Investigating the relationship between weather and violence in Baltimore, Maryland, USA

Samuel J. Michel, Han Wang, Shalini Selvarajah, Joseph K. Canner, Matthew Murrill, Albert Chi, David T. Efron, Eric B. Schneider *

Department of Surgery, Johns Hopkins University School of Medicine, Baltimore, MD, USA

A B S T R A C T

Background: It is a common refrain at major urban trauma centers that caseloads increase in the heat of the summer. Several previous studies supported this assertion, finding trauma admissions and crime to correlate positively with temperature. We examined links between weather and violence in Baltimore, MD, through trauma presentation to Johns Hopkins Hospital and crime reports filed with the Baltimore Police Department.
Methods: Crime data were obtained from the Baltimore City Police Department from January 1, 2008 to March 31, 2013. Trauma data were obtained from a prospectively collected registry of all trauma patients presenting to Johns Hopkins Hospital from January 1, 2007 to March 31, 2013. Weather data were obtained from the National Climatic Data Center. Correlation coefficients were calculated and negative binomial regression was used to elucidate the independent associations of weather and temporal variables with the trauma and crime data.
Results: When adjusting for temporal and meteorological factors, maximum daily temperature was positively associated with total trauma, intentional injury, and gunshot wounds presenting to Johns Hopkins Hospital along with total crime, violent crime, and homicides in Baltimore City. Associations of average wind speed, daily precipitation, and daily snowfall with trauma and crime were far weaker and, when significant, nearly universally negative.
Conclusion: Maximum daily temperature is the most important weather factor associated with violence and trauma in our study period and location. Our findings suggest potential implications for hospital staffing to be explored in future studies.

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Introduction

It is a common refrain among medical professionals that trauma cases increase during the summer [1,2]. Higher temperatures lead to more activity, more accidents, more confrontations and thus, increased trauma, or so the thinking goes.

The effects of weather on trauma admission have been investigated in the United States at Level I trauma centers in Boston, MA, [1] Louisville, KY, [2] and Minneapolis-St. Paul, MN [3]. These studies each demonstrated a positive linear correlation between increasing daily temperatures and the frequency of trauma presentation. Two of the studies (MN, KY) reported a positive correlation between increasing precipitation and trauma presentation, while the third study (MA) reported a negative correlation between precipitation and trauma. There was also a study from New York City, NY, that found a positive correlation between baseball-bat related trauma and temperature, but did not look at other weather factors [4].

Internationally, reports have been similar. Researchers from the United Kingdom [5] and from Tokyo, Japan [6] reported positive correlations between both temperature and precipitation and trauma. A study from the Netherlands reported that trauma increased with "good" weather [7] Researchers in Seoul, Korea, reported a positive correlation between higher temperatures and all disease presentation, but did not establish linearity or investigate precipitation [8]. One study, however, from Leicester, UK, found no correlations between any meteorological variables and trauma admissions at their hospital [9].

While these studies have demonstrated correlations between temperature and trauma presentation, none specifically investigated trauma due to violence. Studies performed in the US cities of

* Corresponding author.
E-mail address: edu">eschnei1@jhmi.?edu (E.B. Schneider).

Dallas, TX [10] and Durham, NC [11], found strong associations between temperature and violent crime, but these studies were based on police department data and did not investigate trauma presentation.

We sought to elucidate how weather correlates with the occurrence of violent crimes and the utilisation of trauma care services in Baltimore, Maryland, USA, using crime data from the Baltimore City Police Department (BPD) and trauma data from Johns Hopkins Hospital (JHH). Combining these data with meteorological data from nearby Baltimore-Washington International Airport, we examined the hypothesis that an increasing daily temperature is positively correlated with an increase in both violent crime and trauma presentation, while precipitation and snow are negatively correlated with both violent crime and trauma presentation.

Methods

Baltimore crime data were extracted from the Victim Based Crime Data on the Baltimore Police Department Website (https://data.baltimorecity.gov/Public-Safety/BPD-Part-1-Victim-Based-Crime-Data/) for January 1, 2008, through March 31, 2013. Statistical analysis focused on date, type of crime, and weapon use.

After approval was obtained from the Johns Hopkins Medicine Institutional Review Board, patient data was obtained from a prospective trauma registry at Johns Hopkins Hospital for patients presenting from January 1, 2007, through March 31, 2013. The registry contains all cases of adult trauma (age 15 and older) presenting to the Emergency Department at JHH during the study period. The Johns Hopkins Hospital registry uses the Maryland Trauma Registry inclusion criteria [12]. Thus, these records include both admitted and non-admitted patients and include select patients who arrived via emergency medical services, inter-hospital transfer, and personal transportation. Statistical analysis focused on the time of presentation and mechanism of injury. Records that were incomplete for either of these data points were excluded.

