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Association between outdoor temperature and fatal police shootings in the United States, 2015–2021

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Background: Here, we investigate the association between outdoor temperature and fatal police shootings in the United States between 2015 and 2021.

Methods: We conducted a time-stratified case-crossover study. Data on fatal police shootings were from the Washington Post's Fatal Force database and temperature data were from Daymet.

Results: A 5°C increase in maximum same-day temperature was associated with a 1.033 (95% CI = 1.002, 1.065) increased odds of a fatal police shooting. In stratified analyses, the strongest associations were observed in victims who were armed (OR, 1.052 [95% CI = 1.017, 1.088), White (OR, 1.052 [95% CI = 1.006, 1.100), or aged 45+ (OR, 1.110 [95% CI = 1.044, 1.181]). In additional subgroup analyses, relative risks were also generally higher among those who were armed.

Conclusions: There is evidence of an association between outdoor temperature and fatal police shootings in the United States, particularly when the victims were reported as armed. This study cannot determine if the associations are a result of any specific causes (e.g., increased police aggression or other factors).

Introduction

There is growing evidence of a link between higher outdoor temperatures and violent activity, both internationally[1,2] and in the United States.[3–5] For example, studies have reported positive associations between temperature and multiple types of interpersonal violence, including assault,[4,5] sexual violence,[4,5] and homicide.[1,4]

There are two leading theories to explain the relationship between ambient temperature and interpersonal violence. The first, which connects to a theory of crime known as routine activity theory,[6] posits that warmer weather increases the likelihood of an interaction between a perpetrator and a suitable target.[5] The second theory, in contrast, suggests that heat may trigger a physiological response that increases the probability of aggressive behavior. Both may be true.

Most prior studies have focused on violence within civilian populations, but interest in identifying factors that contribute to the use of lethal force by police has heightened in the wake of recent social justice demonstrations and research describing the high (and unequal) burden of police violence.[7,8] Estimates based on recent evidence suggest that over the life course, approximately 52 (90% CI: 39-68) per 100,000 men and boys in the United States will be killed by police use-of-force compared with 3 (90% CI 1.5-4.5) of every 100,000 women and girls.[7] Black men are more than twice as likely to be killed by police than are White men.[7,8] The age-standardized mortality rate due to police violence increased by ~40% between the 1980s and 2010s.[8]

The need to better understand the environmental determinants of all types of violence, including temperature, is heightened in the context of climate change. The world has already warmed by more than 1°C on average, but with substantial heterogeneity across the globe. It is increasingly assumed that violence may rise in the future in many locations as a result of climate change,[9,10] and that this rise could be costly to society in both human health and economic terms,[11] but the impact on police violence specifically is not well characterized.

Here, we investigate the association between outdoor temperature and fatal police shootings in the United States, including by the victim's race and age, the season when the shooting occurred, and the region of the country.

Methods

We conducted a case-crossover study, as described below.

What this study adds

To our knowledge this will be one of the first peer-reviewed paper on the association between ambient temperature and police killings. We present evidence that higher outdoor temperatures may be a risk factor for fatal police shootings in the United States, particularly when victims are armed.

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All data used in this study is publicly available. Analysis code is available on request.

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Health data

We used fatal police shooting data from The Washington Post's Fatal Force database.[12] Fatal Force is a publicly available database with data capture beginning on January 1, 2015, with event data collected from local news reports, law enforcement websites, public records, social media, and original reporting. We chose not to use an official governmental source of data, as these are known to underreport police-related fatalities and/or had limited geographical coverage until very recently.[8,13,14] We selected Fatal Force among other open-sourced databases due to its restrictive case definition—confined to fatal shootings of civilians by on-duty police officers—its prior use in peer-reviewed research, and because it is arguably more consistent and reliable than government or crowdsourced databases.[15–17] The dataset includes the date and location (latitude and longitude) of the event, as well as the victim's race, age, and if they were armed; records without location information were excluded.

Exposure data

Latitude, longitude, and date were used to link each shooting to meteorological data from the Daymet product.[18] Daymet provides 1 km^2 gridded estimates of daily weather parameters throughout the United States, with the exception of Hawaii; we therefore excluded incidents from Hawaii. Daymet is based on observed meteorology from US-automated surface observing stations, which include airports, cooperative network stations (e.g., US National Weather Service cooperative network stations), and some regional mesonets (e.g., Remote Automatic Weather Station), providing roughly 10-15,000 temperature observations per day across the contiguous United States. Spatial and temporal interpolation is performed using truncated Gaussian filter and topographical predictors. Daymet has been found to accurately describe ambient temperature and mean heat index at weather stations.[19] Variables of interest for the current analysis included daily maximum and minimum temperature, daily precipitation, and daily average vapor pressure (a meteorological parameter related to relative humidity). We used same-day (lag 0) maximum temperature as our *a priori* metric of choice, and explored lags of up to 3 days before the shooting to investigate potential delayed effects of temperature; analyses of other health outcomes have demonstrated that heat can affect health several days after exposure.[20,21] As Daymet data were not available for 2022 at the time of writing, we limited our analysis to 2015–2021.

