Hot Temperatures, Aggression, and Death at the Hands of the Police: Evidence from the U.S.

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Abstract

We study the effect of temperature on police-involved civilian deaths in the U.S. from 2000 to 2016. We show that violent crimes and assaulted or killed officers increase with warmer days ($\geq 17^{o}$C), indicating an increased risk of personal harm on such days. Despite higher threat level, temperatures have a precise null impact on the number of deaths via firearms, suggesting officers exercise judgment over their use of firearms independently of threat level. However, deaths from Tasers significantly increase during 'extremely warm' days ($\geq 32^{o}$C), indicating a need to reevaluate Taser-use policies to prevent unintended deaths.

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1 Introduction

For every ten murders in the U.S., one civilian dies as the result of an encounter with the police.[1] Death at the hands of the police has increasingly captured the attention of the public, with most of the focus on the racial disparities in police shootings and how much race plays a role in these shooting (Ross [2015], Fryer [2018a,b], Edwards et al. [2018], Knox and Mummolo [2019]). Meanwhile, the factors in the threats that police officers face have been left unexplored, as have the reactions of the police to these threats. One threat, in particular, hot weather, is often associated with increased violent behavior (Bell and Baron [1976], Jacob et al. [2007], Burke et al. [2015]). This paper explores the risk associated from higher temperatures to the use of deadly force by the police.

We exploit county and monthly variation in temperatures to estimate the effect of weather on civilian deaths by firearm, conducted electrical weapons (CEWs, also known as Taser), less-than-lethal weapons, and physical restraint. We document that an increase in temperature is associated with a higher level of risk for officers and bystanders. However, we find a precise and robust null effect of temperature on the number of fatal police shootings. We also find that fatal interactions involving a CEWs or physical restraints are significantly higher for any additional days above 32^oC.[2]

Our results indicate that officers exercise judgment over their use of firearms independently of the increased threat level. However, our findings suggest that one should be careful when using CEWs or techniques of physical restraints that could result in asphyxia when temperature increases. Further research is needed in order to understand the physiological relationships between non-lethal tactics and high temperatures that increase the likelihood of death. We do not find evidence that temperature impacts the number of civilian deaths by other kinds of less-than-lethal weapons.[3]

Demonstrating these findings requires overcoming two empirical difficulties. First, there is a lack of readily available public data that records interactions between civilians and police resulting in the death of civilians (Banks et al. [2016]). Secondly, it is

[1] Authors' calculation, See fig A.4 in the Appendix.

[2] For the rest of the paper, we define 'warm' to refer to temperatures between 17 and 24^oC (i.e. 63 and 75^oF); we use 'hot' to refer to temperatures between 24 and 32^oC (i.e. 75 and 90^oF); and 'very hot' or 'extremely warm' indicate to temperatures above 32^oC

[3] See Section 2 for a discussion of our categorization of force options.

a challenge to disentangle whether these deaths are related to behavior, either from civilians or police officers, or result from an unintended physiological response to temperature, which would indicate that certain weapons are more dangerous during warm days.

This study addressed these challenges in three steps. Firstly, we used novel data from Fatal Encounters, which has crowd-sourced records on civilian-police interactions resulting in a civilian casualty in the United States from 2000 to 2016. Secondly, we used temporal variation in daily temperatures over the different geographical regions in the U.S. to account for county-level unobservables and seasonal patterns in crime data. Finally, we disentangled the nonlinear impact of temperature for each type of force in order to evaluate whether to interpret our results as a behavioral or physiological effect.

We first establish the link between temperature and threat level for police officers and civilians. We defined incidents as cases in which a suspect poses a serious threat of injury or death to officers or bystanders. We argue that these incidents, potentially dangerous, are captured by (1) the number of violent crimes and (2) the number of officers who are assaulted and/or killed. Hence, we show that temperature has a positive and statistically significant impact on the number of these incidents. This is consistent with previous studies that suggest that higher temperatures are associated with more aggressive behavior (Ranson [2014], Jacob et al. [2007], Burke et al. [2015]). We hypothesized that, in response to an increase threat level during warm weather, there should be an increase in the number of civilian deaths.

In the second part of our analysis, we explored the effect of temperature on police-related deaths, controlling for the threat level and taking into consideration the officers' exposure to risks. We found that temperature has a precise null impact on the number of civilian deaths by firearm. Although higher temperatures are associated with a higher level of threat, officers are not more likely to kill a civilian by firearm. This result is surprising, given our expectation that use of lethal force by officers would be correlated with the level of threat they face. Furthermore, this paper finds that the number of civilian deaths caused by CEWs use increases by 5.5% on very hot days. The effect of CEWs on casualties is null for days that are not extremely warm. We also document that the number of civilian deaths by physical restraint increases by 16.1% during very hot days. Although physical restraints and CEWs are not categorized as lethal, these results suggest that there can be unintended consequences to the use of this type of force in extremely warm weather. The results for incidents involving other kinds of less-than-lethal forces (see Section 2) were too imprecise to draw any conclusions.[4]

This paper contributes to different strands of the literature. CEWs are considered a less-than-lethal weapon. Some police departments have recently expanded their Taser arsenals, arguing that the increased availability of CEWs will lead to a reduction in police shootings (Bustamante [2017], Hinkel and Smith Richards [2017]). However, Ba and Grogger [2018] find no evidence that Tasers reduce firearm usage. Using a randomized controlled trial, Ariel et al. [2019] find that the introduction of Tasers leads to more use-of-force.[5] This paper provides additional evidence for the potential dangers of Taser use by demonstrating the possible consequences of using CEWs in hot weather. Finally, despite widespread findings that higher temperatures are related to higher crime rates and more aggressive behavior, we show that higher temperatures have no statistical effect on the number of casualties from police shootings.

2 Background

2.1 Use-of-force options

Most law enforcement agencies in the U.S. have policies that guide their use-of-force. The International Association of Chiefs of Police have defined use-of-force as the "amount of effort required by police to compel compliance by an unwilling subject." Depending on the level of danger, the continuum of force includes verbal commands, physical restraint, less-than-lethal force and lethal force. Less-than-lethal force involves technologies to gain control of a situation. Deaths by vehicle are not part of the continuum.

[4]We also found that temperature modestly impacts vehicular accidents, but our results were not statistically significant (See Section B in the Appendix).

[5]Ba and Grogger [2018] find similar results in Chicago; however, their findings might be sensitive to their interpretation of the level of severity of Tasers, in the use-of-force model. The authors claim that Tasers can be used on active resisters; however the Chicago Police Department's use-of-force model indicates that Tasers can be used on both active resisters and assailants (CPD [2017]). As a result, the authors lowered the level of severity of Tasers and might be mischaracterizing the level of danger of Tasers. We later document that Tasers are the third leading cause of civilian deaths when interacting with the police behind firearms and vehicular accidents.

Our data is crowdsourced information from public news articles that do not rely on administrative information from police departments. This explains why the cause of death does not perfectly fit the use-of-force model in our case. Below, we provide definitions of the causes of death that are part of the use-of-force model in order to provide some context necessary to interpret our results.

Physical restraint We define physical restraints by soft and hard techniques such as grabs, holds, joint locks, punches, or kicks to restrain or subduethe subject. The casualties from physical restraints correspond to "asphyxia/restrained" in the Fatal Encounters' classification.

Less-than-lethal We define less-than-lethal force as involving intermediate weapons such as an impact weapon (e.g., baton) or chemical weapons. Although CEWs are considered a less-than-lethal weapon, we analyze the use of this weapon separately. Our definition of less-than-lethal corresponds to "Beaten or Bludgeoned with instrument" and "Chemical agent or Pepper spray" in the Fatal Encounters' classification. Officers may use less-than-lethal weapons if the subject is physically aggressive or exhibits assaultive behavior with an immediate likelihood of injury to self or others (Use of force project (2017)). Non-lethal force options are used to limit the escalation of conflict where employment of lethal force is undesirable or prohibited.

CEW CEWs are considered a less-than-lethal force. CEWs discharge a high-voltage and low-amperage jolt of electricity through a dart. The electrical charge overrides the subject's nervous system and should temporarily incapacitate him. The use of CEWs requires training and periodic recertification.

Firearm Firearms are considered lethal use-of-force. Officers are allowed to use lethal weapons, i.e., firearms, if they reasonably believe that a suspect poses a serious threat to the officer or another individual. Many police departments collect data on officer-involved shootings and systematically investigate them. The use of firearms requires training and periodic recertification.

2.2 CEWs

The most common CEWs used by law enforcement agencies are manufactured by Taser International (now Axon).[6] In addition to selling the device, Axon provides training and certification to sworn law enforcement officers, military personnel, and licensed professional security employees.

According to Axon's training material, CEWs have limited effectiveness on loose or thick clothing, low nerve or muscle mass, and obese subjects (Axon [2018]). This suggests that officers might be less likely to use CEWs when the temperature is low, because people tend to wear thicker clothes in such weather. Axon also recommends against using CEWs on elderly, pregnant, or low body mass index individuals, warning that use on such subjects could increase the risk of death or serious injury to the subject.

Due to the electrical discharge, CEWs frequently cause subjects to fall, thereby increasing the risk of bodily trauma, particularly when the fall occurs on a hard surface, such as a sidewalk. Other potential effects of CEW use that could increase the risk of sudden death include changes in blood chemistry, blood pressure, respiration, heart rate, adrenaline, and stress hormones. Last but not least, CEWs are also liable to cardiac effects. Other factors that increase cardiac risks associated with the use of CEWs are the duration of the delivered electrical charge and the distance to the heart from where the dart impacts the body (Axon [2018]).

