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Weather and Crime: New York State

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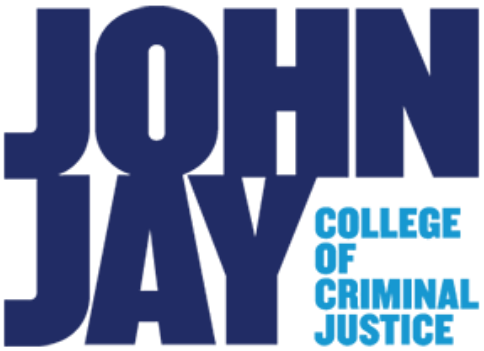

Weather and Crime: New York State

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Abstract

The present study assesses the degree to which temperature affects the crime rates in all 62 counties in the State of New York. Five different crimes (i.e., robbery, aggravated assault, burglary; larceny, and motor vehicle theft) for the year 2019 were selected from the Division of Criminal Justice Services of New York to be examined. The current study examined whether the rate of these crimes was associated with the changes in weather, with the assumption that higher weathers would lead to higher property and violent crimes, when controlling for the effect of various control variables. The findings suggest that the likelihood of all five crimes to happen was, indeed, affected by weather when controlling for the population, age, gender, race, and immigration trends of the counties. Relevant policy recommendations are suggested in light of these findings.

Key words: weather and crime, environmental criminology, temperature, New York State

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INTRODUCTION

The climate is changing rapidly due to ongoing global warming (Meehl, et al., 2000). Over the last years, noticeable changes in annual temperate and weather patterns have occurred, such as more frequent and severe floods, hurricanes/typhoons, tsunamis, droughts, and forest fires. Researchers note that climate change has impacted populations in many ways from increased displacement and extreme weather to the potential population decline in countries most affected by climate change (Mclaughlin, 2002; von Möllendorff, C., & Hirschfeld, J., 2016).

Weather also impacts one's level of life satisfaction and other issues, including crime. For example, researchers that study the environmental factors and how these affect crime rates are usually focused on social causes. If extreme weather affects life satisfaction, it is hypothesized that it may also lead to changes in crime patterns. If there is a relationship between climate change and crime rates, this understanding would benefit police departments to use their available manpower and other resources more efficiently and effectively depending on the weather forecast (Cohn, E., 1990).

Climate Impact on Human

Research on the relationship between climate variables and crime rates did not draw attention until the 1960s. However, climate change has been a subject of discussion since the 1800s with studies focusing on the relationship between weather and crime (Morrison, 1891). In Mapou's research (2017), the first experiment suggesting that human-produced carbon dioxide (CO_2) and other gases could collect in the atmosphere and insulate the Earth were initially met

more with curiosity than concern. By the late 1950s, CO_2 readings would offer some of the first data to corroborate the global warming theory (Onion, et al., 2020).

Curry (1948) studied two types of climates and the residents living in certain climate zones and the causes of death (suicide/homicide). He designated the persons sensitive to warm air (the south wind) as the "W" type, and those sensitive to cold air (the north wind), as the "C" type. Curry indicated the biological change due to the weather and analyzed that the "W" type people had a higher probability of dying due to suicide, while the "C" type people had a higher chance of being murdered. The climate conditions affected people's emotion due to the loss of willpower combined with a negative attitude toward life, leading to suicide, whereas murder is the result of an exaggerated expression of the will (Curry, 1948).

Temperature and its effect on health is extensive, encompassing several decades, and heat waves are well known for accelerating mortality. Immoderate rainfalls facilitate the entry of human sewage and animal waste into waterways and drinking water supplies, potentially leading to the increase of water-borne diseases. Besides infectious diseases, weather changes affect regional food yields, and disrupt fisheries, as well as lead to the loss of livelihoods and population displacement (McMichael, et al., 2006). McLaughlin et al. (2002) used precipitation data to show that the extinctions of plants in Jasper Ridge Preserve in California were caused by climate change. Climate change forecasts also warn of growing extinction risks caused by shifts in the abiotic environment (e.g., water, air, soil, gases) (McLaughlin, et al., 2002). The conflicts and the migrant and refugee flow likely to result from these wide-ranging effects – sea-level rise, infectious disease, drought, flood, etc. – would, typically, increase infectious diseases, malnutrition, mental health problems, and injury and violent death (McMichael, et al., 2006). McMichael, et al. say that if the climate is predictable, then human health could get a better

future plan. Even though there should be further examinations on the long-term effects of climate on human health, knowing the impact would make it possible to enhance our understanding about the relationship between human health and the behavior. Thus, this proposal study aims to examine the effect of weather on crime rates in New York State.

LITERATURE REVIEW

Current trend of environmental criminology

It has been only since the early 1990s that climate models have started to be analyzed to study possible changes in future weather and climate extremes (Houghton et al., 1996). More than 2000s works of research state that crime rates in North America are affected by increased precipitation (resulting in moister soil) and extreme temperature (Meehl A. et al., 2000). They also note that in the second half of the 20th century, increased El Niño[1] was an important issue. El Niño more frequently occurs when surface water in the equatorial Pacific becomes warmer than average, and east winds blow weaker than normal (National Oceanic and Atmospheric Administration, 2015). This affects the areas in the tropical Pacific, and Indian Ocean regions that are anomalously wet during El Niño could become wetter, and anomalously dry areas would become drier during future El Niño events (Meehl A. et al., 2000).

