data will be needed to identify the modifiable factors that will reduce racial and ethnic disparities in avoidable circumstances.

**Conclusions**

Gun violence has evolved from a neighborhood problem into a social network problem that is a public health concern (Green et al. 2017). Recent studies have found similar results that show the likelihood of an event occurring which varies based on census tract social polarization (Feldman et al. 2019). We examined the differing effects that racial evenness, exposure, and population diversity have on the racially distinct outcome of police shootings. Hispanics protective effects were visible in regions with less evenly distributed Hispanic populations, but there was no effect when modeling focused on the likelihood of majority–minority encounters. Black populations were at higher risk for police shootings in regions with less even Hispanic or Asian distributions. All populations except Hispanics were more at risk in regions that were more diverse. Our modeling to connect residential segregation to regions with more than one fatal shooting did not observe effects substantially different from models examining a single shooting or any nonzero number.

We echo policy limitations elsewhere that efforts must be made in jurisdiction that oversee diverse and segregated communities to address not just the individual interactions police have with residents, but also of the frequency of these interactions and the locational context within which they are occurring (Siegel et al. 2021). We affirm the importance of indirect effects of disparities in socioeconomic status that can alter the police behavior in a region. Black communities often have poor access to health care, education, employment, and housing (Hahn et al. 2018), and police may be called to respond to evictions or illness that might be treated at a hospital more frequently in regions that lack non-criminogenic resources. In areas with segregated minority populations, the unequal amount of time spent may account for uneven outcomes in police encounters and shootings (Hattery and Smith 2021). With our results and the understanding that police shootings are shaped by a number of cultural and organizational factors (Prenzler et al. 2013), trust-building and de-escalation police training should be concentrated in police departments serving highly segregated communities (Diehr and McDaniel 2018, Engel et al. 2022). Our findings align with scholarship elsewhere showing that Black communities are more willing to engage in police partnerships, and concentrated disadvantage further enhances this receptiveness (Wehrman and De Angelis 2011). We believe that direct confrontation of these matters by criminologists and law enforcement of all levels will be necessary to stem the racist outcomes in police shootings that exist in American society.

**Abbreviation**

SVI: Social Vulnerability Index.

**Acknowledgements**

Not applicable.

**Authors’ contributions**

TL and CF contributed to concept and initial draft; CF performed analysis; TL, CF, and AH helped in interpretation and substantial revisions. All authors read and approved the final manuscript.

**Funding**

Not applicable.
Availability of data and materials
All data utilized in this analysis are publicly available from the US American Community Survey and Washington Post Fatal Force Database.

Declarations

Ethics approval and consent to participate
George Mason University IRB classified the work as not having human subjects research.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Author details
1Department of Geography and Geoinformation Science, George Mason University, 4400 University Dr, MS 6C3, Fairfax, VA 22030, USA. 2Public Health Program, University of Puget Sound, 1500 N. Warner St., Tacoma, WA 98416, USA. 3Department of Women and Gender Studies, University of Delaware, 25 N. College Ave, Newark, DE 19716, USA.

Received: 5 October 2021 Accepted: 15 February 2022
Published online: 03 March 2022

References

Arcaya MC, Schwartz G, Subramanian SV. A multi-level modeling approach to understanding residential segregation in the United States. Environ Plan B Urban Anal City Sci. 2018;45(6):1000–105.

Arizona Depart of Transportation. 2018. Arizona driver license manual and customer service guide. https://www.azdot.gov/docs/default-source/mvd-forms-pubs/99-0117.pdf.

Associated Press. 2020. Explaining AP style on Black and white. 2020. https://apnews.com/article/archive-race-and-ethnicity-910566462.

Beard JH, Morrison CN, Jacoby SF, Dong B, Smith R, Sims CA, Wiebe DJ. Quantifying disparities in urban firearm violence by race and place in Philadelphia, Pennsylvania: a cartographic study. Am J Public Health. 2017;107:371–3.

Bishop B. The big sort: why the clustering of like-minded america is tearing us apart. Boston: Houghton Mifflin Harcourt; 2009.

Brownlow A. The uneven geographies of America’s hidden rape crisis: a district-level analysis of underpolicing in St. Louis. Ann Am Assoc Geogr. 2017;107:371–3.

Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry, and Geospatial Research, Analysis, and Services Program. Social vulnerability index 2014 US Database. 2017. https://svi.cdc.gov/SVIDataToolsDownload.html.

Chenane JL, Wright EM. The role of police officer race/ethnicity on crime rates in immigrant communities. Race Justice. 2021;11(1):3–27.

Comer BP, Ingram JR. Comparing fatal encounters, mapping police violence, and washington post fatal police shooting data from 2015–2019: a research note. Crim Justice Rev 07340168211071014.