Axon strongly recommends that officers keep a detailed account of any incident in which they use a CEW. The company suggests the officer note their own actions as well as the subject's, and document the subject's medical status. For law enforcement agencies, it is important to keep this information in case of a lawsuit or for internal investigations.

3 Data

3.1 Source

Our primary analysis used Fatal Encounters data spanning from January 2000 to December 2016. We supplemented this dataset with combined daily climate data from the European Centre for Medium-Range Weather Forecasts. Finally, we

[6] According to Forbes Taser International holds 95% of market share.

obtained the FBI's Uniform Crime Reporting Data System (UCR) from Kaplan [2018], who constructed a monthly dataset on a police-department-level basis for index crimes from 1968 to 2016. We merged climate data and Fatal Encounters data with FBI UCR data by county and month.

Fatal Encounters is a crowdsourced database on deaths through police interaction in the United States since 2000 that relies on available public news articles. Every entry is manually checked and properly sourced with an accompanying police report, when available, or other official statements. The dataset includes key variables such as the date of the incident, county and cause of death. The data also indicates whether the subject displayed symptoms of mental illness or substance abuse. However, this information is reported by the person who submitted the incident to Fatal Encounters and that it therefore may be unreliable or subject to reporting bias. Our final sample includes only fatal incidents that can be tied to police use-of-force or those caused by vehicles.[7]

No national data on police killings is managed by the U.S. government. The Bureau of Justice Statistics acknowledges their current data-collection methodology for arrest-related deaths is defective and could be improved by crowdsourcing (Arrest-related deaths program Assessment, March 2015). In particular, the BJS states that Fatal Encounters "most closely matched the Arrest-related deaths program scope" **(**Banks et al. [2016]**).** To our knowledge, this is the best source of information on this subject and has yet to be stringently analyzed.

3.2 Summary statistics

Table 1 presents the distribution of type of death from 2000 to 2016. Firearms and vehicular accidents represent the most common cause of death with 73.4% and 21.1% of the final sample, respectively. Death by CEWs is the third most common fatal use-of-force death and represents about 3.7% of arrest-related deaths. Meanwhile, less-than-lethal force and physical restraints correspond to about 1% of the sample. We also disaggregate the distribution according to age, gender, race, and symptom of mental illness or substance abuse of the civilian who died during the interaction. About 5-6% of the civilians who died by firearm, less-than-lethal weapon,

[7]Cases of death by vehicle are included because they represent a large share of the RAW data (19.22%). We ignore the following categories of cause of death: drowned, drug overdose, fell from height, stabbed, undetermined, burned/smoke inhalation, and others.

and physical restraints are female, while only 2.5% of those who died by CEW are female. CEWs have the lowest share of juvenile and elderly in the sample, which is consistent with the safety guidelines provided to police officers by Axon.[8] About 31% of the civilians who die in police shootings are white, which represents the largest proportion for identified race for this type of death. In contrast, the largest share of civilians who die as a result of less-than-lethal force or physical restraints are black. CEWs and physical restraints are also the most common causes of death for subjects who exhibited symptoms of mental illness or substance abuse.

4 Empirical strategy

Figure 1 provides the geographical distribution of temperatures across the U.S. We divided the U.S. into ten climate zones and assigned each county to a climate zone based on its mean average daily temperature throughout the year. This map shows a high degree of heterogeneity in temperature across the U.S. The northern parts of the country are more likely to have lower temperatures (i.e., less than 13^oC), whereas the southern areas tend to have warmer weather (15^oC and above). Figure 1 shows the average yearly number of civilian deaths when interacting with police per 100,000 capita for each county in the U.S. We did not find any obvious relationship between the temperature zones and civilian death rates.

To identify the causal effect of temperature on civilian death as a result of police interaction, we used the exogenous daily variation in ambient temperatures at the county level. Daily variation matters if we believe that temperature has a non-linear effect on fatal encounters. Binned regression allows for heterogeneous response at different parts of the temperature distribution. This method has been successfully used to estimate the non-linear effect of temperature on mortality (Deschenes and Greenstone [2011]), the crime rate (Ranson [2014]), civil conflict (Hsiang et al. [2011]), and agricultural yield (Schlenker and Roberts [2009]).

Fatal encounters are relatively rare events at the county level and need to be estimated using a count model. The Poisson regression approach accounts for the skewed distribution of fatal encounters. Our data is aggregated by type of death τ for every year y at the month m and county c level. The number of deaths $Y_{\tau cym}$ follows a Poisson distribution with a probability density function and mean $\lambda_{\tau cym}$

[8]See Taser use guidelines: cga.ct.gov/2007/rpt/2007-R-0068.htm

such that:

$$f(Y_{\tau cym}|\lambda_{\tau cym}) = \frac{\exp(\lambda_{\tau cym})}{Y_{\tau cym}!}\lambda_{\tau cym}^{Y_{\tau cym}} \tag{1}$$

To ensure that the mean $\lambda_{\tau cym}$ is strictly positive, we estimate the following parametric specification:

$$\lambda_{\tau cym} = \exp(\sum_{\tau=1}^{5}\sum_{b=1}^{9} Type_{\tau} \cdot Temp_{cym}^{b}\beta_{\tau b} + h(Precip_{cym}) + X'_{cym}\beta_x + \gamma_{\tau cy} + \delta_{state} + \varepsilon_{\tau cym})$$

where $Type_{\tau}$ are dummy variables for the distinct types of force (cause of death) which are Firearm, CEW-related, Vehicle, Physical restraint, and Less-than-lethal weapon. Following Deschenes and Greenstone [2011], we captured the full distribution of monthly fluctuations in weather. The variables $Temp_{cym}^{b}$ denoted the number of days where the daily mean temperature is in one of the nine bin variables[9] b in county c within a month m and year y. This method allowed us to combine daily variation in temperature with more aggregated variables such as monthly death count. We omitted the bin $[12; 17)$ from the regression and used it as the reference category for the temperature effect.[10] The interaction between type of force and temperature, $Type_{\tau} \cdot Temp_{cym}^{b}$, enabled us to recover separate effects of temperature on the number of civilian deaths for each cause of death. Hence, the parameters of interest are given by the whole vector $\beta_{\tau b}$. As a robustness check, we relaxed the parametric assumption on temperature and instead considered a polynomial function (4th order).

The term X_{cym} represents a vector of time-varying explanatory variables that may influence the probability of afatal interaction between police and civilians. A list of these variables is provided in the notes to Tables A.2-A.6 in Appendix B. These controls include the level of precipitation in county c during month m and year y. To ensure that our results are not biased by using a restrictive form of precipitation, we model it using a polynomial function (quadratic), $h(Precip_{cym})$. The term δ_{state} is a state-by-season fixed effect and $\gamma_{\tau cy}$ is a vector for each type of use-of-force county-by-year fixed effect, which control for space and time varying non-observables. As controlling for crime variation was a key component of our analysis, we performed

[9]The bins are in 5^oC increments from -3 to 32^oC , including one for temperatures lower and greater than this range.
[10]The choice of the reference bin only affects the interpretation.

estimation with multiple types of crime being either directly included in the vector X_{cym} or defined as the exposure variable. Setting crimes and arrests within a month as the exposure variable adjusted our estimate for the amount of "opportunity" officers had to use any kind of force. In other words, we account for crimes and arrests as risk sets.

The identifying assumption for our analysis was that, after controlling for county-year-type of death and state-by-season fixed effects, differences in weather and crime between months within a county represent the true effect -$\beta_{\tau b}$- of weather on the number of civilian deaths by type of force used. Moreover, this specification allows for a joint estimation of each type of force which accounts for correlated shocks among type of death. Unless specified, we clustered standard errors at the year-by-type of death.

5 Results

5.1 Effect of temperature on the level of threat

We began our analysis by examining the effect of temperature on the level of threat for police officers and bystanders. Figure 2 presents the coefficients from estimating equation 1 on the number of officers assaulted or killed and on the number of violent crimes.

These figures indicate that there is a positive and statistically significant impact of temperature on the number of violent crimes and the number of officers assaulted or killed when the temperature is 17^oC or higher. Compared to a day in the $[12^oC, 17^oC)$, an extra day at 17^oC or above leads to 0.2%-0.5% more assaulted or killed officers, and to 0.28%-0.62% more violent crimes[11]. As pointed out by Ranson [2014], these coefficients seem small; however, they represent the effect of a single day of weather per month, and yield important effects in the aggregate. For instance, in a spring month with ten unusually warm days ($[22^oC, 27^oC)$), violent crimes and assaulted or killed officers would be 4.3 to 4.4% higher than the number of violent crimes and assaulted or killed officers relative to the reference bin.

The nonlinear impacts of temperature on violent crimes[12] and officers assaulted

[11] As a reference, Chalfin and McCrary [2018] find that a one percent increase in the size police causes violent crimes to go down by 0.29 to 0.34%.

[12] Our results are consistent with those found in Ranson [2014]. Our analysis uses the same data

or killed indicate that the level of threat for both officers and civilians is higher when the temperature is 17^oC or higher. The level of danger for an officer is statistically similar between extremely hot days and hot days.

This confirms that higher temperatures are associated with more aggressive behavior from civilians (Burke et al. [2015]). Thus, we deduce from Figure 2 that it is more dangerous for officers to perform their job when the ambient temperature is higher. Because the level of threat increases above a certain temperature, we expect officers to be more likely to discharge their weapon during warm days. As a result, we hypothesized that, in response to an increase in the level of threat during warm days, there should be an increase in the number of civilian deaths by police shootings .