In the 21st century, the rise in average temperature, changing patterns of precipitation, the rise in sea levels, and increases in extreme weather events (including heat waves, droughts, cyclones/hurricanes/floods, and wildfires) are emerging issues particularly because they have various effects in many directions: habitat change, flooding of coastal areas/deltas/low-lying

[1] An irregularly occurring and complex series of climatic changes affecting the equatorial Pacific region and beyond every few years, characterized by the appearance of unusually warm, nutrient-poor water off northern Peru and Ecuador, typically in late December. It is Spanish, literally 'the (Christ) child' because of the occurrence near Christmas.

islands and river basins, negative health effects, food and fresh water shortages, the loss of and threats to livelihood, increased migration with the growth of megacities in developing nations, and increased social conflict (Agnew, 2017).

Contrary to green criminologists[2], who focused on the social, economic, and political conditions, Agnew focused on the possible impact of climate change on individuals' behaviors and actions related to crime (Agnew, 2017). Social conflict, specifically crime and how it is influenced by these environmental and weather condition changes is the focus of the current inquiry that will help expand on Agnew's ideas.

The table below is the literature of this study proposal that recorded the prior climate variables and the types of crime types researched by the scholars. Also, it shows the trend of climate-related criminological studies. While this type of research inquiry started from the 1990s, more attention has been drawn to the issue from 2010 onward, with the number of studies related to this issue peaking post 2010. The studies mainly focused on high temperature and precipitation and the effect of these weather conditions on various forms of crime (see Table 1).

Table 1. List of the Articles Published Since 1948 Examining Weather and Crime

Title	Year of Publication	Climate variable	Crime type
The relationship of weather conditions, facial characteristics, and crime	1948	Warm & Cold type area – Facial expression	Murder
In defense of the negative affect escape model of heat and aggression	1992	Temperature (high)	Aggression

[2] Green criminology is the analysis of environmental harms from a criminological perspective or the application of criminological thought to environmental issues. This means thinking about offenses, offenders, and victims and also about responses to environmental crimes: policing, punishment, and crime prevention. On a more theoretical level, green criminology is interested in the social, economic, and political conditions that lead to environmental crimes; on a philosophical level, it is concerned with which types of harms should be considered as 'crimes' and therefore within the remit of green criminology.

The effect of temperature on crime	1992	Temperature	Violent and Property crime
The effects of weather on homicide	1995	Temperature	Homicide
Climate change hastens population extinctions	2002	Greenhouse gas emission	
Is there more violence in very hot weather? Test over time in Pakistan, and across countries worldwide	2005	Temperature (high)	Violent crime
Climate change and human health: Present and future risks	2006	Temperature	
The effects of weather on crime	2011	Temperature, Precipitation	Violent and Property crime
Climate change and crime: Monthly temperature and precipitation anomalies and crime rates in St. Louis, MO 1990-2009	2013	Temperature, Precipitation	Homicide, Rape, Robbery, Aggravated Assault, Burglary, Larceny, Motor Vehicle Theft
Weather shocks, crime and agriculture: Evidence from India	2014	Temperature (high)	Burglary, Robbery, Riots, Kidnapping, Banditry, Rape, Theft
The relationship between temperature and assault in New Zealand	2015	Temperature (high)	Assaults
Investigating the relationship between weather and violence in Baltimore, Maryland, USA	2016	Temperature (high), Precipitation	Violent crime
Measuring impacts of extreme weather events using the life satisfaction approach	2016	Storm, hail, flood	
Dire forecast: A theoretical model of climate change on crime	2017	Temperature (high), Precipitation, Sea level	Violent and Property crime
Bad Weather, safe Day? The effect of weather and pollution on crime	2017	Temperature (high), Pollution	Violent and Property crime
Relationships between typhoons, climate and crime rates in Taiwan	2017	Temperature (high), Precipitation <Typhoon>	Violent crime and Automobile theft
The effects of weather on crime rates in Malaysia	2017	Temperature, Rainfall	Violent and property crime

Impact of climate variability and change on crime rates in Tangshan, China	2017	Temperature (high), Humidity	Rape, Violent and Property crime
Climate, crime, and suicide: empirical evidence from Japan	2017	Temperature (high)	Murder, Assault, Sexual assault, Robbery, Burglary, Vehicle theft, Suicide
Weather and crime in South Africa	2017	Temperature (high)	Violent crime
The influence of interannual climate variability on regional violent crime rates in the United States	2018	Seasonality region	Violent and Property crime
Comparing apples to apples: An environmental criminology analysis of the effects of heat and rain on violent crimes in Boston	2018	Temperature, Precipitation	Violent crime
The effect of weather on crime in a Torrid Urban Zone	2019	Temperature (high), Humidity, Precipitation, Wind Speed	Homicide and Interpersonal violence
Violence in hot weather: Will climate change exacerbate rates of violence in South Africa?	2019	Temperature (high)	Interpersonal violence

The Impact of the Weather on Overall Crime Rates

Climate change has various impacts on human health, lifestyle and crime. It is widely believed that "bad weather can precipitate negative emotional responses" (Garzino, 1982). Thus, it can be assumed that an increase in contaminated air/water/soil leads to the increases in aggressive behavior among and subsequent increase in the likelihood of crime occurrence. Temperature plays a significant role on violent crime but not property crime (Garzino, 1982). Also, in regard to the level of temperature change, the crime rate draws a U-shape: that is if the weather is too extreme, criminals do not tend to come out into the street.

There are various options regarding the effect of the temperature/precipitation on crime rates (violent crime and property crime). Field (1992) found that temperature influences the

chance that people would leave their homes, and subsequently, this will have an impact on crime rates (Field, 1992). He indicated that the hottest months see peaks and the coldest months see lower than expected in violence, burglary, and robbery rates. However, some other crimes, including theft, showed a weaker pattern. Then, would 'heat stress' always play a positive role on crime? Field (1992) also suggests that there is a level of temperature that does not necessarily cause aggression and have an effect on property crime to the same degree (Field, 1992). Much research aims at examining the relationship between violent and property crime, and temperature precipitation.