Statistical analysis

We used a case-crossover study design—frequently applied in violence research[1,3] as well as environmental epidemiology more generally[22,23]—analyzed with conditional logistic regression models. In a case-crossover study, each subject serves as their own control,[24] with the temperature on the case day (the day of the killing) compared with that on control days. To select control days, we used a bidirectional, time-stratified approach where control days were chosen as (matched on) the same day of the week within the same month, year and location. For example, if a fatal police shooting occurred on Wednesday May 8, 2019 (the case day), the case-crossover design compares the temperature on that day (the case day) with the temperature in the same location on the control days, which in this case would be all the other Wednesdays in that month and year (May 1, 15, 22, and 29, 2019). This approach inherently controls for long-term trends, seasonality, and day of the week.

Results are reported as odds ratios per 5°C increase in temperature, but any exposure contrast would define the same relationship since we used linear models. Effects on subgroups were analyzed by stratification, including on the victim's armed status, race, age group, region, and season. Regions were defined by the US Census Bureau's four classifications: South, West, Northeast, and Midwest. In sensitivity analyses, vapor pressure and precipitation were considered as potential confounders and minimum temperature, which reflects night-time temperature, was included as an alternative to maximum temperature. Potential nonlinearities were analyzed by grouping events into temperature quintiles and comparing the effect individually in each of the warmest four (quintiles 2–5) to the coldest (quintile 1).

All analyses were conducted using R version 4.1.3.

Results

Between January 1, 2015, and December 31, 2021, there were 6991 incidents recorded in Fatal Force. After excluding 37 from Hawaii and 570 additional incidents without location information, there were 6384 available for analysis; 44.5% of victims were White, 69.8% were under the age of 45 and 82.9% were armed (Table 1). There were more incidents in the South and West compared with the Midwest and Northeast, and there were only small differences across seasons. The median same-day maximum temperature was 23.7°C for cases (IQR: 15.4–29.9) and 23.6°C for controls (IQR: 15.1–29.9), but varied across seasons (Table 2).

Overall, a 5°C increase in maximum same-day temperature was associated with a 1.033 (95% CI = 1.002, 1.065) increased odds of a fatal police shooting (Figure 1). In stratified analyses, the strongest associations were observed in victims who were armed (OR, 1.052 [95% CI = 1.017, 1.088]), White (OR, 1.052 [95% CI = 1.006, 1.100]), or aged 45 and above (OR, 1.110 [95% CI = 1.044, 1.181]). Effects were also elevated in incidents occurring in the South and West. In more detailed analyses of a victim's armed status, relative risks were higher among

Table 1.

Descriptive statistics of individuals shot and killed by police between 2015 and 2021, as reported by Fatal Force

	Number (percent of total)
Total	6384 (100%)
Armed[a]	
Yes	5295 (82.9%)
No	404 (6.3%)
Undetermined/other	685 (10.7%)
Race	
White, non-Hispanic	2844 (44.5%)
Black, non-Hispanic	1495 (23.4%)
Hispanic	1044 (16.4%)
Other	205 (3.2%)
Age, years	
≤24	976 (15.3%)
25–44	3477 (54.5%)
≥45	1633 (25.6%)
Region	
Northeast	455 (7.1%)
Midwest	1018 (15.9%)
South	2692 (42.2%)
West	2219 (34.8%)
Season	
Fall	1495 (23.4%)
Spring	1629 (25.5%)
Summer	1654 (25.9%)
Winter	1606 (25.2%)

Numbers exclude incidents from Hawaii (n = 37) and those from other states without exact location information.

[a] Includes any type of weapon (gun, knife, etc.). The undetermined/other category includes incidents where the armed status was unknown (N = 267), missing (N = 193), or where the victim had a toy weapon (N = 225). The percentage of armed cases by subgroup can be found in Supplementary Table 1 (http://links.lww.com/EE/A244).

those who were armed compared with unarmed in nearly all subgroups (Figure 2).

Sensitivity analyses are reported in Supplementary Figure 1 (http://links.lww.com/EE/A244), showing that including vapor pressure and precipitation in the model did not meaningfully change the results and that same-day maximum temperature had the highest effects compared with longer time lags. Same-day minimum temperature showed a lower effect estimate compared with maximum temperature. The association did not display any clear nonlinearities, though there may be some suggestion of concavity at the highest temperatures (Supplementary Figure 2, http://links.lww.com/EE/A244).