However, it is possible that police officers do not respond to higher levels of threat by using their firearms. They could, for e.g., use de-escalation techniques, such as restraining methods or less-than-lethal weapons. Although these approaches are not intended to be fatal, there might be some unintended consequences of using these types of force, e.g., death of the suspect or a bystander. Restraining techniques, for example, can result in death by asphyxia.[13]

5.2 Effect of temperature on civilian deaths

Figure 3 presents the coefficients from estimating equation 1 which accounts for the different causes of death. Allowing heterogenous effects per causes of death shows that there is a precise null impact of temperature on the number of civilian deaths by firearm. In other words, we found that all coefficients of temperature are close to zero, with small standard errors. The fact that temperature did not impact the number of civilian deaths by shooting might indicate that although officers are in a riskier situation due to temperature, they exhibit self-control by not discharging their firearm.

This result is surprising for two reasons. First, we would expect the use of deadly weapon to be proportional to the level of risk experienced by the police officers (Use of force project (2017)). However, although higher temperatures are associated with higher levels of threat, officers are not more likely to kill a civilian by using their firearm. Second, it contradicts the experimental results from Vrij et al. [1994]

source and extends it to include recent years.

[13]For e.g., Eric Garner's 2014 death in New York City, which resulted from a chokehold.

who found that police officers are more likely to fire their weapons at assailants during a training simulation conducted in hot temperatures. Our results raise some concerns about the external validity of their findings. On the one hand, it may be very difficult to design a credible experiment that has such high and potentially real-life stakes for both the officers and the civilians involved. On the other hand, in our data we only report fatal interactions; i.e., we do not have data on use-of-force incidents that did not result in the death of a civilian. Thus, we cannot rule out with certainty some behavioral hypothesis.[14]

We now discuss our results for other forms of less-than-lethal force in turn. In terms of the use of less-than-lethal force, we find that there is a significant impact of 'very hot' days on the number of deaths by CEWs and physical restraint. The results for less-than-lethal force are too imprecise to draw any conclusions.

For CEWs, we found that the monthly number of civilian deaths increased by about 5.5% for every additional hot day compared to a day in the $12 - 17^oC$ range. The results for hot days ($> 17^oC$) are highly significant (p<0.001[15]). The incidence ratio is about 1.0 when the temperature is between 2^oC and 32^oC with small standard errors; in other words, there is a null impact of temperature on the deaths by CEWs. When the temperature is lower than 2^oC, the number of deaths by CEWs is lower compared to the reference temperature; however, the results are not statistically significant. Results in Figure 5 also suggest that law enforcement officers are unlikely to substitute CEWs for their firearms during hot days. Indeed, more than the absence of a positive effect for gunshot fatalities, weapon substitution during hot days would imply a reduction in the number of deaths caused by firearms (i.e., a negative coefficient).

In addition to CEW-related deaths, we found that deaths caused by physical restraints tended to increase significantly during 'extremely warm' days. The incident rate ratio is about 1.15 when the temperatures are at least 32^oC, meaning that the number of civilian deaths by physical restraints increases by 16.1% on 'very hot' days. Due to the low number of cases, the effect of an additional day at 32^oC or above is much less precise for incidents in which physical restraints was used, but remains statistically significant (p-value = 0.038). The effects are at most 3% and

[14]For instance, it is possible - although unlikely - that police officers do shoot more often and are more aggressive during warmer days but that it somehow does not impact the number of civilian deaths.

[15]The estimate is also statistically significant at the 1% level when adjusting for multi hypothesis using the very conservative Bonferroni correction.

not statistically significant when the temperature is less than $32^o C$. The physical restraints of an individual during arrest can sometimes leads to fatal hyperthermia and asphyxiation if the victim is subject to excited delirium or controlled in the wrong position. Though the number of asphyxiation and restraint-related deaths only accounts for 1% of all fatal encounters, police officers could nonetheless take simple precautions on hot days to avoid civilian deaths (e.g., limit the use of handcuffs and other restraints when possible).

For types of less-than-lethal force, excepting CEWs, we found that the effect of temperature on civilian deaths is non-monotonic, i.e., temperature does not increase (or decrease) the number of civilian deaths for these types of force. Moreover, we did not find a statistically significant impact of temperature on civilian deaths for these types of force. The results have large standard errors.

We present alternative specifications in Appendix B. We found that our results are robust to the inclusion of controls (such as number violent crimes, number of property crimes, and number of assaulted or killed officers). We also considered a 4th order polynomial function for temperature, rather than a bin specification. Finally, we found similar results when analyzing response to temperature at the daily level.

Appendix B investigates whether our estimates are not mechanically driven by the fact that the usage of CEWs is strongly correlated with the time of year. Weather might alter officers' choice of force: CEWs are less effective when used on individuals wearing thicker or more layers of clothing. Therefore, it is important to account for the fact that officers are less likely to use their CEWs when temperatures are low. In order to address this, we repeat our analysis on counties where the annual average temperature is at least $19^o C$. This approach provides an upper bound on civilians' clothing use and officers' force options throughout the year with respect to temperature. We confirmed that temperature has no effect on civilian deaths due to police shootings for warmer regions in the U.S. We show that the number of civilian deaths by CEWs increases by about 6.8% during 'very hot' days only. Our preferred interpretation of this result is that the use of CEWs on hot days triggers unknown physiological factor(s) that increase the risk of death.

Appendix B also evaluates the effect of temperature on the number of deaths when the behavior of the civilian is less predictable for the officer. We explored the fact that an officer might perceive civilians who exhibit symptoms of mental illness or substance abuse as less predictable or cooperative. We find similar results for both groups for the deaths by firearm and CEWs. Temperature did not impact the number of deaths by firearm, which might indicate that officers exhibit self-control in their decision to use lethal force when facing less predictable civilians or, alternatively, that officers do not perceive such civilians as sufficiently threatening to warrant force. For CEWs, we confirmed that high temperatures increase the odds of a lethal interaction regardless of the mental status of the civilian.

6 Discussion

In contrast to the documented racial differences in police shootings (Ross [2015], Fryer [2018a,b], Edwards et al. [2018], Knox and Mummolo [2019]), our research focuses on the following question: how does the level of threat faced by police officers or civilians impact the use of deadly force by the police? To answer this question, we first show that police officers and civilians face a higher level of threat due to higher temperatures. We exploit this result to test whether the number of police-involved civilian fatalities increases with temperature and, by extension, test the relationship between the use of deadly force and the level of threat faced by officers. We focus on two types of force: (1) lethal force (firearms) and (2) non-lethal force, namely Tasers and forms of physical restraints.

We find that temperature has a precise null impact on civilian deaths from police discharging their firearms. The fact that fatal police shootings do not increase in warmer conditions, when officers face a statistically higher level of threat, indicates that the decision by officers to use deadly force is not a linear function of the level of danger. Our interpretation of this result is that officers exercise restraint in their use of deadly force even in the face of an elevated degree of threat. Our results are identical regardless of whether one includes covariates on crimes or arrests to account for police-civilian interactions ("risk set"). When considering that an officer might perceive as less predictable or cooperative civilians who exhibit symptoms of mental illness or substance abuse, we found a null impact of temperature on death by firearm for both groups. This indicates that officers exercise restraint even in situations in which they might reasonably see themselves facing a seemingly increased level of threat from unstable civilians.

These results bear consideration in light of recent high-profile trials for police officers charged with killing civilians in the U.S. (McWhorter [2016]). The officers on trial cited self-defense in response to a perceived threat. Given our identification strategy based on temperature, our results, insofar as they undermine a direct link between the level of threat and the officer's decision to use deadly force, indicate that more research is needed to explain the relationship between threat and police use-of-force. Such research may have important consequences for future legal and policy decisions regarding officer liability with regard to officer-involved civilian shootings.

Secondly, the significant number of unintented deaths from CEWs and physical restraints in hot temperatures may incentivize police departments and policymakers to reevaluate their guidelines around the use of less-than-lethal types of force. Less-than-lethal types of force are not, by definition, intended to be deadly, although these deaths may be related to unknown physiological/biological factors. Guidelines restricting the use of CEWs on vulnerable members of the population—namely, pregnant women, children, and the elderly— already recognize this. However, to the best of our knowledge, there is no study that links CEWs and temperature. Unfortunately, because our study relies on observational data, it is difficult to identify the potential mechanisms behind our results. We believe that more research is needed in this matter from medical and natural science experts, in particular to identify the channels that explain the increased probability of dying from CEWs under these conditions.[16]

7 Conclusion

We provide evidence that, although the level of risk increases with temperature, police officers are not more likely to fatally shoot civilians. These results also hold when civilians exhibited symptoms of mental illness or substance abuse. Our interpretation of this finding is that officers are capable of exercising restraint in their use of lethal force even when facing an elevated degree of threat. Although Tasers are considered a less-than-lethal weapon, we demonstrate that the number of deaths by CEWs significantly increases on extremely warm days. We suspect that deaths by CEWs on very hot days are driven by compounding physiological factors, and not by an increase in Taser usage from officers.

[16] Potential channels that have been suggested to us from discussions with physicians are that tasers and high temperatures might have an impact on sweat, humidity, hypertension, or electrolytes. However, we do not have the expertise or medical knowledge to evaluate these theories.