Literature suggests that the rate of murder/attempted murder tends to be higher in hot months (Simister and Van de Vliert, 2005). The influence of rainfall differs from temperature. Simister & Van de Vliert (2005) suggested that the drizzle level of rainfall would cool the body in hot weather but increase thermal stress in the cold weather. However, when the wet summer comes, the violence level graph forms approximately a vertical or slightly steep line due to the intervening humidity variable. This shows that combining the variables and examining their interactions is important to predict the pattern. Now we think rainfall tends to reduce violence, whereas humidity tends to increase it, but temperature plays a significant role in interpreting the correlations (Simister and Van de Vliert, 2005).

The weather could act as a direct predictor of criminal activity (Horrocks and Menclova, 2011). Police need to observe closely when the temperature or humidity rises. However, that is only up to a certain point. The relationship changes to being negative as the discomfort increases to a level where the motivation to escape uncomfortable situations outweighs the motivation to be aggressive (Bell, 1992). The 'inverse-U shaped' relationship between the temperature and aggression appears here. Horrocks and Menclova (2011) assert that the absence of a capable

guardian, in essence the Routine Activity theory elements, is the most important point of crime occurrence. Better weather will increase mobility and social interaction as more people leave their homes thereby presenting more opportunities for violent crime to occur, but it also increases the people's interaction that there should be more capable guardians (Horrocks and Menclova, 2011).

Inverse U-shaped or U-shaped relationship pattern shows that different variables impact different kinds of crime; high temperature and humidity rises violence, whereas heavy rainfall decreases overall crime. However, police cannot only follow the weather change to strengthen public security. Cheatwood (1995) said the role or impact of weather on homicide is far less significant than common myth would lead us to believe (Cheatwood, 1995). Also, Cheatwood stated that the study regarding overall crime is ambiguous about the effects of temperature and precipitation on property crime.

International Affect

Some tropical countries have rapid annual changes in the environment, for example, with typhoons, the wet/dry season, and humidity levels. In Taiwan, the country has regular typhoons in the summer months, and these serious climate conditions have affected the crime rates in the country. Yu and colleagues (2017) measured both the immediate and the long-run effects of these changes on crime. The type of disaster and also the intensity of the condition immediately affects all violent crimes and automobile theft, but longer duration significantly reduced burglaries (Yu, et al., 2017). Another tropical country, Malaysia also had a similar condition whereas precipitation seemed to have been associated with the increases in violent crimes. When

the temperature goes up, the physiological change[3] occurs but when it comes to maximum temperatures and the duration of sunshine becomes longer, the sexual assaults, on the contrary, decrease (Habibullah, 2017). Habibullah (2017) also used the short-run/long-run effect method and found that, in the long run, the climate has a positive effect on crime. In Tangshan, China, the city was challenged with a rising number of crimes and Hu and colleagues (2017) found it was due to the deliberate affect by a humid climate with cold, dry winter and hot, and rainy summer (Hu, et al., 2017).

New Zealand has recently experienced irregular warm summers and cold winters. However, it showed that there should be necessarily negative effects on crime rates. Investigating the relationship between temperature and assault incidence in New Zealand, researchers found a small positive relationship regardless of the temperature (Williams, et al., 2015). Williams, et al. clarified that anthropogenic climate change is likely to comprise not just temperature increases but changes to other meteorological variables, such as precipitation, wind, and tropical storm intensity – hard to study due to uncertainty and difference widely across geographical regions.

Colombia, one of the countries located near the equator, has high humidity and precipitation. Trujillo and Howley studied Barranquilla (a port town) with four weather variables (temperature, relative humidity, precipitation, and wind speed), and two indicators of criminal activity (homicides and interpersonal violence). They found a significant and positive correlation between temperature and interpersonal violence, but humidity and precipitation were both

[3] In hot temperature, sweating occurs when the ambient air temperature is above 95°F (35°C) and the body fails to return to the normal internal temperature. The evaporation of the sweat helps cooling the blood beneath the skin. In cold temperature, shivering occurs in an unclothed person when the ambient air temperature is under 77°F (25°C). it is limited by the amount of glycogen available in the body.

negatively related to it. Regarding homicide, they could not observe any significant correlation except windspeed, which was positively correlated with both homicides and interpersonal violence (Trujillo and Howley, 2019). This research also indicates the other variable, such as weekend/weekday or another climate variable must have been compounding the outcome.

In relation to how temperature affects climate rate and human health, Takahashi researched the average temperature, finding that crime and suicide occur the most. As his research aim was to ascertain how crime and suicide cases per 100,000 persons in Japan will be affected under different climate change scenarios, he focused on the average temperature predictions in Japan the year in 2100. Due to the average temperature's significantly positive effect on many types of crime, such as murder, assault, sexual assault, robbery, burglary, and vehicle theft, Takahashi (2017) predicted there will be an additional 67 murder cases in 2100 based on 2009-2014 temperature average (Takahashi, 2017).

The agriculture sector is the main source of income in many developing countries and therefore climate change is highly correlated to income fluctuation for people living in the developed world. In India, Blakeslee and Fishman (2014) observed that the temperature shock doesn't really indicate additional, non-economic mechanisms at work that when the temperature goes too high, then the crime rate falls to zero. However, during the monsoon, rainfall affects agriculture directly. Negative annual rainfall shocks yield crime increases of 2.8%, especially property crimes (Blakeslee and Fishman, 2014). South Africa already has high levels of violence and a rapidly warming climate and that violence should increase with hotter weather (Chersich, et al., 2019). Similar to India, the weather in South Africa had a short-term effect on crime, with the strongest effect found for increasing temperatures on violent crime, however, property crime did not respond to temperature fluctuations. Rainfall, which is linked to agriculture, affects both

violent and property crime, however this is less pronounced than the effect of warm temperatures (Bruederle, et al., 2017).