Discussion

We estimated the association between ambient temperature and fatal police shootings in the United States from 2015 to 2021, finding that a 5°C increase in same-day maximum temperature was associated with a 1.033 (95% CI = 1.002, 1.065) increased odds of an event. The association did not meaningfully change when considering vapor pressure and precipitation as confounders and did not show clear signs of non-linearity across the temperature distribution. Relative risks were highest on the day of the shooting and maximum temperature showed a stronger signal than minimum temperature. In stratified analyses, several subgroups showed elevated positive associations including those who were armed, White, aged over 45, and incidents in the South and West. Being armed was associated with higher estimates in almost all subgroups.

A small number of studies have investigated how heat may affect police behavior. For example, a 1994 experiment during police shooting exercises found that subjects felt more threatened by suspects and were more likely to shoot under hotter conditions,[25] which provides support for a physiological reaction to heat. Similarly, a study from Pittsburgh[26] found that police are more likely to issue traffic citations when temperatures are warmer, even after controlling for driving behavior, but a positive relationship between heat and traffic violations was not observed in studies from other locations.[27,28] Importantly, a recent working paper using different data and methods than we do here reported a null association with fatal police shootings after attempting to account for increased civilian-police interaction, but did report an association with killings from Tasers and physical restraints on extremely warm days.[29] A World Bank working paper focused on crime and policing in Texas similarly did not find that heat increased police killings of civilians, and in general reported little evidence that heat led to meaningful increases in police aggression overall.[27]

Our paper has several limitations. First, although Fatal Force is widely praised for its rigor, it may not include all fatal police shootings and may be subject to some exposure misclassification due to incorrect date information, which has

Table 2.

Median temperature with standard deviation on case and control days overall and by region

	Cases		Controls	
	Median	IQR	Median	IQR
All year	23.7	15.4–29.9	23.6	15.1–29.9
Fall	24.1	17.8–29.3	24.1	17.6–29.3
Winter	12.4	5.4–18.4	12	5.4–18.2
Spring	22.4	16.8–27.5	22.3	16.6–27.2
Summer	31.4	28.1–34	31.6	28–34.2

