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Weather Impacts on Crime

INTRODUCTION

Does inclement weather deter certain criminal activities? Do storms only impact certain kinds of crime? Our theory is that many criminal activities are opportunistic, requiring advantageous circumstances such as specific weather events. To isolate the impact of weather, we also need to separate potential confounding factors such as days of the week or times of the month and to investigate the supposed effect of lunar cycles. Using the extensive data set released by Chicago PD on their crime rates, our team investigated the relation between Chicago crime rates and Chicago weather patterns, seasonal changes, specific time events, and lunar cycles.

Due to size limitations, we limited our scope to January 2011 to December 2015. At the end of this document is a google drive link that contains all of our data and further descriptions of our data sets.

ANALYSIS

Before diving into our hypothesis, we needed to explore our data sets. We first examined the Chicago Crime data as our primary variable data set (figure 1).
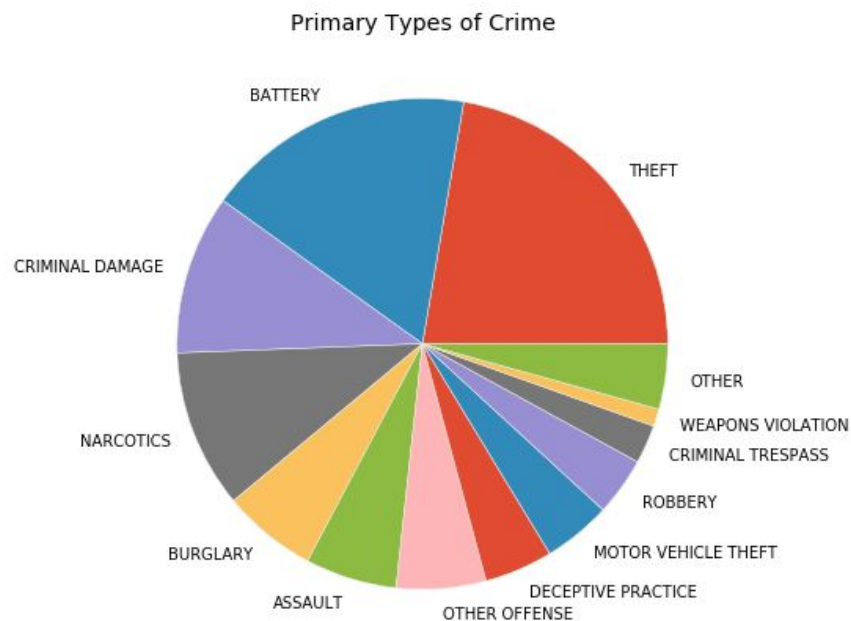

Figure 1. Types of Crime Distribution

Theft and battery types are by far the most prevalent crimes in Chicago. Criminal damage, narcotics, burglary, and assault round out the top six criminal activities. Together, these account for nearly 75% of crimes committed in Chicago. Although we analyzed all crime types, these top types will generally be isolated in any analysis done by crime type in the remainder of this paper. The limited counts of other criminal activities reduced the significance of their analysis and did not show a different enough trend to warrant explicit discussion.

Our data set spans fives years of activity from 2011 through 2015. To better understand how time impacts crime, we plotted a timeline of crime by type (figure 2).
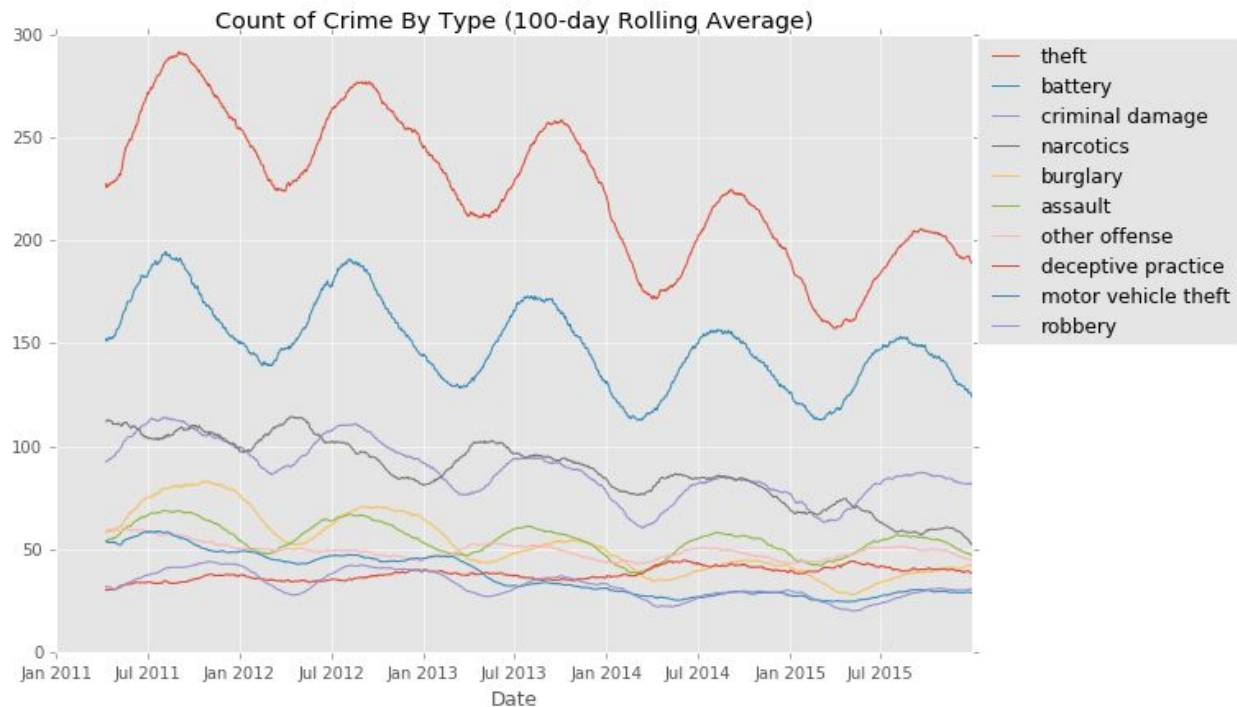