The impact of weather/climate studied in United States

Mares (2013) studied the relationship between climate change and crime in St. Louis, MO, focusing on temperature and precipitation anomalies since the data would help estimate the U.S. crime changes in the future. As many other researchers did, Mares (2013) collected 10 years of data for short-period research. Anomalous monthly climatic conditions remain correlated to most crime types except rape. However, it does not appear in precipitation correlation. In Boston, rainy days have fewer reported crimes than dry days on average, and more aggravated assaults occur on very cold vs. extremely cold days, on temperate vs. cold days, and extremely hot vs. very hot days (Sommer, et al., 2018). Although Sommer, et al. (2018) proved the correlation between temperature variables and certain crimes, they warned that generalizing these effects might be complicated. When applying the same analysis strategy to Los Angeles, it exhibited to have a stronger heat-crime relationship.

The weather also stimulates the trauma, such as post-traumatic stress disorder (PTSD) of victims. Based on the study of Johns Hopkins University, Michel, et al. (2016) found that maximum daily temperature was positively associated with total trauma, intentional injury, and gunshot wounds along with total crime, violent crime, and homicides in Baltimore City, MD. The trauma peaked in July, often recording the warmest days in the calendar year, and increased with temperature (Michel, et al., 2016).

Harp and Karnauskas (2018) mentioned the future work of climate and crime relationship while highlighting the importance of the cold weather on crime. Similarly, other studies aimed at

the similar goal that the data analysis of this kind of study would be used as an effective policing and future prediction of climate-crime relationship change. When certain weather conditions can be predicted (Sommer, et al., 2018), reducing greenhouse gas emissions may benefit crime levels (Mares, 2009) to the idea of the right deployment of police in the right locations. These researchers all point the prediction and prevention of crime.

Extreme climate change does not necessarily increase or decrease crime rates. It might cause more indoor retention time which does not give enough motivation for the offenders. Also, typhoons, extraordinarily high or low temperatures, humidity, and hurricane are all due to extreme climate change, but each region has experienced different fluctuations in crime rates. The climate in the world is slowly changing in different aspects. Therefore, crime types that are affected by environmental factors vary based on the regional and social environments.

From previous studies cited above, it is hypothesized that the weather in the state of New York has an effect on crime rates. Such an effect may vary by counties. New York State has a wide range of latitude and longitude (43.2994° N, 74.2179° W). This means the state has various climate patterns and the impact on crime rates would be different. As the literature mentioned above, the cold weather lessens outdoor activity which might decrease the chance for crimes to happen. The research question explored in this study, therefore is ‘How does the cold weather affect the Index crime rates (Robbery, Aggravated Assault, Burglary, Larceny, Motor Vehicle Theft) in the State of New York when controlling for other social factors?’

THEORETICAL FRAMEWORK

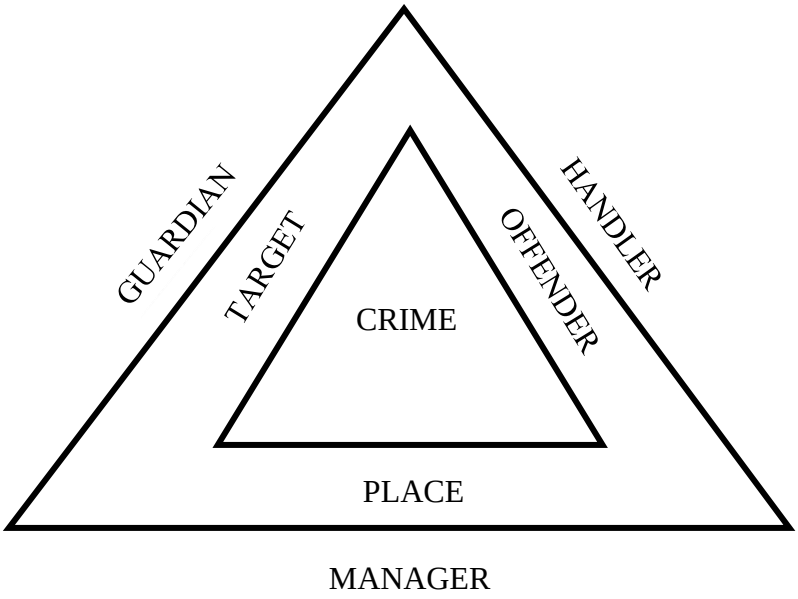
Environmental criminology is a family of theories that studies the crime events and the circumstances in which they occur. This study uses two of the environmental criminological

theories, namely the Rational Choice Theory and Routine Activity Theory (RAT). The Rational Choice Theory argues that a crime will be committed if the calculated benefits of committing a crime exceed the expected costs. For example, if the probability of being arrested or captured by CCTVs increases, motivated offenders will not likely engage in crime . The Routine Activity Theory follows the basic notions of this rationality in crime. Cohen and Felson (1979) created a 'crime triangle' that shows that for a crime to occur, there needs to be an interaction between three basic terms– the presence of a motivated offender, a suitable area, time, targets, and fewer risks as attractive conditions to commit a crime.

Figure 1. Crime Triangle

Eck (2015) expanded the 'crime triangle' by Cohen and Felson to the one that has internal factors and external factors. The inside triangle has three elements that must converge for a crime to occur: the potential offender, the crime target, and the place or setting for the crime. The outside triangle depicts three types of supervisors: the handler, the guardian, and the place manager. The handler supervises the offender, the guardian supervises the target, and the manager supervises the crime setting.

