

# Quantifying Disparities in Urban Firearm Violence by Race and Place in Philadelphia, Pennsylvania: A Cartographic Study

Jessica H. Beard, MD, MPH, Christopher N. Morrison, PhD, Sara F. Jacoby, PhD, MPH, MSN, Beidi Dong, PhD, Randi Smith, MD, MPH, Carrie A. Sims, MD, and Douglas J. Wiebe, PhD

**Objectives.** To describe variability in the burden of firearm violence by race, income, and place in an urban context.

**Methods.** We used Philadelphia Police Department data from 2013 to 2014 to calculate firearm assault rates within census block groups for both victim residence and event locations, stratifying by race and block group income. We used cartographic modeling to determine variations in incidence of firearm assault by race, neighborhood income, and place.

**Results.** The overall rate of firearm assault was 5.0 times higher (95% confidence interval [CI] = 4.5, 5.6) for Black people compared with White people. Firearm assault rates were higher among Black people across all victim residence incomes. Relative risk of firearm assault reached 15.8 times higher (95% CI = 10.7, 23.2) for Black residents in the highest-income block groups when compared with high-income White individuals. Firearm assault events tended to occur in low-income areas and were concentrated in several “hot spot” locations with high proportions of Black residents.

**Conclusions.** Profound disparity in exposure to firearm violence by race and place exists in Philadelphia. Black people were substantially more likely than White people to sustain firearm assault, regardless of neighborhood income. (*Am J Public Health.* 2017;107:371–373. doi:10.2105/AJPH.2016.303620)

Firearm violence is endemic in the United States.<sup>1</sup> On a national level, disparities exist in firearm victimization; young adults, males, and non-Hispanic Black persons are at highest risk for violent firearm injury.<sup>2</sup> There has been increasing interest in describing factors associated with firearm injury in urban environments. In one of the few published analyses of city-level firearm violence, Walker et al.<sup>3</sup> found that Hispanic and non-Hispanic Black people were significantly more likely than White people to be victims of firearm homicide in Chicago, Illinois. These authors suggested that because race may be a surrogate for income, public health interventions should be aimed at alleviating poverty to reduce firearm violence in the city.<sup>3</sup>

The relations between race, socioeconomic status, and place, as they determine firearm injury risk, are complex. To guide

local public health interventions, a greater understanding of how these factors potentiate violent firearm injury in the cities where firearm violence is most prevalent is needed. In particular, delineating the unique contributions of race, income, and place as correlates of violent firearm injury risk is an important first step in developing targets for prevention. In this descriptive epidemiological analysis, we used police data to map the burden of firearm violence and

quantify its variability by race and neighborhood income in Philadelphia, Pennsylvania, a city with a historically high rate of firearm violence.

## METHODS

The Philadelphia Police Department collects person-level data for every firearm assault in which a person is killed or injured. For this analysis, we accessed records from January 2013 to December 2014 (n = 2175). Available fields included victim characteristics (sex, age, race), event location and residential address (both masked to city block), and assault type (interpersonal violence, robbery). We geocoded each event location and victim residence and calculated counts of firearm assault within the 1336 US Census block groups in Philadelphia. Geographic data were available for most records; 2149 event locations (98.8%) and 2001 victim addresses (92.0%) were geocoded.

We used American Community Survey 5-year estimates (2010–2014) to identify the total population, racial composition, and median household income for each block group.<sup>4</sup> We calculated the mean yearly incidence of firearm assault events and victim residences by block group, stratifying by race and income. Then, we created raster layers describing kernel densities of victim

## ABOUT THE AUTHORS

Jessica H. Beard, Randi Smith, and Carrie A. Sims are with the Division of Traumatology, Surgical Critical Care, and Emergency Surgery, Perelman School of Medicine, University of Pennsylvania, Philadelphia. Christopher N. Morrison, Sara F. Jacoby, Beidi Dong, and Douglas J. Wiebe are with the Penn Injury Science Center, University of Pennsylvania. Christopher N. Morrison is also with Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia. Douglas J. Wiebe is also with the Department of Biostatistics and Epidemiology, University of Pennsylvania.