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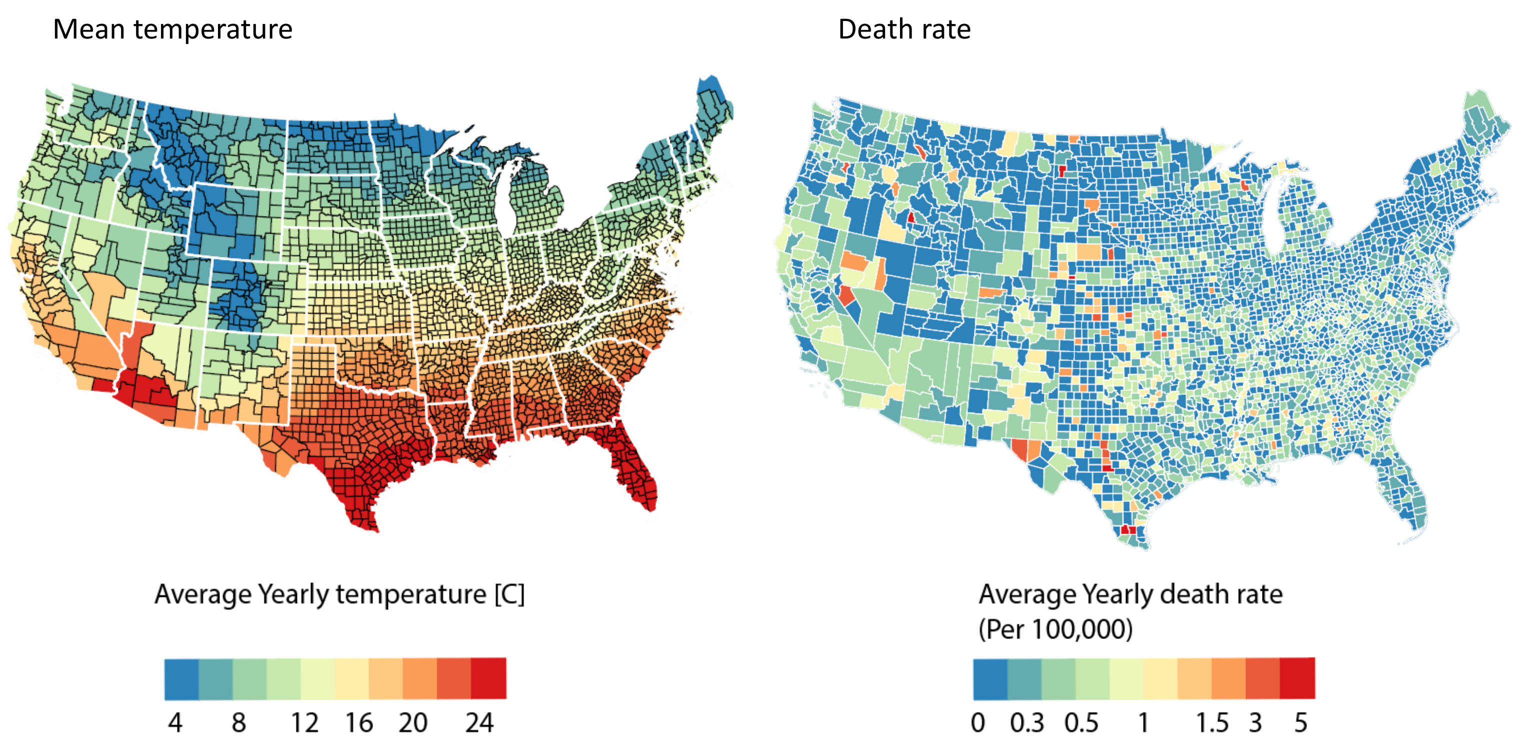
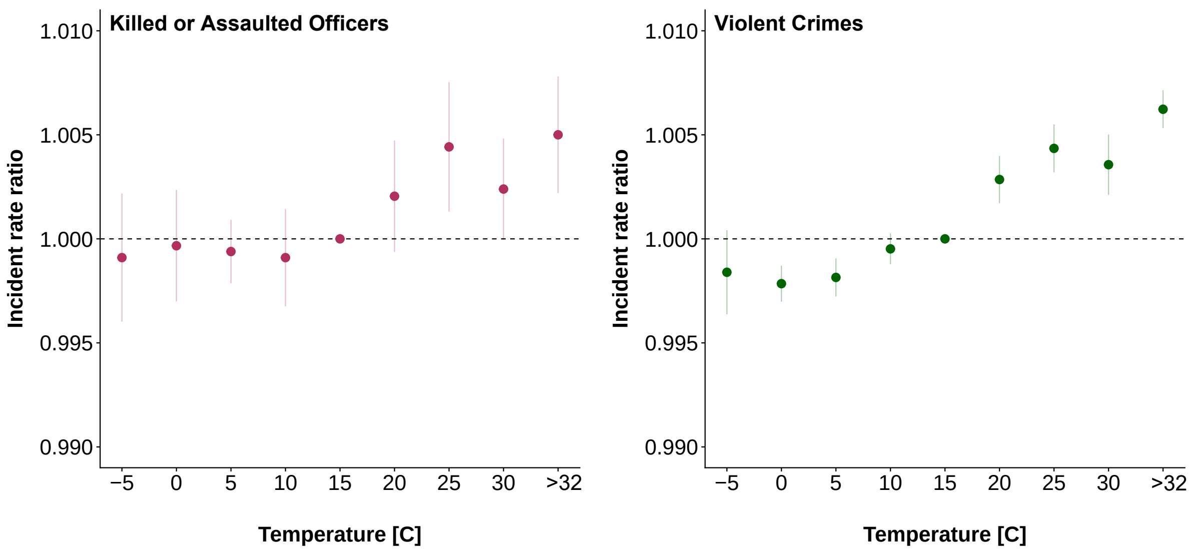
Figure 1: Yearly average of mean temperature and death rate in U.S. counties



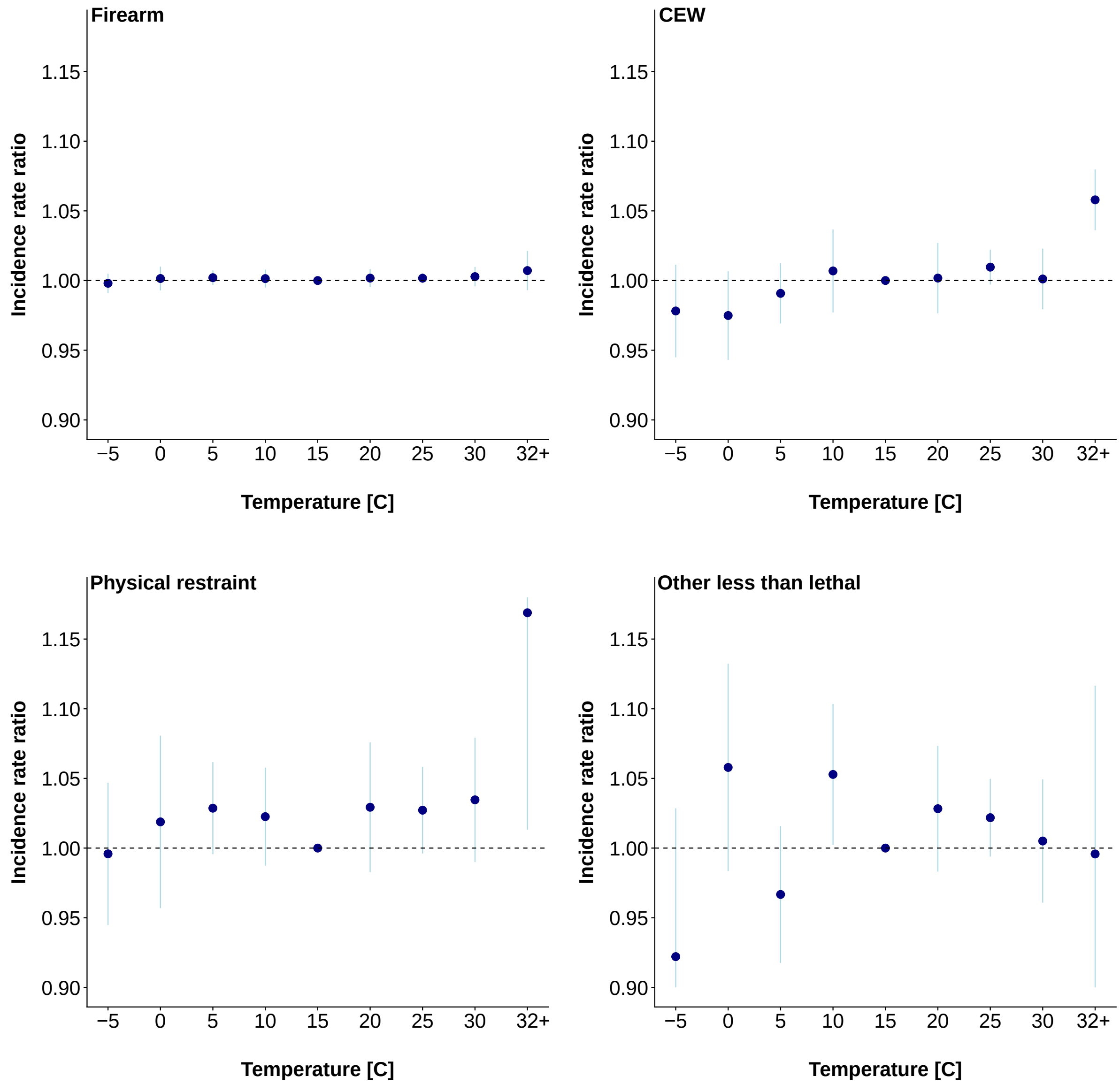
Notes: These maps present the mean temperature and death rate (number of death per 100,000 residents) in U.S. counties from 2000 to 2016.