Figure 2. Crime Triangle Expanded to Include External Factors



Both Cohen and Felson and Eck's crime triangles show the process of choosing the right target, place, and time that this approach assumes that the offender has already been motivated (Cullen, et al., 2008). RAT suggests that an interaction between victim and offender in time and place is a necessary prerequisite for a crime to occur (Cohen and Felson, 1979). The environment of crime sites tells us something about the offender, the target, and the factors necessary for committing crimes (fewer guardians or fewer risks). The cold weather discourages people to engage in outdoor activities. It can be assumed that the environmental condition decreases the opportunities for the crime to occur or may have an effect on the probability of not being caught.

MATERIALS AND METHODS

Variable Descriptions

This study uses the 2019 weather history data from www.weatherunderground.com as the predictor variable. To observe the difference in 2019 crime rates among the 62 New York counties, crime data is collected from the Division of Criminal Justice Services (DCJS) of New York State. The Division uses the definitions of crime provided by the Uniform Crime Reporting (UCR) program of the Federal Bureau of Investigation (FBI). Crime data from this source will be used as dependent variables. During the analysis of this study, the overall population, risky youth population, male population, heterogeneity, and immigration flow variables will be used as controls. Lastly, the data collected by the U.S. Census Bureau, namely those related to population, risky youth population (percent of population ages between 18 and 21), male population, heterogeneity (percent minority population), and immigration variables, have been collected to be used as control variables.

- *Outcome Variables*

Division of Criminal Justice Services (DCJS) of New York State Data

This study will investigate robbery, aggravated assault, burglary, larceny, and motor vehicle theft crimes that fall within two broad categories of violent and property crime. Violent crime is defined as an incident where a victim is harmed by or threatened with violence, and includes murder, robbery, rape, sexual assault, and aggravated assault. In property crime, a victim's property is stolen or destroyed, without the use or threat of force against the victim. It includes burglary and theft, as well as vandalism and arson (insert citation). The New York State and the Federal Bureau of Investigation (FBI) use seven Index crimes that fall into four broad

categories: murder, rape, robbery and aggravated assault. The FBI created these categories to allow for uniform crime reporting (UCR) across all 50 states. This report details 2019 Index crimes in the New York State, its 62 counties and two regions: New York City, and the 57 counties outside of the five boroughs (Rest of the State).

Police departments and sheriffs' offices report Index crimes to the Division of Criminal Justice Services (DCJS) through the UCR and Incident-Based Reporting programs. This report also details Index crime rates per 100,000 population statewide and by county and region. DCJS uses county population data from the FBI, which is based on U.S. Census estimates, to calculate those crime rates.

The New York State implemented the FBI's expanded definition of rape in 2015; this resulted in an uptick in violent crime and reported rapes in that year when compared to prior years. As a result, caution should be used when citing or interpreting any percentage changes between rapes reported in 2015 and any subsequent year, to those reported in 2014 and earlier. The FBI made the change to more accurately reflect the scope and volume of sexual assaults nationwide[4]. Before the implementation, those offenses would have been classified by the FBI and state as Part 2 sex offenses.

Robbery: The taking or attempting to take anything of value from the care, custody, or control of a person or persons by force or threat of force or violence and/or by putting the victim in fear. Robbery is a type of theft committed in the presence of the victim.

[4] The historical UCR definition of rape only included female victims penetrated vaginally by a male. This definition has been in place since 1929 and includes only a limited number of New York's Penal Law crimes. The expanded UCR definition of rape encompasses additional offenses and is defined as follows: "Penetration, no matter how slight, of the vagina or anus with any body part or object, or oral penetration by a sex organ of another person, without the consent of the victim."

Aggravated Assault: Assault is an unlawful attack by one person upon another. Agencies participating in the UCR Program collect assault information on the offenses that are aggravated in nature, as well as on those that are not. Assaults that are not aggravated are classified by the FBI UCR Program as Other Assaults – Simple, Not Aggravated. Aggravated Assault is an unlawful attack by one person upon another for the purpose of inflicting severe or aggravated bodily injury.

Burglary: The unlawful entry of a structure to commit a felony or a theft. The UCR Program classifies offenses locally known as burglary (any degree), unlawful entry with intent to commit a larceny or felony, breaking and entering with intent to commit a larceny, housebreaking, safe-cracking, and all attempts at these offenses as burglary.

Larceny: The unlawful taking, carrying, leading, or riding away of property from the possession or constructive possession of another. Constructive possession is "control or dominion over a property without actual possession or custody of it." Larceny and theft are synonymous in the UCR Program.

Motor vehicle theft: The theft or attempted theft of a motor vehicle. Motor Vehicle Theft includes the theft or attempted theft of a motor vehicle, which the UCR Program defines as a self-propelled vehicle that runs on land surface and not on rails, for example, sport utility vehicles, automobiles, trucks, buses, motorcycles, motor scooters, all-terrain vehicles, and snowmobiles are classified as motor vehicles.