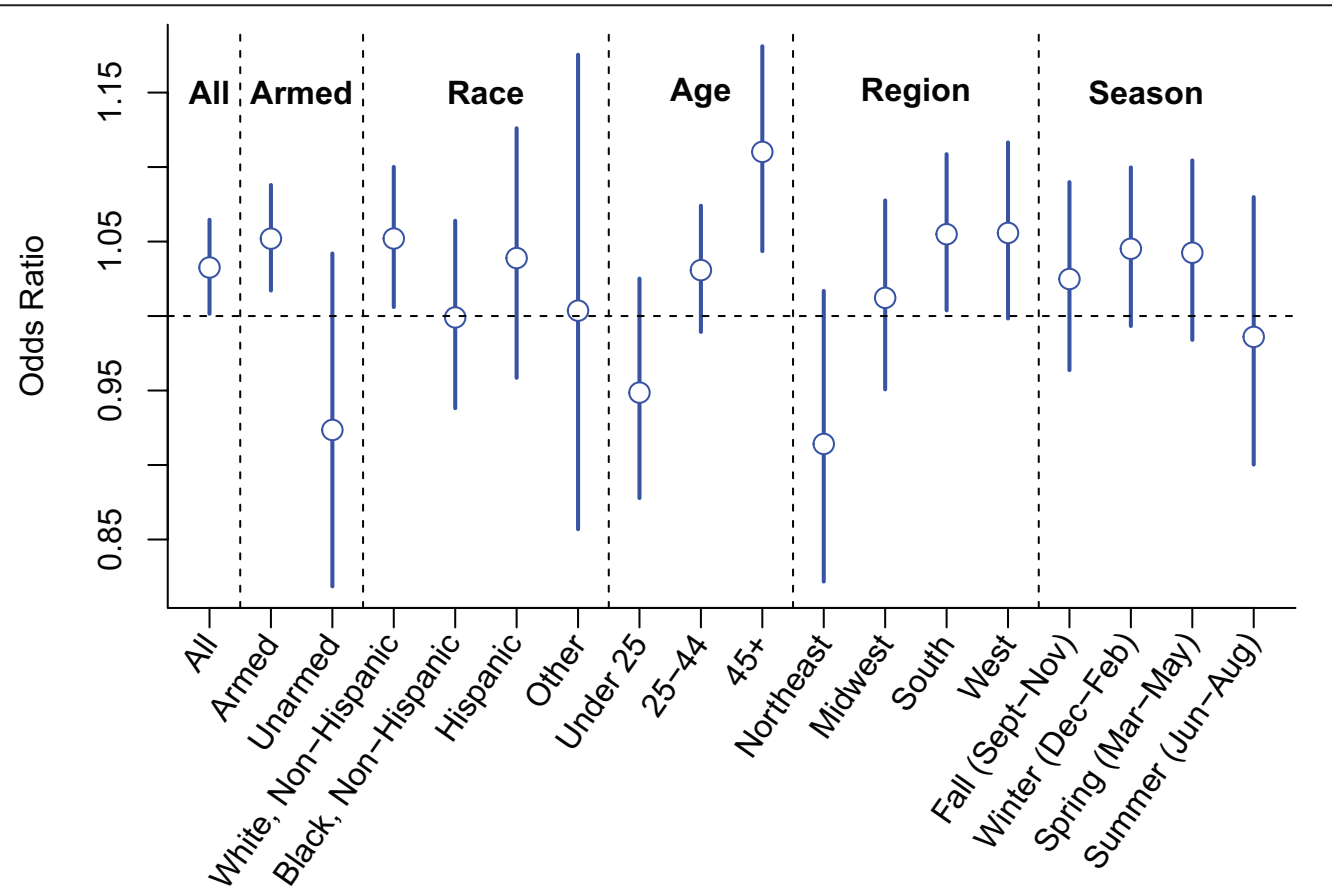

Figure 1. Association between temperature and fatal police shootings, reported as odds per 5°C increase in same-day maximum temperature. Bars represent 95% confidence intervals.

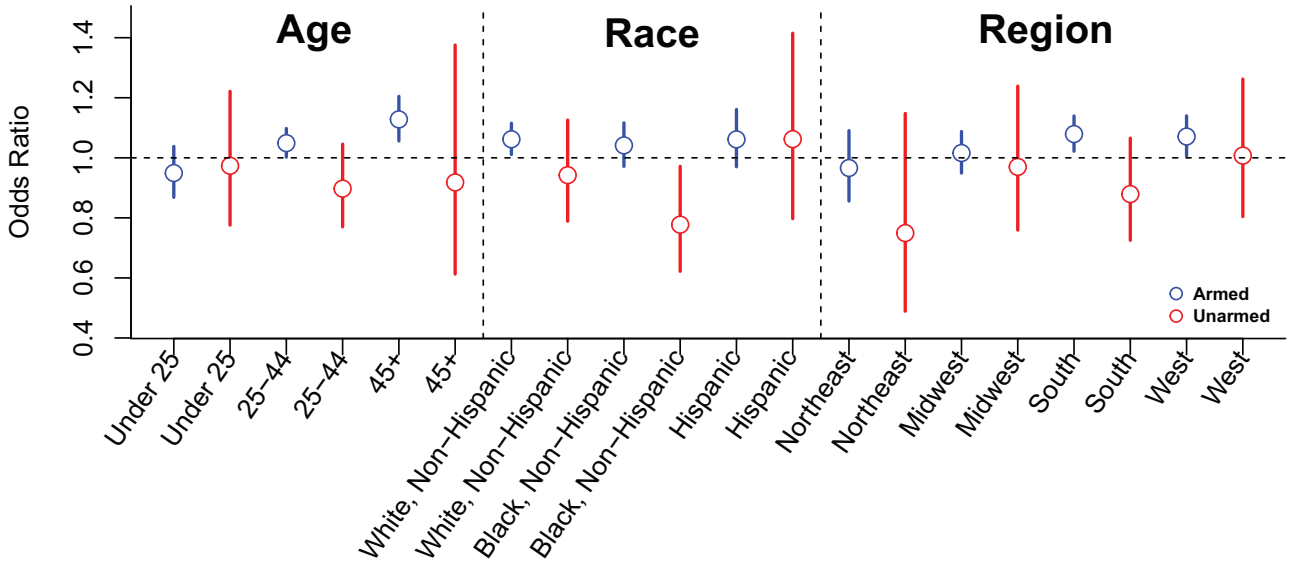

Figure 2. Association between temperature and fatal police shootings when the deceased was reported as armed or unarmed. Effects are reported as the odds per 5°C increase in same-day maximum temperature, with lines representing 95% confidence intervals. Individuals armed with toy weapons or where the armed status was undetermined or missing were excluded.

been reported (at low rates) in other open-source databases.[16] In general, the leading databases on police killings show good agreement overall.[8,17] Second, complex temperature phenomena such as urban heat islands may not be well-captured by Daymet. And third, Fatal Force does not report details on the context of the event, for example demographics of the officers involved or why the police were called, and does not collect data on nonfatal police violence; these are topics worthy of future study. Our study cannot determine whether the observed associations with temperature are a result of increased police aggression or other factors (e.g., increases in violent crime).

To conclude, we have conducted one of the few studies on the association between temperature and fatal police violence in the United States, using individual-level incident data combined with high-quality meteorology. We find a modest but significant ($P < 0.05$) effect overall, which appears to be stronger when the victim is reported as armed. The result adds to the evidence on the relationship between heat and interpersonal violence, which has particular relevance in the context of climate change.

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