Correspondence should be sent to Jessica H. Beard, MD, MPH, University of Pennsylvania, Penn Presbyterian Medical Center, 51 N 39th St, Philadelphia, PA 19104 (e-mail: jbeard08@gmail.com). Reprints can be ordered at <http://www.ajph.org> by clicking the “Reprints” link.

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residence and firearm assault event locations, stratifying the city’s population by race and income. At the victim level, we spatially joined block group characteristics to both the event location and the residential locations. At the block group level, we used the Pearson  $\chi^2$  test to compare annual rates of victim residences per 10 000 population according to local area income.

## RESULTS

Victims were mostly young (mean age = 28 years; SD = 10 years), Black (82.0%), and male (92.0%). Most injuries resulted from interpersonal violence (92.0%), and 18.8% of firearm assaults were fatal. Firearm assaults were most likely to occur in lower-income block groups (event location median income = \$25 125; interquartile range = \$18 074–\$433 500).

The rate of violent firearm injury was 5.0 times higher (95% confidence interval [CI] = 4.5, 5.6) for Philadelphia’s Black population compared with its White population (Table 1). The rate of firearm assaults decreased as residence block group income increased for all victims. Absolute rates for firearm violence decreased to near zero for White populations residing in the highest-income areas. Across all income levels, however, firearm assault rates remained higher in Blacks. In the highest-income block groups, relative risk of firearm assaults reached 15.8 times higher (95% CI = 10.7, 23.2) for Black residents compared with White residents. Black residents of block groups with incomes greater than \$60 000 per year had firearm assault rates similar to those of White residents of areas with incomes between \$20 001 and \$30 000.

Visual inspection of kernel density maps in Figure A (available as a supplement to the online version of this article at <http://www.ajph.org>) suggests that both victim residence and firearm assault event locations were found more often in lower-income areas. Event locations tended to concentrate in several “hot spots,” whereas residential locations were slightly more dispersed. The racially stratified kernel density maps (Figure A) illustrate how violent firearm injury event locations tended to concentrate in areas with higher proportions of Black residents. There

appears to be 1 hot spot of both event location and victim address for firearm violence involving White victims located in an area of the city with a relatively higher proportion of Black residents compared with White residents.

## DISCUSSION

Our findings indicate substantial racial, economic, and geographic disparities in rates of firearm violence in Philadelphia. Firearm assaults were concentrated in low-income areas with predominantly Black residents. Although living in a higher-income area was protective for the population overall, it did not protect Black residents from firearm violence to the same degree as White residents. In fact, Black residents of the city’s wealthiest block groups had the highest relative risk of firearm injury when compared with White residents. Therefore, unlike previous research in Chicago, race does not appear to be a surrogate for economic status in determining violent firearm injury risk in Philadelphia.<sup>3</sup> Rather, our findings echo those of Kalesan et al.,<sup>5</sup> who found that nationally, Black children were more likely than White children to be hospitalized with firearm injury regardless of neighborhood income level.

The literature supports the idea that living in a higher-income block group in a neighborhood with higher collective efficacy (e.g., social cohesion) mitigates individual

firearm assault risk, even for those at high risk for victimization.<sup>6,7</sup> However, Black residents of higher-income areas experienced firearm injury at rates similar to low-income White residents. Thus, something distinct links racial status and firearm assault risk in our study. Structural factors such as segregation of Black communities likely contributed to the increased risk of firearm violence we observed.<sup>8–10</sup>

This study should be interpreted with its limitations in mind. First, it included only descriptive analyses and cannot suggest the causative mechanisms by which disparities in firearm violence develop and persist. Moreover, the study was limited to a 2-year period in 1 city and did not include other socio-demographic factors such as ethnicity. However, these analyses make several critical contributions. First, we used cartographic modeling to characterize the geographic concentration of firearm violence in an urban context. The maps (Figure A) and their derived quantified rate ratios support previous conclusions that urban firearm violence may be best understood as occurring at several high-risk locations or hot spots, which represent important targets for place-based violence prevention interventions.<sup>7,11</sup> Second, although indicators of social disadvantage have been correlated with homicide rates in general, less is known about their effects on firearm violence specifically. This analysis makes an important first step and is, to our knowledge, the first

**TABLE 1—Firearm Assault Rates and Rate Ratios, by Race and Income of Victim Residence Block Group: Philadelphia, PA, 2013–2014**