- *Predictor Variables*

Weather Underground Data

This research will use the yearly weather data as a predictor variable. The average temperature of each month will be collected and converted into yearly averages. The temperature is measured in Fahrenheit, which is a scale for measuring temperature in which water freezes at 32 degrees and boils at 212 degrees. It is represented by the symbol F. The weather forecast and historical data collecting website, Weather Underground, has shared its weather information since 1993. It gets the neighborhood weather data from the system 'BestForecast^{TM}'. It has an expanded network of 250,000+ personal weather stations which provide the most local forecasts based on actual weather data points. It also gives users the option to switch to view the forecasts generated from the National Weather Service's National Digital Forecast Database (NDFD). The BestForecast^{TM} uses 4km grid of spatial resolution from Personal Weather Station (PWS) – quality-controlled to only include stations with accurate observations) – Cooperative Observer Program [5](COOPs), airport data, and weather balloon data. It measures temperature, cloud cover, humidity, chance of precipitation, dew point, pressure, and "Feels Like". The snow depth information listed by state is taken by volunteers in the National Weather Service (NWS) COOP. More than 11,000 NWS-trained volunteers take observations on farms, in urban and suburban areas, National Parks, seashores, and mountaintops.

[5] The COOP was formally created in 1890 under the Original Act with two missions. 1) To provide ovservational meteorological data, usually consisting of daily maximum and minimum temperatures, snowfall, and 24-hour precipitation totals, required to define the climate of the United States and to help measure long-term climate changes. 2) To provide observational meteorological data in near real-time to support forecast, warning and other public service programs of the NWS.

- *Control Variables*

U.S. Census data

This study will use population, risky youth population (percent of population ages between 18 and 21), male population, heterogeneity (percent minority population), and immigration variables as control variables.

Data.census.gov is the new platform to access demographic and economic data from the U.S. Census Bureau. The U.S. Census collects once-a-decade population and housing count data for all 50 states, the District of Columbia, and Puerto Rico as required by the U.S. Constitution. The American Community Survey (ACS) is an ongoing annual survey that shows what the U.S. population looks like and how it lives. The ACS helps communities decide where to target services and resources. Demographic surveys measure income, poverty, education, health insurance coverage, housing quality, crime victimization, computer usage, and many other subjects. Economic surveys are conducted monthly, quarterly, and yearly. They cover selected sectors of the nation's economy and supplement the Economic Census with more-frequent information about the dynamic economy. Also, the Census Bureau maintains a nationwide geographic database that includes boundary information for legal, statistical, and administrative areas. It tracks physical features such as streets and rivers for geographic area delineation. Also, it maintains a national address file to support censuses and surveys. Table 2 below provides a summary of the variables that were directly extracted from the U.S. Census. Bureau and shows how each of these variables has been measured.

Table 2. Control Variables Used in This Study Extracted from the U.S. Census Bureau

Variables	Calculation method	Level of measurement
Overall population	Total population within the county	Ratio
Risky Youth population	Percent of population ages between 18 and 21	Ratio
Male population	Percent male population	Ratio
Heterogeneity	Percent minority population	Ratio
Immigration flow	Influx of immigrant population	Ratio

RESULTS

Pre-Analysis Diagnostics

Considering multivariate analyses was performed in this study, we first set out to explore the correlations between the independent variables in order to detect and address the potential multi-collinearity problem should it exist. The correlation analyses conducted between all the independent variables revealed that the percent minority population, the number of immigrants from abroad, and total county population are significantly and highly correlated (with the Pearson Correlation Coefficient (r) above .6) (see Table 3).

Table 3. Pre-Analysis Diagnostics on the Correlations Between the Predictor Variables

	Percent male	Percent minority	Percent youth (18-21)	Number of immigrants	Total county population
Average temp. in 2019	-.433**	.704**	-.277*	.625**	.685**
Percent male		-.424**	-.031	-.442**	-.509**
Percent minority			-.141	.639**	.812**
Percent youth (18-21)				-.126	-.188
Number of immigrants					.855**

This indicates that should these variables be put together in a single multivariate model, it will lead to a severe multi-collinearity problem and subsequently significantly affect the results. Thus, this study will use the percent male population and the percent of population ages between 18 – 21 for further multivariate regression analyses as control variables, along with "the average temperature 2019" predictor variable in the final models.

Descriptive Statistics

The descriptive analysis results for all the variables used in this research are summarized in Table 4. The number of Robberies (n=62) averaged 291.05 (SD=825.25) cases in 2019. The number of Aggravated Assaults (n=62) averaged 718.13 (SD=1898.92) cases in 2019. The number of Burglaries (n=62) averaged 442.97 (SD=699.77) cases in 2019. The number of Larcenies (n=62) averaged 3643.23 (SD=6917.92) in 2019. The number of Motor Vehicle Theft (n=62) averaged 204.05 (SD=393.62) in 2019. The average temperature in 2019 of each county (n=62) averaged 48.38 (SD=3.24). Percent male population (n=62) averaged 49.82 (SD=1.43). Percent minority population (n=62) averaged 18.93 (SD=17.15). Percent of youth (18-21)

population (n=62) averaged 6.12 (SD=2.95). The number of immigrants from abroad (n=62) averaged 2,158.82 (SD=5409.7). Total county population (n=62) averaged 314,048.95 (SD=54,1071.33).

Table 4. Summary Statistics on All the Variables Used in this Study

	Min	Max	Mean	SD
Dependent Variables				
Robbery (2019)	0	4031	291.05	825.25
Aggravated Assault (2019)	2	9221	718.13	1898.92
Burglary (2019)	6	3203	442.97	699.77
Larceny (2019)	18	37064	3643.23	6971.92
MV Theft (2019)	2	1833	204.05	393.62
Predictor Variable				
Average temp. (2019)	42.16	55.84	48.38	3.24
Control Variables				
Percent male	47.20	54.45	49.82	1.43
Percent minority	4.05	91.25	18.93	17.15
Percent youth (18 - 21)	3.59	19.95	6.12	2.95
Number of immigrants	0	31177	2158.82	5409.7
Total county population	4515	2559903	314048.95	541071.33

Bivariate Correlations Between the Predictor, Control and all Aependent Variables

The bivariate correlations shown in Table 5 indicate the relationship between the predictor, control variables, and all the outcome variables. Based on the results of these correlations, all the variables are significantly and relatively highly correlated with all the outcome variables. These correlations indicate that, (1) the weather variable is an important variable that should be considered in subsequent analyses (to test our hypotheses), and (2) even though we are unable to use the other control variables in our final regression models, it is important to note that these are significantly and highly correlated with the outcome variables, a limitation that we will address in the discussion/conclusion section of this paper.