Meteorological data pertaining to the Baltimore-Washington International Airport were extracted from the Global Historical Climate Network via the website of the National Climatic Data Center (http://www.ncdc.noaa.gov/cdo-web/datasets). This database contains daily maximum temperature ($^{\circ}$C), daily minimum temperature ($^{\circ}$C), total daily precipitation (mm), total daily snowfall (mm), and snow depth (mm). All but snow depth were included in the statistical analyses.

Data were compiled and analysed using STATA 12.1 (StataCorp, College Station, TX). Weather variables were linked with the trauma and crime databases based on the date that the injury or crime actually occurred. This was not necessarily the same day that the patient presented to JHH or the crime was reported to the BPD. Correlation coefficients were calculated to establish the relationship between the weather and the numbers and types of traumas or crimes occurring. Multivariable regression was used to elucidate the independent effects of the weather variables on amount and type of crime and trauma. Minimum daily temperature was not used for the regression analysis due to its strong correlation with maximum daily temperature. Temporal effects of month and weekends were also included in this regression analysis. Weekend was defined as 00:00 on Saturday through 23:59 on Sunday. Since the data were overdispersed, negative binomial regression was used for these analyses. These coefficients were then converted to display the incidence rate ratio (IRR) for a 1 unit change in the weather variables. Additionally, relationships between weather and the proportion of shootings among crimes involving a firearm were analysed using a generalised linear model (GLM) with a log-link function; the resulting coefficients were exponentiated and reported as risk ratios (RR).

Results

Baltimore Police Department crime data

A total of 259,095 crimes were reported to the BPD between January 1, 2008 and March 31, 2013, an average of 135 per day. All had complete records for date and type of crime and were included in our study. There were 32,654 violent crimes (12.6% of total crime, 17 per day) and 1159 homicides (0.5% of total crime, 0.6 per day). Violent crime was defined as aggravated assault, rape, shooting, and homicide. There were 929 homicides committed with a firearm. Of the 17,860 crimes where a firearm was involved, 3197 (17.9%) resulted in a shooting or homicide. Daily total crime peaked in July, while daily violent crime peaked in June (Fig. 1A). Daily total crime and daily violent crime both increased with temperature (Fig. 2A).

The daily number of total crimes, violent crimes, and homicides, along with the proportion of gun crimes resulting in a shooting or homicide were all positively correlated with maximum and minimum daily temperatures. Each crime-type except homicide was negatively correlated with average daily wind speed and precipitation. Snowfall was not correlated with crime (Table 1).

In negative binomial regression models controlling for maximum daily temperature, average wind speed, precipitation, snow, month of the year, and day of the week, increased maximum daily temperature was associated with an increase in total crime (IRR = 1.0067, $p < 0.001$) and violent crime (IRR = 1.0128, $p < 0.001$). Precipitation was associated with a decrease in total crime (IRR = 0.9884, $p = 0.001$) and violent crime (IRR = 0.9804, $p = 0.013$). Snow was associated only with a decrease in total crime (IRR = 0.9827, $p < 0.001$). Wind speed was not significantly
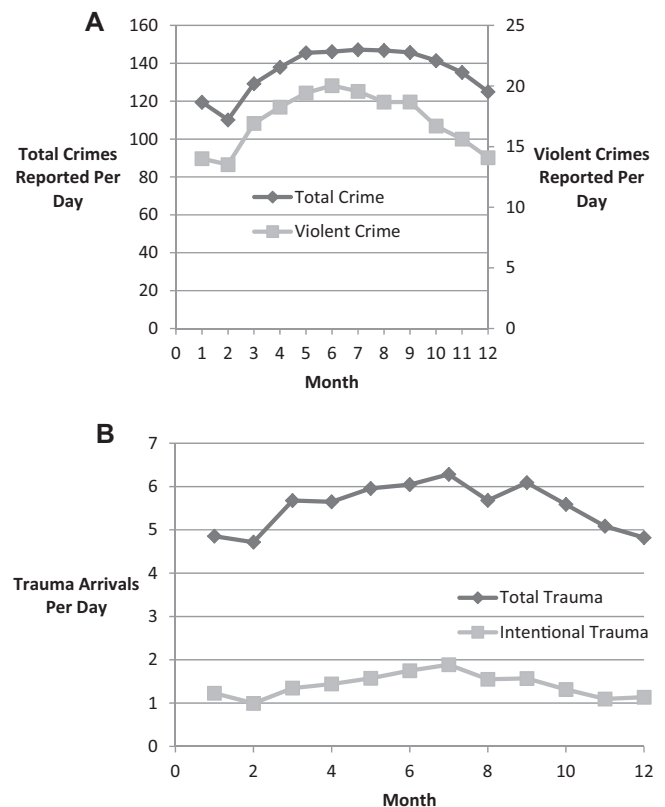

Fig. 1. (A) Average number of daily crimes and violent crimes committed in Baltimore, MD, for each month of the year over a 75 month period. (B) Average number of daily traumas and intentional traumas presenting to Johns Hopkins Hospital for each month of the year over an 87 month period.