Dai D. Black residential segregation, disparities in spatial access to health care facilities, and late-stage breast cancer diagnosis in metropolitan detroit. Health Place. 2010;16(5):1038–52.

Diehr AJ, Mc Daniel JT. Lack of community-oriented policing practices partially mediates the relationship between racial residential segregation and “Black-on-Black” homicide rates. Prev Med. 2018;112:179–84.

Drowos J, Hennekens CH, Levine RS. Variations in mortality from legal intervention in the United States—1999 to 2013. Prev Med. 2015;81:290–3.

Engel RS, Corsaro N, Isaza GT, McManus HD. Assessing the impact of de-escalation training on police behavior: Reducing police use of force in the Louisville, KY Metro Police Department. Criminology & Public Policy. 2022;21:984–1002.

Federal Bureau of Investigation. 2019. National use-of-force data collection. https://www.fbi.gov/services/cjis/ucr/use-of-force.

Feldman JM, Gruskin S, Coull BA, Krieger N. Police-related deaths and neighborhood economic and racial/ethnic polarization, United States, 2015–2016. Am J Public Health. 2019;109(3):458–64.

Flanagan BE, Gregory EW, Hallsey EJ, Heitgerd J, Lewis B. A social vulnerability index for disaster management. J Home Secur Emerg Manag. 2011;8(1):25.

Fowler CS. Key assumptions in multiscalar segregation measures: how zoning and strength of spatial association condition outcomes. Environ Plan B Urban Anal City Sci. 2018;45(6):1055–72.

Frankenfeld CL, Hakes JK, Leslie TF. All-cause mortality and residential racial and ethnic segregation and composition as experienced differently by individual-level race, ethnicity, and gender: mortality disparities in american communities data. Ann Epidemiol. 2022;65:38–45.

Frankenfeld CL, Leslie TF. County-level socioeconomic factors and residential racial, Hispanic, poverty, and unemployment segregation associated with drug overdose deaths in the United States, 2013–2017. Ann Epidemiol.

Frankenfeld CL, Leslie TF. Descriptive epidemiology of homicides with victim and suspect race or Hispanic ethnicity discordance in the United States: analysis of National Violent Death Reporting System (NVDRS) 2005–2015. J Interpers Violence 0886260519861656. 2021.

Frantsz L, Ribble JC, Keddie AM. Understanding the Hispanic paradox. Ethn Dis. 2001;11(3):496–518.

FrideLLU, Lim H. Assessing the racial aspects of police force using the implicit- and counter-bias perspectives. J Crim Just. 2016;44:36–48.

Fu Q, Land KC, Lamb VL. Bullying victimization, socioeconomic status and behavioral characteristics of 12th graders in the united states, 1989 to 2009: repetitive trends and persistent risk differentials. Child Indic Res. 2013;6(1):1–21.

Fyfe JJ. Geographic correlates of police shooting: a microanalysis. J Res Crime Delinq. 1980;17(1):101–13.

Fyfe JJ. Blind justice: police shootings in memphis. J Crim Law Criminol. 1982;73(2):707–22.

Fyfe JJ. Police use of deadly force: research and reform. Justice Q. 1988;5(2):165–205.

Gaston S, Tett MJ, Sanchez M. Does racial congruence between police agencies and communities reduce racialized police killings of civilians? Criminol Public Policy. 2021.

Gaynor TS, Kang SC, Williams BN. Segregated spaces and separated races: the relationship between state-sanctioned violence, place, and black identity. RSF Russell Sage Found J Soc Sci. 2021;7(1):50–66.

GBD 2019 Police Violence US Subnational Collaborators, 2021. Fatal police violence by race and state in the USA, 1980–2019: a network meta-regression. The Lancet 398(10307), 1239-1255.

Gelman A, Hill J, Yajima M. Why we (usually) don’t have to worry about multiple comparisons. J Res Educ Effect. 2012;5(2):189–211.

Gilbert KL, Ray R. Why police kill black males with impunity: applying public health critical race praxis (PHCRP) to address the determinants of policing behaviors and “justifiable” homicides in the USA. J Urban Health. 2016;93(1):127–40.

Gittner LS, Kilbourne BJ, Vadapalli R, Khan HM, Langston MA. A multifactorial obesity model developed from nationwide public health exposome data and modern computational analyses. Obes Res Clin Prac. 2017.

Gray AC, Parker KF. Race, structural predictors, and police shootings: are there differences across official and “unofficial” accounts of lethal force? Crime Delinq. 2019;65(1):26–45.

Green B, Horel T, Papachristos AV. Modeling contagion through social networks to explain and predict gunshot violence in Chicago, 2006 To 2014. JAMA Intern Med. 2017;177(3):326–33.