Table 5. Bivariate Correlations Between the Predictor, Control, and Dependent Variables

	Robbery	Aggravated Assault	Burglary	Larceny	MV Theft
Average temp. in 2019	.608**	.614**	.527**	.638**	.592**
Percent male	-.484**	-0.485**	-.549**	-.529**	-.526**
Percent minority	.752**	.791**	.689**	.681**	.803**
Percent youth (18-21)	-0.159	-.157	-0.141	-0.159	-0.17
Number of immigrants	.880**	.850**	.787**	.931**	.749**
Total county population	.873**	.872**	.887**	.915**	.940**

Note: **=p<.01

Multivariate Analyses and Hypothesis Testing

1) Robbery

Multivariate regression models were constructed to examine the effect of weather on robbery in the State of New York. Based on the R-value, the overall model can explain 43% of the variance in the outcome variable, i.e. in the variation of robberies across the NYS counties. In other words, knowing the percent male population, percent youth (18-21) population, and the average temperature, we can explain approximately 43% of the variance in robbery these counties. Based on ANOVA result, the overall model can significantly predict the outcome variable $F(3,58)=14.67$, $p<.01$. The positive B value for "the average temperature in 2019" indicates that warmer temperatures are associated with higher robbery incidents. The variable significantly contributes to model when controlling for the percent male population and the percent of youth population ($t=4.12$, $p<.01$). Based on the Standardized Coefficient values, the temperature variable is the strongest predictor in the model ($\beta=.48$) (See Table 6).

Table 6. Predicting Robbery in 2019

	B	*SE B*	*β*	*p*
Average temp. (2019)	121.85	29.57	.48	.000
Percent male	-161.11	64.48	-.28	.015
Percent youth (18-21)	-9.82	29.32	-.04	.739

2) Aggravated Assault

Multivariate regression models were constructed to examine the effect of weather on aggravated assault in the State of New York. Based on the R-value, the overall model can

explain 44% of the variance in the outcome variable, i.e. in the variation of aggravated assaults across the NYS counties. In other words, knowing the percent male population, percent youth (18-21) population, and the average temperature, we can explain approximately 44% of the variance in aggravated assault these counties. Based on ANOVA result, the overall model can significantly predict the outcome variable $F(3,58)=15$, $p<.01$. The positive B value for "the average temperature in 2019" indicates that warmer temperatures are associated with higher aggravated assault incidents. The variable significantly contributes to model when controlling for the percent male population and the percent of youth population ($t=4.22$, $p<.01$). Based on the Standardized Coefficient values, the temperature variable is the strongest predictor in the model (β=.49) (See Table 7).

Table 7. Predicting Aggravated Assault

	B	*SE B*	*β*	*p*
Average temp. (2019)	285.48	67.71	.49	.000
Percent male	-365.75	147.65	-.28	.016
Percent youth (18-21)	-19.49	67.15	-.03	.773

3) Burglary

Multivariate regression models were constructed to examine the effect of weather on burglary in the State of New York. Based on the R-value, the overall model can explain 41% of the variance in the outcome variable, i.e. in the variation of burglaries across the NYS counties. In other words, knowing the percent male population, percent youth (18-21) population, and the average temperature, we can explain approximately 41% of the variance in burglary these

counties. Based on ANOVA result, the overall model can significantly predict the outcome variable F(3,58)=13.32, p<.01. The positive B value for "the average temperature in 2019" indicates that warmer temperatures are associated with higher burglary incidents. The variable significantly contributes to model when controlling for the percent male population and the percent of youth population (t=2.83, p<.01). Based on the Standardized Coefficient values, the temperature variable is the second strongest predictor in the model (β=.34) (See Table 8).

Table 8. Predicting Burglary

	B	*SE B*	*β*	*p*
Average temp. (2019)	72.3	25.59	.34	.006
Percent male	-199.12	55.8	-.41	.001
Percent youth (18-21)	-14.35	25.38	-.06	.574

4) Larceny

Multivariate regression models were constructed to examine the effect of weather on larceny in the State of New York. Based on the R-value, the overall model can explain 47% of the variance in the outcome variable, i.e. in the variation of larcenies across the NYS counties. In other words, knowing the percent male population, percent youth (18-21) population, and the average temperature, we can explain approximately 47% of the variance in larceny these counties. Based on ANOVA result, the overall model can significantly predict the outcome variable F(3,58)=18.29, p<.01. The positive B value for "the average temperature in 2019" indicates that warmer temperatures are associated with higher larceny incidents. The variable significantly contributes to model when controlling for the percent male population and the

percent of youth population (t=4.45, p<.01). Based on the Standardized Coefficient values, the temperature variable is the second strongest predictor in the model (β=.49) (See Table 9).