Figure 2: Effect of temperature on the level of threat



Notes: These figures present the estimated effect of temperature on the number of killed/assaulted officers and violent crimes. The specification controls for precipitation, state-by-season fixed effect, and county-by-year fixed effect. For interpretation, we report the incident rate ratio on the y-axis. Standard errors are clustered at the state level. We report the 95% CI. We report the midpoints for bins with temperature between -3 and 32^oC, with 5 degree increments. Bins -5 and $32+$ report temperatures lower and greater than the -3, and 32^oC range.

Figure 3: Effect of temperature on the number of civilian deaths by type of force



Notes: These figures present the estimated effect of temperature on the number of civilian fatalities by type of deaths. Section 2 provides details about the different causes of death. The specification controls for precipitation, state-by-season fixed effect, and county-by-year fixed effect. For interpretation, we report the incident rate ratio on the y-axis. Standard errors are clustered at the year-by-type of death. We report the 95% CI. We report the midpoints for bins with temperature between -3 and 32^oC, with 5 degree increments. Bins -5 and $32+$ report temperatures lower and greater than the -3, and 32^oC range.

Table 1: Summary statistics from 2000 to 2016

	Firearm	CEW	Other less-than-lethal	Physical restraint	Vehicle
Age					
<16	1.8%	0.3%	1.9%	1.4%	9.5%
[16;30)	40.0%	26.7%	24.7%	25.4%	44.7%
[30;65)	53.5%	70.8%	70.3%	68.1%	37.4%
65 and more	4.8%	2.2%	3.2%	5.2%	8.4%
Male	94.7%	97.5%	94.3%	94.4%	74.2%
Race					
Black	20.3%	29.6%	31.7%	28.2%	15.2%
Hispanic	12.8%	10.8%	14.6%	12.2%	10.1%
White	30.8%	24.9%	21.5%	24.4%	24.5%
Unknown	33.7%	33.3%	27.9%	33.8%	48.4%
Symptom of mental illness or substance abuse					
Without symptom	59.1%	31.5%	39.2%	29.1%	85.4%
With symptoms	18.8%	45.0%	32.3%	42.7%	5.6%
Total	15175	771	158	213	4355
Percent	73.4%	3.7%	0.8%	1.0%	21.1%

Notes: This Table presents the summary statistics of the civilians our sample by cause of death from 2000 to 2016. Section 2 provides details about the different causes of death.

Appendix

Hot Temperatures, Aggression, and Death at the Hands of the Police

Sébastien Annan-Phan and Bocar A. Ba

A Data Appendix

European Centre for Medium-Range Weather Forecasts Data Climate variables are based on reanalysis data from the European Centre for Medium-Range Weather Forecasts (ERA-Interim), which is based on a climate model combined with observational data. We used their 0.25 x 0.25 gridded data on daily temperature and precipitation to generate aggregated daily temperature at the county level using population weights.[17] Population weights ensure to report an average of the temperature for places that matter for our study.

FBI Uniform Crime Reporting Data The crime data are obtained from the FBI Uniform Crime Reporting (UCR) data for offenses known and clearances by arrest from 1960 to 2016. The data are available monthly on a police department-level basis for index crimes (violent and property crimes) and assault on officers. For each county, we compute the monthly number of violent crimes (aggravated assault, murder, robbery, and rape), property crimes (burglary, larceny, motor vehicle theft), and officers by assault. We exclude agencies that report negative crimes in a given year. We also drop agencies than reported fewer than 12 months of data for a given year.

[17]For our polynomial regression, it is important to take such nonlinear transformations at the cell level before spatially aggregating the data at the county level. This transformation preserves the tails of the distribution within the administrative region and ensure consistent results.

B Robustness

B.1 Effect of temperature on civilian deaths by type of force

Figure A.5 compares the mortality temperature dose-response of CEW related death versus gunshot fatalities using a nonparametric regression to mitigate the effect of bins' cut-off. The polynomial approach confirms the nonlinear relationship between temperature and CEW related deaths: only the extremely high temperatures increase the number of fatalities while cold temperatures have a neutral to negative impact. The negative effect of cold days is likely due to the drop in CEW efficiency and use as people wear thicker clothes. However, the effect of warm temperatures is unlikely to be explained by clothing, as only extremely high temperatures significantly impact CEW-related deaths.

B.2 Results from warm regions

We revisit our analysis from the previous section using U.S. counties where the annual average temperature is at least 19^oC. We do this for two reasons. First, because CEWs are less effective when used on individuals wearing thicker clothing (common during cold weather), it is important to account for the fact that officers are less likely to use their CEWs during cold weather. After 19^oC, people are less likely to wear thicker clothes (Morgan and de Dear [2003]). The behavior from civilians with respect to temperature is more likely to be held constant throughout the year. This helps mitigate the problem that officers are less likely to use CEWs because they anticipate that it would be less effective because subjects are more likely to wear thick clothing. Secondly, this section is intended to disentangle the effect of warm days from the effect of 'very hot' days. Figure A.6 presents the coefficients from estimating equation 1 on counties with an average annual temperature of at least 19^oC.

We found analogous results to the previous section. For warm regions in the U.S., we confirmed that temperature has no effect on civilian deaths due to police shooting. The results remain precise. The number of civilian deaths by CEWs increased by about 6.8% during extremely warm days, whereas the effect of temperature was close to zero and statistically non-significant for days where the temperature is less than 32^oC.

For physical restraints or less-than-lethal force (except CEWs), we found that the effect of temperature on civilian deaths is non-monotonic and very imprecise. The results for physical restraints during 'extremely warm' days were not robust using this subsample.

B.3 Effect of temperature on civilian deaths by symptom of mental illness or substance abuse

In order to assess the sensitivity of our results to abnormal behavior of civilians in warmer conditions, we exploited the fact that Fatal Encounters data provides information on whether the civilian exhibited symptoms of mental illness or substance abuse (drug or alcohol). Intuitively, a civilian who exhibits symptoms of a kind associated with mental illness or substance abuse would present behavior that officers find unpredictable, and therefore more threatening. One can also argue that officers might perceive individuals with these symptoms as more combative and/or less cooperative. In this case, substance use becomes an additional compounding factor, making it difficult to pin down the physiological impact of temperature on death by CEWs.

Figure A.7 presents the coefficients from estimating equation 1 by symptom status. For both groups, there was a precise null impact of temperature on the number of deaths by firearm. This indicates that even if a civilian exhibits less predictable behavior, he or she is not more likely to die from a police shooting.

For CEWs, we confirmed the results from previous sections and obtained similar point estimates for the two groups. We show that the monthly number of civilian deaths by CEW increases by about 7.3% for any additional hot day compared to a day in the $12 - 17^{o}C$ range. The impact of temperature on civilian deaths by CEWs is null and non-significant for days with temperature lower than $32^{o}C$. Despite the fact that substances might be an important factor that affect the number of deaths, it is surprising that both groups have similar point estimates for high temperatures. We view this finding as suggestive evidence that use of CEWs in high temperatures increases the odds of unintended death through some combination of physiological factors.

The significant impact of extremely warm days on the number of deaths by physical restraints seemed to be driven by civilians who exhibit symptom of mental illness or substance abuse. However, the confidence interval is fairly wide. For subjects that do not present symptoms, the temperature is null and not significant for very hot days. However, there does seem to be a marginally significant positive effect ($p<.1$) on the number of deaths of subjects without symptoms for temperatures between 22 and 27^oC.

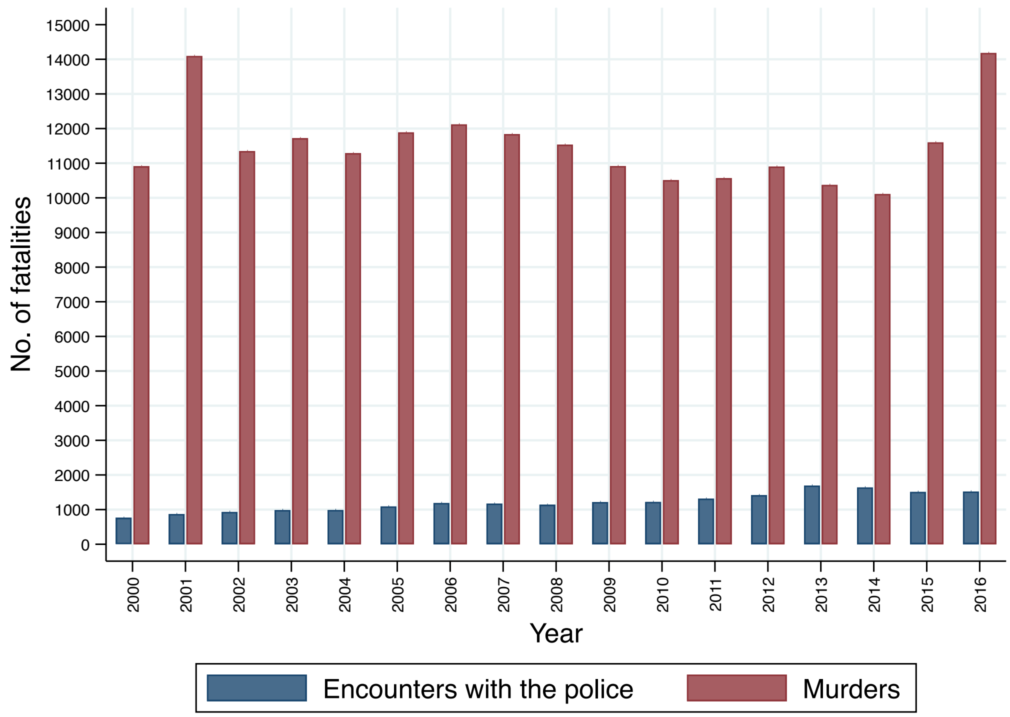
As discussed and documented in previous sections, results for other less-than-lethal uses of force remain very imprecise. One cannot draw any conclusions about the effect of temperature on the number of civilian deaths for these types of police action.