Median Household Income, US \$	Firearm Assault in Black People		Firearm Assault in White People		Firearm Assault in Black vs White People, RR (95% CI)
	No. of Victims	Rate <sup>a</sup>	No. of Victims	Rate <sup>a</sup>	
0–20 000	431	16.1	100	11.7	1.4 (1.1, 1.7)
20 001–30 000	530	13.8	88	6.4	2.2 (1.7, 2.7)
30 001–40 000	394	12.7	54	2.3	5.4 (4.2, 7.0)
40 001–50 000	190	9.4	41	1.9	5.1 (3.7, 6.9)
50 001–60 000	56	6.3	16	0.8	7.9 (4.9, 12.5)
> 60 000	55	7.6	19	0.5	15.8 (10.7, 23.2)
All income levels	1656	12.5	318	2.5	5.0 (4.5, 5.6)

Note. CI = confidence interval; RR = rate ratio.

<sup>a</sup>Rate is per 10 000 population per year.

of its kind to examine the relations between race, income, and violent firearm injury incidence within an urban context.

## PUBLIC HEALTH IMPLICATIONS

In Philadelphia, race and geography correlate with firearm assault risk in ways that may be independent from other markers of social disadvantage. Although public health programs such as CeaseFire have had some success combating urban violence by addressing high-risk individuals, the structural factors that result in concentrated disadvantage along racial lines need equal consideration in the effort to address violent firearm injury in US cities.<sup>12</sup> Public health interventions and policies should focus on further understanding and alleviating the structural causes of disparities in exposure to firearm violence to promote health equity. *AJPH*

## CONTRIBUTORS

J. H. Beard, C. N. Morrison, and D. J. Wiebe contributed to the conceptualization and design of the study, analysis and interpretation of the data, and drafting and revision of the article. S. F. Jacoby, B. Dong, R. Smith, and C. A. Sims contributed to the analysis and interpretation of the data and revision of the article. All authors approved the final version of the article.

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## HUMAN PARTICIPANT PROTECTION

The Institutional Review Board of the University of Pennsylvania approved this study.

## REFERENCES

1. Christoffel KK. Firearm injuries: epidemic then, endemic now. *Am J Public Health*. 2007;97(4):626–629.
2. Wintemute GJ. The epidemiology of firearm violence in the twenty-first century United States. *Annu Rev Public Health*. 2015;36:5–19.
3. Walker GN, McLone S, Mason M, Sheehan K. Rates of firearm homicide in Chicago by region, age, sex, and race/ethnicity, 2005–2010. *J Trauma Acute Care Surg*. 2016;81:S48–S53.
4. US Census Bureau. American FactFinder Web site. Available at: <http://factfinder.census.gov>. Accessed February 8, 2016.
5. Kalesan B, Vylipambal MA, Bogue E, et al. Race and ethnicity, neighborhood poverty, and pediatric firearm hospitalizations in the United States. *Ann Epidemiol*. 2016;26(1):1–6.e1–2.
6. McNeeley S, Wilcox P. Street codes, routine activities, neighbourhood context and victimization. *Br J Criminol*. 2015;55(5):921–943.
7. Braga AA, Papachristos AV, Hureau DM. The concentration and stability of gun violence at micro places in Boston, 1980–2008. *J Quant Criminol*. 2010;26(1):33–53.
8. Sampson RJ. *Great American City: Chicago and the Enduring Neighborhood Effect*. Chicago, IL: University of Chicago Press; 2012.
9. Sharkey P. Spatial segmentation and the Black middle class. *Am J Sociol*. 2014;119(4):903–954.
10. Reardon SF, Fox L, Townsend J. Neighborhood income composition by household race and income, 1990–2009. *Ann Am Acad Pol Soc Sci*. 2015;660(1):78–97.
11. Braga AA. The effects of hot spots policing on crime. *Ann Am Acad Pol Soc Sci*. 2001;578(1):104–125.
12. Whitehill JM, Webster DW, Frattaroli S, Parker EM. Interrupting violence: how the CeaseFire Program prevents imminent gun violence through conflict mediation. *J Urban Health*. 2014;91(1):84–95.