Table 9. Predicting Larceny

	B	*SE B*	*β*	*p*
Average temp. (2019)	1057.58	237.48	.49	.000
Percent male	-1550.21	517.86	-.32	.004
Percent youth (18-21)	-76.78	235.51	-.03	.746

5) Motor Vehicle Theft

Multivariate regression models were constructed to examine the effect of weather on motor vehicle theft in the State of New York. Based on the R-value, the overall model can explain 44% of the variance in the outcome variable, i.e. in the variation of motor vehicle thefts across the NYS counties. In other words, knowing the percent male population, percent youth (18-21) population, and the average temperature, we can explain approximately 44% of the variance in motor vehicle theft these counties. Based on ANOVA result, the overall model can significantly predict the outcome variable F(3,58)=15.39, p<.01. The positive B value for "the average temperature in 2019" indicates that warmer temperatures are associated with higher motor vehicle theft incidents. The variable significantly contributes to model when controlling for the percent male population and the percent of youth population (t=3.71, p<.01). Based on the Standardized Coefficient values, the temperature variable is the second strongest predictor in the model (β=.43) (See Table 10).

Table 10. Predicting Motor Vehicle Theft

	B	*SE B*	*β*	*p*
Average temp. (2019)	51.82	13.96	.43	.000
Percent male	-94.6	30.44	-.34	.003
Percent youth (18-21)	-8.28	13.84	-.06	.552

DISCUSSION

Summary of Findings

Past studies found that temperature has an impact on various types of crime rates. Most of the findings indicated that the higher temperature caused more aggression, leading to the increases in violent crimes. From the mid-20th century when scholars started to study climate variables regarding the effect on crime, many regions showed a positive correlation between high temperatures and overall crimes. The high precipitation (humidity) usually comes with the high temperature, and we can reasonably infer that the summer season provokes more aggression.

The results of the analyses for all the five types of crime examined in this study indicated that there is a positive correlation between temperatures in New York State and crime, when controlling for the rates of male and young (18-21) populations in the counties. Knowing the percent male population, percent youth (18-21) population, and the average temperature, the regression models were able to explain approximately 43% variation in robbery, 44% in aggravated assault, 41% in burglary, 47% in larceny, and 44% in motor vehicle theft. The findings suggest that the warmer weather in New York State can lead to not only higher rates of

violent crimes, but also higher rates of property crimes. Among the five crimes, judging from the standardized beta values, the temperature emerged as the strongest predictor variable except for predicting burglary rates.

Study Limitations

Unfortunately, due to the high correlation between the predictor and control variables initially selected, as shown in pre-analysis diagnostics, it was not possible for this research to use all the control variables in the analysis when examining the relationship between temperature and the five types of crimes selected. The variables "percent minorities" (with immigration r=.639; with total population r=.812), "immigrant flow" (with total population r=.855), and "total population" were highly correlated with each other and also with temperature (with minorities r=.704, with immigration r=.625, and with total population r=.685). It can be inferred that there are more minorities and immigrants in higher population counties and more crime occurring in high population areas. However, this study was unable to control for all these variables in the final regression models.

This study is limited to New York State. NYS has unique seasonality in that it has large land territory, as well as has both the continental and oceanic climate (71° W - 79°W and 40° N - 45° N). Also, it is the 5th most populated state in the United States, with unique population densities in specific counties (Kings, Queens, and New York). Thus, this research remains cautious when generalizing the analyses to other states.

Policy Implications

There are several ways to evaluate the short-term practical significance of results in studies that focus on annual temperatures and criminal behavior. Tiihonen and colleagues (2017) suggested that the rise in temperature modulates serotonergic transmission which may increase impulsivity and general human activity levels, resulting in increased social interaction and risk of violent incidents. Their research showed that a 2°C (approx. 4.5°F) increase in average temperatures increased violent crime rates by more than 3% in non-tropical and non-subtropical areas. Also, there have been a number of studies conducted in Japan and United Kingdom revealing the frequency and intensity of crimes committed during periods of increased temperature (human interaction and psychological stress) (Chambers, et al., 2011). All of the past research, as well as this study indicate that it is important for police departments to take the results related to weather into account when scanning their environment and formulating prevention strategies to reduce or mitigate the incidence of violence and property crimes in their communities.

Climate change and challenges related to require policies designed to reduce air pollution, greenhouse gas emissions and oil resources use, and to prepare populations for the impacts of extreme climate through adaptation. It is important to keep in mind that climate change will affect humans in different ways and arouse social costs of increased/decreased crime depending on the regions. When various different crimes peak in different seasons, the police can concentrate its resources on limiting the crime that is most prevalent at given seasons. Uncovering seasonal variations in crime can help us to understand the expected crime rates at a given point in time, and aid in deploying police resources more efficiently (Dong, et al., 2016 & Baker, 2011).

Future Research

This study examined data on weather and its effects on crime within the counties in New York State. Future research can include a larger variety of regions. For example, future research can examine different states from different parts of the United States: East, West, South, and North. The articles and studies so far found that increased temperatures provoked more aggression levels and would cause more crimes, most violent crimes. However, as the climate changes, the average temperature of summer is getting higher and the winter is getting lower. It would imply that not only hot weather but the tolerance level of people on both high and low temperature could be related to crime occurrence. This would require more longitudinal studies on not only annual average temperature but also on seasonal variations. Fluctuations of different kinds of crimes across seasons will show various results, clearly indicating that there is a fixed pattern that humans are similarly affected by certain climate patterns.

Conclusion

This study demonstrates a strong influence of climate variables – temperature – on crime rates using crime statistics and observed climate records collected from 57 counties within the state of New York. It is found that temperature is highly correlated with crime rates, specifically those of robbery, aggravated assault, burglary, larceny, and motor vehicle theft. The findings of this study seem to be consistent with the past literature on the expectations that human behavior changes in hot weather, and that aggression levels are likely to rise along with temperature. Future comparative research should continue to build on this study's efforts by further examining the trends in various categories of crimes across the United States and how these relate to the

changes and fluctuations in weather and do so longitudinally by taking into account seasonal variations.

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