B.4 Effect of temperature on the number of civilian deaths by vehicle

This section briefly presents the effect of temperature on the number of fatalities by vehicle when interacting with the police. Figure A.8 shows that the number of civilian deaths by vehicle is not statistically influenced by temperature for days with a temperature of at least -3^oC. The coefficients are close to zero when the temperature is between -3 and 32^oC. The incident rate ratio is larger for warm days (1.025) but the effect is not statistically significant. The number of deaths by vehicle seems to be statistically smaller when the temperature is less than -3^oC.

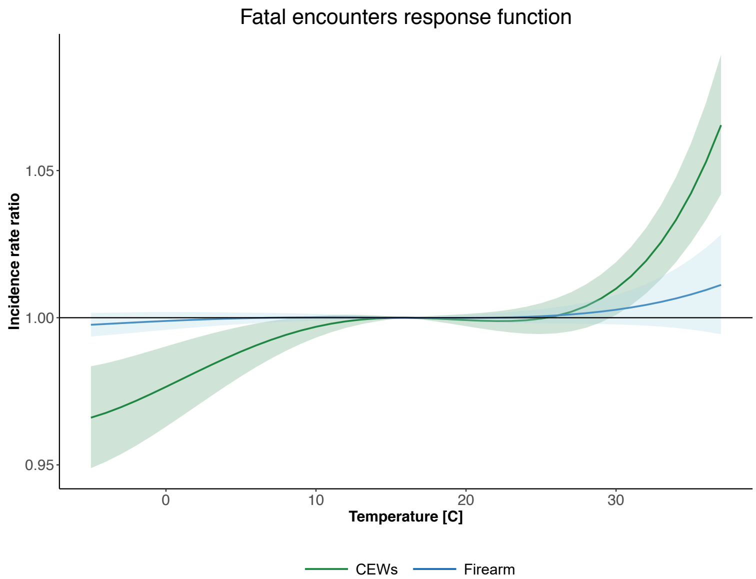
C Additional tables and figures

Figure A.4: Police Fatal Encounters vs. Murders in the U.S.



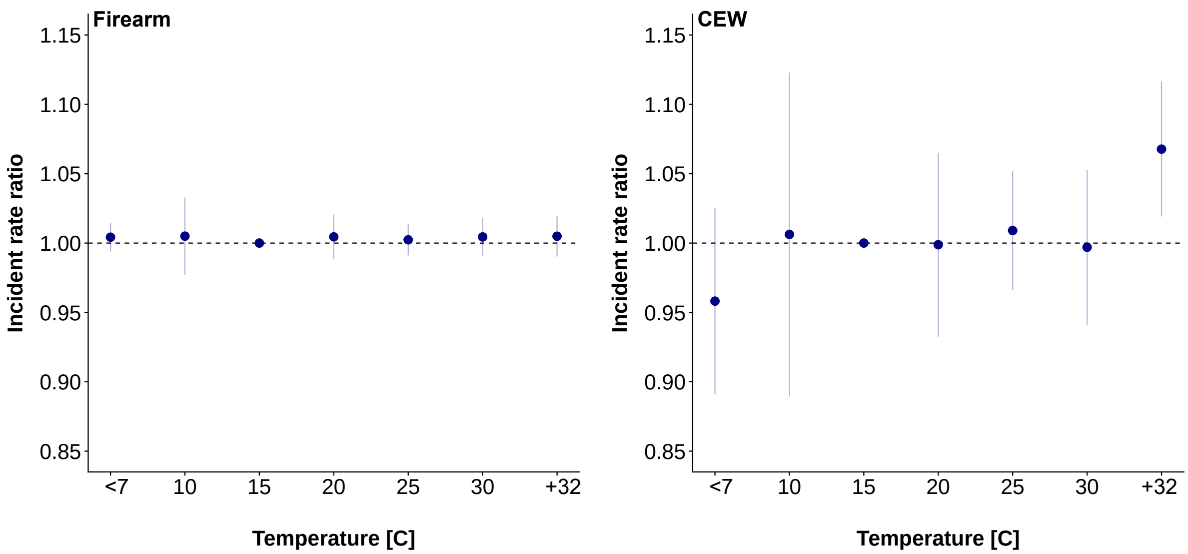
Notes: This figure presents the number of fatal encounters with the police and murders in the U.S. from 2000 to 2016. Sections 3 and A provide details about the sample selection.

Figure A.5: Effect of temperature on the number of civilian deaths by firearm and CEWs



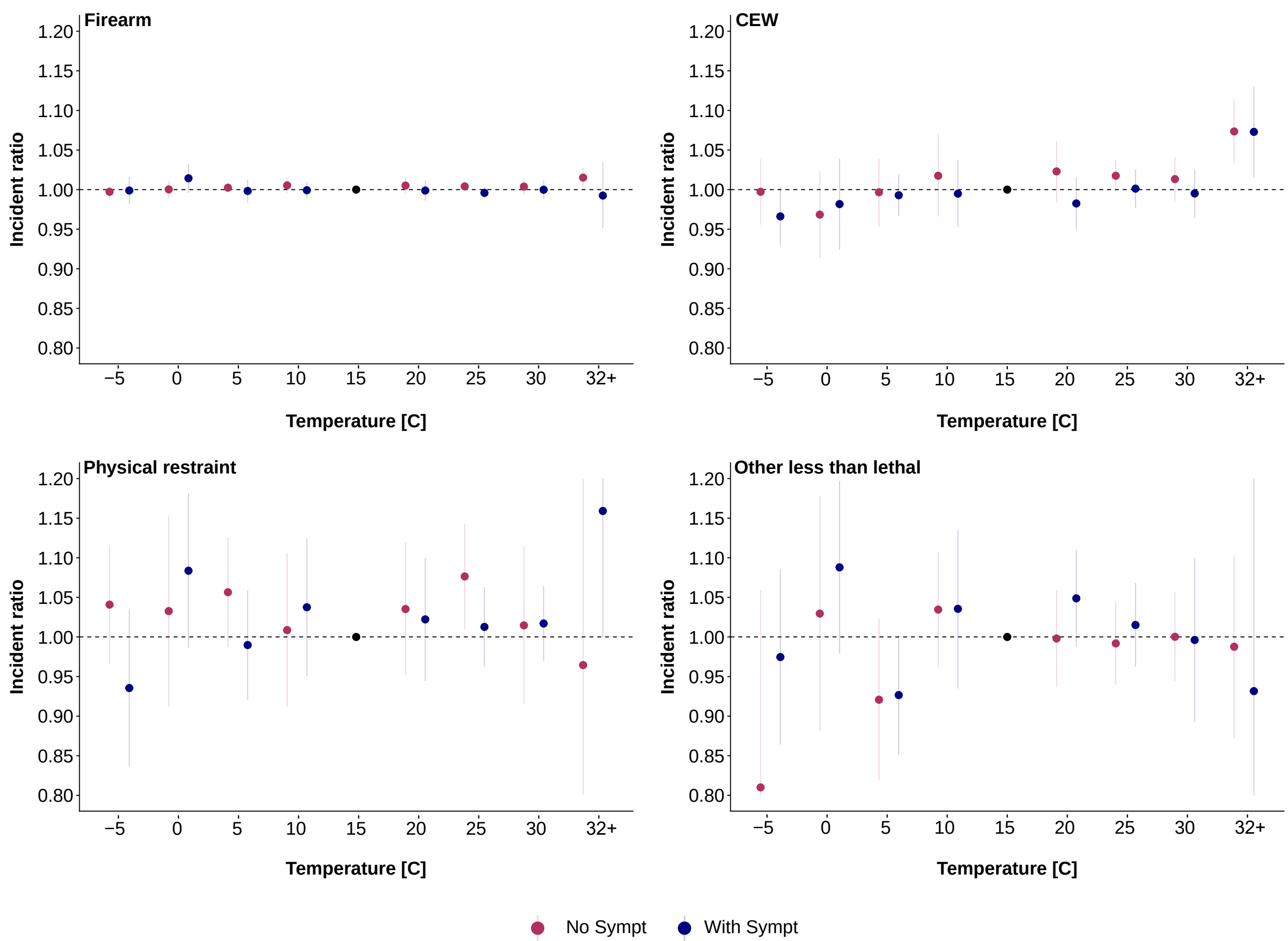
Notes: This figure presents the estimated effect of temperature on the number of civilian fatalities by CEWs (Taser) and firearm. The specification considers a 4th polynomial of temperature. The specification controls for precipitation, state-by-season fixed effect, and county-by-year fixed effect. For interpretation, we report the incident rate ratio on the y-axis. Standard errors are clustered at the year-by-type of death. We report the 95% CI. We report the midpoints for bins with temperature between -3 and 32^oC, with 5 degree increments. Bins -5 and $32+$ report temperatures lower and greater than the -3, and 32^oC range.