Hahn RA, Truman BI, Williams DR. Civil rights as determinants of public health and racial and ethnic health equity: health care, education, employment, and housing in the United States. SSM Popul Health. 2018;4:17–24.

Hall AV, Hall EV, Perry JL. Black and blue: exploring racial bias and law enforcement in the killings of unarmed black male civilians. Am Psychol. 2016;71(3):175.

Harris R, Johnston R. Measuring and modelling segregation—new concepts, new methods and new data. Environ Plan B Urban Anal City Sci. 2015;48(6):999–1002.

Hattery AJ, Smith E. Social stratification in the new/old south: the influences of racial segregation on social class in the deep south. J Pover Res. 2007;11(1):55–81.
O’Hanlon ME. Brookings: big ideas for America. New York: Brookings Institute Press; 2017.
Oka M, Wong DW. Capturing the two dimensions of residential segregation at the neighborhood level for health research. Front Public Health. 2017;5(1):135.
Ong M, Jenks DA. Hispanic perceptions of community policing: is community policing working. J Ethn Crim Justice. 2004;2(3):53–66.
Ozkan T, Worrall JL, Zettler H. Validating media-driven and crowdsourced police shooting data: a research note. J Crime Justice. 2018;41(3):334–45.
Peregrine TV. What’s Wrong with Bonferroni Adjustments. BMJ. 1998;316(7139):1236–8.
Perry B. Nobody trusts them! Under-and-over-policing Native American communities. Crit Criminal. 2006;14(4):411–44.
Washington Post. 2016. https://www.washingtonpost.com/national/how-the-washington-post-is-examining-police-shootings-in-the-united-states/2016/07/07/d9c52238-43a1-11e6-8856-f26de2537a9d_story.html.
Washington Post. 2021. Fatal Force Database. https://www.washingtonpost.com/comographics/investigations/police-shootings-database/.
Penzler T, Porter L, Alpert GP. Reducing police use of force: case studies and prospects. Aggress Violent Beh. 2013;18(2):343–56.
Pruitl SL, Lee SJIC, Tio JA, Xuan L, Ruiz JM, Inrig S. Residential racial segregation and mortality among Black, White, and Hispanic urban breast cancer patients in Texas, 1995 to 2009. Cancer. 2015;121(11):1845–55.
Radil SM, Dezzani RJ, McElon LD. Geographies of US police militarization and the role of the 1033 program. Prof Geogr. 2017;69(2):203–13.
Ray R, Brown M, Frisait N, Summers E. 2017. Ferguson and the death of michael brown on Twitter # Blacklivesmatter # TCOT, and the evolution of collective identities. Ethnic Rac Stud. 1–17.
Readon SF, Fox L, Townsend J. Neighborhood income composition by household race and income, 1990–2009. Ann Acad Polit Soc Sci. 2015;660(1):78–97.
Ross CT. A multi-level Bayesian analysis of racial bias in police shoot- ings at the county-level in the United States, 2011–2014. PloS ONE. 2015;10(11):e0141854.
Sampson RJ, Sharkey P. Neighborhood selection and the social reproduction of concentrated racial inequality. Demography. 2008;45(1):1–29.
Shane JM, Lawton B, Swenson Z. The prevalence of fatal police shootings by US police, 2015–2016: patterns and answers from a new data set. J Crim Just. 2017;52:101–11.
Siegel M, Sherman R, Li C, Knopov A. The relationship between racial residential segregation and black-white disparities in fatal police shootings at the city level, 2013–2017. J Natl Med Assoc. 2019;111(6):580–7.
Siegel M, Poulsen M, Sangar R, Jay J. The Interaction of race and place: predictors of fatal police shootings of black victims at the incident, census tract, city, and state levels, 2013–2018. Race Soc Prob. 2021;15:1–21.
Tregle B, Nix J, Alpert GP. Disparity does not mean bias: making sense of observed racial disparities in fatal officer-involved shootings with multiple benchmarks. J Crim Justice. 2019;49(1):18–31.
Vitala AS. The end of policing. New York: Verso; 2017.
Wehrman MM, De Angelis J. Citizen willingness to participate in police-community partnerships: Exploring the influence of race and neighborhood context. Police Q. 2011;14(1):48–69.
Wetzer R. Theorizing racial discord over policing before and after Ferguson. Justice Q. 2017;34(7):1129–53.
Williams DR, Collins C. Racial residential segregation: a fundamental cause of racial disparities in health. Public Health Rep. 2001;116(5):404–16.
Wright JE, Gaozhao D, Snow MA. Place plus race effects in bureaucratic discretion: an analysis of residential segregation and police stop decisions. Public Perform Manag Rev. 2021;44(2):352–77.
Zhao Y, Yang TC, Messner SF. Segregation and racial disparities in post-stop searches. org/ fact- tank/ 2017/ 02/ 08/a- closer- look- at- police- offic