Figure A.6: Effect of temperature on CEW and firearm fatal encounters in warm regions



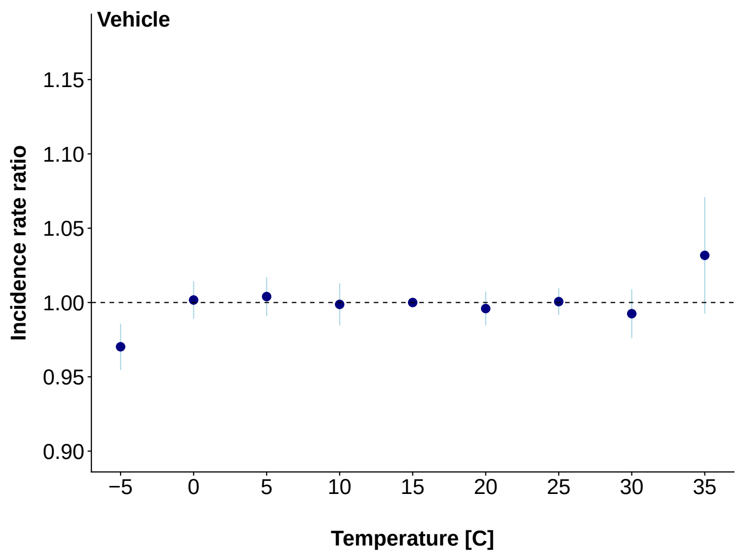
Notes: This figure presents the estimated effect of temperature on the number of civilian fatalities by firearm (fig. A) and CEWs (fig. B). for warm regions (average annual temperature of at least 19^oC). Section 2 provides details about the different causes of death. The specification controls for precipitation, state-by-season fixed effect, and county-by-year fixed effect. For interpretation, we report the incident rate ratio on the y-axis. Standard errors are clustered at the year-by-type of death. We report the 95% CI. We report the midpoints for bins with temperature between -3 and 32^oC, with 5 degree increments. Bins -5 and $32+$ report temperatures lower and greater than the -3, and 32^oC range.

Figure A.7: Effect of temperature on the number of civilian deaths by type of force and symptom status



Notes: These figures present the estimated effect of temperature on the number of civilian fatalities by type of deaths and symptom status. Section 2 provides details about the different causes of death. The specification controls for precipitation, state-by-season fixed effect, and county-by-year fixed effect. For interpretation, we report the incident rate ratio on the y-axis. Standard errors are clustered at the year-by-type of death. We report the 95% CI. We report the midpoints for bins with temperature between -3 and 32^oC, with 5 degree increments. Bins -5 and $32+$ report temperatures lower and greater than the -3, and 32^oC range.

Figure A.8: Effect of temperature on the number of civilian deaths by vehicle



Notes: These figures present the estimated effect of temperature on the number of civilian fatalities by vehicle. Section 2 provides details about the different causes of death. The specification controls for precipitation, state-by-season fixed effect, and county-by-year fixed effect. For interpretation, we report the incident rate ratio on the y-axis. Standard errors are clustered at the year-by-type of death. We report the 95% CI. We report the midpoints for bins with temperature between -3 and 32^oC, with 5 degree increments. Bins -5 and $32+$ report temperatures lower and greater than the -3, and 32^oC range.

Table A.2: Effect of temperature on the number of civilian deaths by physical restraints

	(1)	(2)	(3)	(4)	(5)	(6)
$< 3^o$	-0.00414	-0.00159	-0.00205	0.00569	0.0234	0.0233
	(0.0262)	(0.0281)	(0.0281)	(0.0286)	(0.0299)	(0.0299)
$[-3^o, 2^o)$	0.0186	0.0316	0.0320	0.0365	0.0407	0.0407
	(0.0310)	(0.0296)	(0.0296)	(0.0302)	(0.0290)	(0.0290)
$[2^o, 7^o)$	0.0282	0.0315	0.0308	0.0324	0.0327	0.0325
	(0.0164)	(0.0173)	(0.0173)	(0.0175)	(0.0198)	(0.0198)
$[7^o, 12^o)$	0.0223	0.0229	0.0228	0.0235	0.0278	0.0277
	(0.0176)	(0.0170)	(0.0170)	(0.0167)	(0.0158)	(0.0158)
$[17^o, 22^o)$	0.0289	0.0380	0.0379	0.0361	0.0371	0.0370
	(0.0231)	(0.0216)	(0.0216)	(0.0214)	(0.0213)	(0.0213)
$[22^o, 27^o)$	0.0268	0.0237	0.0226	0.0208	0.0230	0.0227
	(0.0154)	(0.0166)	(0.0165)	(0.0163)	(0.0161)	(0.0161)
$[27^o, 32^o)$	0.0340	0.0485	0.0474	0.0462	0.0472	0.0470
	(0.0220)	(0.0208)	(0.0208)	(0.0207)	(0.0210)	(0.0210)
$> 32^0$	0.156	0.154	0.152	0.153	0.141	0.141
	(0.0679)	(0.0724)	(0.0727)	(0.0734)	(0.0734)	(0.0735)
Precipitation	0.000286	0.000212	0.000223	0.000213	0.000297	0.000306
	(0.000332)	(0.000366)	(0.000363)	(0.000365)	(0.000364)	(0.000364)
Precipitation^2	-1.43e-05	-1.45e-05	-1.47e-05	-1.60e-05	-1.70e-05	-1.72e-05
	(8.91e-06)	(1.02e-05)	(1.02e-05)	(1.03e-05)	(1.00e-05)	(1.01e-05)
Violent Crime		-5.38e-05	-3.35e-05			
		(4.95e-05)	(5.19e-05)			
Property Crime		4.50e-05	-0.000166			
		(8.49e-05)	(7.94e-05)			
No. Officers assulted/killed			0.00537			0.00165
			(0.000613)			(0.00223)
Constant	-1.425	-1.371	-1.390	-8.475	-7.174	-7.205
	(0.0548)	(0.0651)	(0.0592)	(0.0610)	(0.0640)	(0.0679)
Exposure	-	-	-	total crime	total arrest	total arrest
Fixed-effects:						
Season-State	YES	YES	YES	YES	YES	YES
County-Year-Type of death	YES	YES	YES	YES	YES	YES
Observations	128,808	112,036	112,036	111,286	106,226	106,226

Notes: This Table presents the estimated effect of temperature on the number of civilian fatalities by physical restraints using equation 1. Section 2 provides details about the different causes of death. Standard errors are clustered at the year-by-type of death.

Table A.3: Effect of temperature on the number of civilian deaths by less-than-lethal force

	(1)	(2)	(3)	(4)	(5)	(6)
$< 3^o$	-0.0811	-0.0668	-0.0676	-0.0636	-0.0661	-0.0664
	(0.0589)	(0.0615)	(0.0617)	(0.0608)	(0.0670)	(0.0671)
$[-3^o, 2^o)$	0.0563	0.0671	0.0675	0.0711	0.0720	0.0720
	(0.0359)	(0.0397)	(0.0398)	(0.0399)	(0.0406)	(0.0406)
$[2^o, 7^o)$	-0.0338	-0.0316	-0.0324	-0.0357	-0.0303	-0.0305
	(0.0259)	(0.0311)	(0.0313)	(0.0317)	(0.0301)	(0.0301)
$[7^o, 12^o)$	0.0515	0.0634	0.0628	0.0610	0.0646	0.0644
	(0.0245)	(0.0251)	(0.0250)	(0.0241)	(0.0266)	(0.0265)
$[17^o, 22^o)$	0.0279	0.0453	0.0452	0.0414	0.0486	0.0485
	(0.0224)	(0.0214)	(0.0214)	(0.0210)	(0.0230)	(0.0229)
$[22^o, 27^o)$	0.0216	0.0249	0.0236	0.0207	0.0243	0.0239
	(0.0139)	(0.0149)	(0.0149)	(0.0145)	(0.0155)	(0.0155)
$[27^o, 32^o)$	0.00505	0.0184	0.0170	0.0156	0.0209	0.0206
	(0.0225)	(0.0219)	(0.0221)	(0.0221)	(0.0228)	(0.0229)
$> 32^0$	-0.00422	0.0145	0.0160	0.0103	0.00874	0.00910
	(0.0619)	(0.0575)	(0.0569)	(0.0542)	(0.0550)	(0.0548)
Precipitation	0.000286	0.000212	0.000223	0.000213	0.000297	0.000306
	(0.000332)	(0.000366)	(0.000363)	(0.000365)	(0.000364)	(0.000364)
Precipitation^2	-1.43e-05	-1.45e-05	-1.47e-05	-1.60e-05	-1.70e-05	-1.72e-05
	(8.91e-06)	(1.02e-05)	(1.02e-05)	(1.03e-05)	(1.00e-05)	(1.01e-05)
Violent Crime		-5.38e-05	-3.35e-05			
		(4.95e-05)	(5.19e-05)			
Property Crime		4.50e-05	-0.000166			
		(8.49e-05)	(7.94e-05)			
No. Officers assulted/killed			0.00537			0.00165
			(0.000613)			(0.00223)
Constant	-1.425	-1.371	-1.390	-8.475	-7.174	-7.205
	(0.0548)	(0.0651)	(0.0592)	(0.0610)	(0.0640)	(0.0679)
Exposure	-	-	-	total crime	total arrest	total arrest
Fixed-effects:						
Season-State	YES	YES	YES	YES	YES	YES
County-Year-Type of death	YES	YES	YES	YES	YES	YES
Observations	128,808	112,036	112,036	111,286	106,226	106,226

Notes: This Table presents the estimated effect of temperature on the number of civilian fatalities by less-than-lethal force using equation 1. Section 2 provides details about the different causes of death. Standard errors are clustered at the year-by-type of death.

Table A.4: Effect of temperature on the number of civilian deaths by firearm

	(1)	(2)	(3)	(4)	(5)	(6)
$< 3^o$	-0.00198	-0.00287	-0.00310	0.00419	0.00165	0.00157
	(0.00352)	(0.00359)	(0.00364)	(0.00353)	(0.00437)	(0.00440)
$[-3^o, 2^o)$	0.00145	0.00122	0.00115	0.00326	0.00312	0.00305
	(0.00434)	(0.00432)	(0.00430)	(0.00444)	(0.00444)	(0.00444)
$[2^o, 7^o)$	0.00204	0.00243	0.00204	0.00260	0.00315	0.00301
	(0.00266)	(0.00309)	(0.00309)	(0.00318)	(0.00324)	(0.00327)
$[7^o, 12^o)$	0.00139	0.000675	0.000576	-0.000175	-0.000488	-0.000598
	(0.00330)	(0.00345)	(0.00350)	(0.00353)	(0.00371)	(0.00375)
$[17^o, 22^o)$	0.00173	0.00149	0.00120	-0.00177	-0.000950	-0.00110
	(0.00332)	(0.00354)	(0.00347)	(0.00370)	(0.00396)	(0.00400)
$[22^o, 27^o)$	0.00167	0.00179	0.000985	-0.00216	-0.00193	-0.00216
	(0.00180)	(0.00198)	(0.00200)	(0.00194)	(0.00193)	(0.00190)
$[27^o, 32^o)$	0.00279	0.00339	0.00246	0.000513	0.000999	0.000761
	(0.00353)	(0.00427)	(0.00418)	(0.00475)	(0.00503)	(0.00506)
$> 32^0$	0.00711	0.00571	0.00451	0.00231	0.00182	0.00151
	(0.00713)	(0.00675)	(0.00666)	(0.00702)	(0.00656)	(0.00656)
Precipitation	0.000286	0.000212	0.000223	0.000213	0.000297	0.000306
	(0.000332)	(0.000366)	(0.000363)	(0.000365)	(0.000364)	(0.000364)
Precipitation^2	-1.43e-05	-1.45e-05	-1.47e-05	-1.60e-05	-1.70e-05	-1.72e-05
	(8.91e-06)	(1.02e-05)	(1.02e-05)	(1.03e-05)	(1.00e-05)	(1.01e-05)
Violent Crime		-5.38e-05	-3.35e-05			
		(4.95e-05)	(5.19e-05)			
Property Crime		4.50e-05	-0.000166			
		(8.49e-05)	(7.94e-05)			
No. Officers assulted/killed			0.00537			0.00165
			(0.000613)			(0.00223)
Constant	-1.425	-1.371	-1.390	-8.475	-7.174	-7.205
	(0.0548)	(0.0651)	(0.0592)	(0.0610)	(0.0640)	(0.0679)
Exposure	-	-	-	total crime	total arrest	total arrest
Fixed-effects:						
Season-State	YES	YES	YES	YES	YES	YES
County-Year-Type of death	YES	YES	YES	YES	YES	YES
Observations	128,808	112,036	112,036	111,286	106,226	106,226

Notes: This Table presents the estimated effect of temperature on the number of civilian fatalities by firearm using equation 1. Section 2 provides details about the different causes of death. Standard errors are clustered at the year-by-type of death.

Table A.5: Effect of temperature on the number of civilian deaths by CEW

	(1)	(2)	(3)	(4)	(5)	(6)
$< 3^o$	-0.0221	-0.0206	-0.0208	-0.0135	-0.00645	-0.00650
	(0.0173)	(0.0184)	(0.0184)	(0.0180)	(0.0189)	(0.0189)
$[-3^o, 2^o)$	-0.0254	-0.0382	-0.0383	-0.0347	-0.0555	-0.0556
	(0.0167)	(0.0194)	(0.0194)	(0.0200)	(0.0209)	(0.0209)
$[2^o, 7^o)$	-0.00925	-0.00713	-0.00737	-0.00822	-0.00167	-0.00181
	(0.0111)	(0.0126)	(0.0126)	(0.0133)	(0.0135)	(0.0135)
$[7^o, 12^o)$	0.00687	0.00462	0.00432	0.00581	0.00592	0.00575
	(0.0151)	(0.0153)	(0.0153)	(0.0151)	(0.0150)	(0.0150)
$[17^o, 22^o)$	0.00175	-0.000291	-0.000592	-0.00353	0.000170	-2.76e-05
	(0.0129)	(0.0139)	(0.0138)	(0.0142)	(0.0141)	(0.0141)
$[22^o, 27^o)$	0.00957	0.00832	0.00769	0.00547	0.00488	0.00470
	(0.00632)	(0.00770)	(0.00769)	(0.00775)	(0.00849)	(0.00847)
$[27^o, 32^o)$	0.00112	0.00586	0.00497	0.00427	0.00519	0.00492
	(0.0111)	(0.0118)	(0.0117)	(0.0120)	(0.0123)	(0.0122)
$> 32^0$	0.0563	0.0529	0.0512	0.0499	0.0517	0.0512
	(0.0105)	(0.0118)	(0.0117)	(0.0120)	(0.0124)	(0.0124)
Precipitation	0.000286	0.000212	0.000223	0.000213	0.000297	0.000306
	(0.000332)	(0.000366)	(0.000363)	(0.000365)	(0.000364)	(0.000364)
Precipitation^2	-1.43e-05	-1.45e-05	-1.47e-05	-1.60e-05	-1.70e-05	-1.72e-05
	(8.91e-06)	(1.02e-05)	(1.02e-05)	(1.03e-05)	(1.00e-05)	(1.01e-05)
Violent Crime		-5.38e-05	-3.35e-05			
		(4.95e-05)	(5.19e-05)			
Property Crime		4.50e-05	-0.000166			
		(8.49e-05)	(7.94e-05)			
No. Officers assulted/killed			0.00537			0.00165
			(0.000613)			(0.00223)
Constant	-1.425	-1.371	-1.390	-8.475	-7.174	-7.205
Exposure	-	-	-	total crime	total arrest	total arrest
Fixed-effects:						
Season-State	YES	YES	YES	YES	YES	YES
County-Year-Type of death	YES	YES	YES	YES	YES	YES
	(0.0548)	(0.0651)	(0.0592)	(0.0610)	(0.0640)	(0.0679)
Observations	128,808	112,036	112,036	111,286	106,226	106,226

Notes: This Table presents the estimated effect of temperature on the number of civilian fatalities by CEW using equation 1. Section 2 provides details about the different causes of death. Standard errors are clustered at the year-by-type of death.

Table A.6: Effect of temperature on the number of civilian deaths by vehicle

	(1)	(2)	(3)	(4)	(5)	(6)
$< 3^o$	-0.0302	-0.0313	-0.0315	-0.0258	-0.0323	-0.0324
	(0.00816)	(0.00858)	(0.00857)	(0.00900)	(0.00973)	(0.00974)
$[-3^o, 2^o)$	0.00168	-0.000190	-0.000222	0.00234	0.00375	0.00371
	(0.00645)	(0.00705)	(0.00707)	(0.00697)	(0.00750)	(0.00751)
$[2^o, 7^o)$	0.00399	0.00557	0.00538	0.00380	0.00499	0.00490
	(0.00666)	(0.00634)	(0.00632)	(0.00652)	(0.00632)	(0.00633)
$[7^o, 12^o)$	-0.00126	-0.00231	-0.00244	-0.00290	-0.00187	-0.00197
	(0.00728)	(0.00777)	(0.00778)	(0.00797)	(0.00764)	(0.00768)
$[17^o, 22^o)$	-0.00408	-0.00550	-0.00568	-0.0102	-0.00815	-0.00826
	(0.00588)	(0.00642)	(0.00648)	(0.00675)	(0.00681)	(0.00684)
$[22^o, 27^o)$	0.000605	0.00238	0.00171	-0.00116	-0.00102	-0.00121
	(0.00454)	(0.00446)	(0.00445)	(0.00430)	(0.00456)	(0.00456)
$[27^o, 32^o)$	-0.00755	-0.00824	-0.00901	-0.0123	-0.0103	-0.0105
	(0.00849)	(0.00910)	(0.00912)	(0.00965)	(0.00919)	(0.00920)
$> 32^0$	0.0312	0.0317	0.0311	0.0286	0.0169	0.0167
	(0.0194)	(0.0195)	(0.0194)	(0.0189)	(0.0169)	(0.0169)
Precipitation	0.000286	0.000212	0.000223	0.000213	0.000297	0.000306
	(0.000332)	(0.000366)	(0.000363)	(0.000365)	(0.000364)	(0.000364)
Precipitation^2	-1.43e-05	-1.45e-05	-1.47e-05	-1.60e-05	-1.70e-05	-1.72e-05
	(8.91e-06)	(1.02e-05)	(1.02e-05)	(1.03e-05)	(1.00e-05)	(1.01e-05)
Violent Crime		-5.38e-05	-3.35e-05			
		(4.95e-05)	(5.19e-05)			
Property Crime		4.50e-05	-0.000166			
		(8.49e-05)	(7.94e-05)			
No. Officers assulted/killed			0.00537			0.00165
			(0.000613)			(0.00223)
Constant	-1.425	-1.371	-1.390	-8.475	-7.174	-7.205
	(0.0548)	(0.0651)	(0.0592)	(0.0610)	(0.0640)	(0.0679)
Exposure	-	-	-	total crime	total arrest	total arrest
Fixed-effects:						
Season-State	YES	YES	YES	YES	YES	YES
County-Year-Type of death	YES	YES	YES	YES	YES	YES
Observations	128,808	112,036	112,036	111,286	106,226	106,226

Notes: This Table presents the estimated effect of temperature on the number of civilian fatalities by vehicle using equation 1. Section 2 provides details about the different causes of death. Standard errors are clustered at the year-by-type of death.