Figure 2. Rolling Average of Crime Counts by Type

We were very happy to see that, on average, crime rates have steadily decreased since January 2011. In 2009, Dart Center for Journalism and Trauma noted "among crime stories in Chicago's The Tribune in the early 1980's, 26% were about murder, while only 0.2% of crimes known to police were murder." If you listen to major news stations today you'll notice the same situation: murder makes the headline yet accounts for 0.149% of 2015 crimes. Similarly, home invasion is only 0.085% of crime but is a constant, major theme in news coverage.

Like figure 1, figure 2 shows that theft, battery, criminal damage, and narcotics are top crime types. The significance of burglary and assault have diminished but are still high, especially in 2011 and 2012. The cyclical ups and downs of every criminal activity indicates some relation between time and crime. Our hypothesis that weather impacts crime is a plausible initial explanation. The high correlation between warm weather, summer months, and seasonal changes are examined later in our analysis.

To test our hypothesis that criminal activity is impacted by weather, we first needed to define specific weather conditions. Our weather source data contains an explicit measurement for cloud cover in addition to noting specific events, such as thunder, rain, fog, and snow. A cloud cover of less than 3 on a 0-9 point scale is defined as Clear. By defining Clear in this way, we

are able to treat a day with more pleasant conditions as an "event" by itself. Figure 3 shows how specific weather events correlate with an increase or decrease in crime rates for the 6 most common crime types. A negative effect (left of the 0 line) indicates that the weather event is associated with a decrease in that crime's rate. Conversely, anything to the right of zero indicates an increase in the rate at which that crime occurs.

Note: The effect of a weather event is calculated as $(\frac{e}{ne} - 1) * 100$, for which e is the crime rate on days the event was present and **ne** is the crime rate on days the event was *not* present.
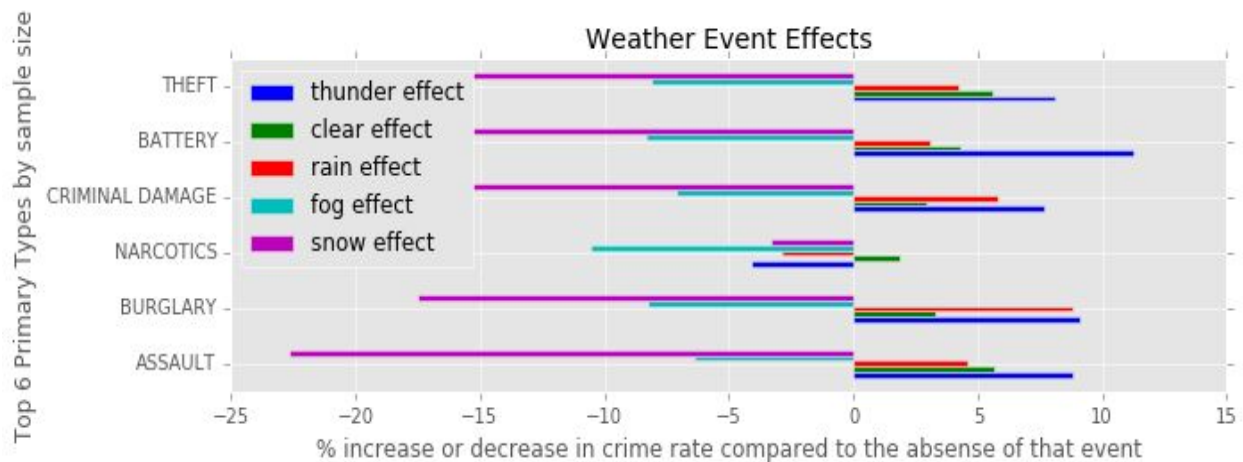

Figure 3. Weather Effects on Average Crime Type Count

As we hypothesized, clear weather is associated with increased crime while snow and fog have an opposite effect for all major crime types. A surprising result is the association of thunder with increased crime. Rain also shows an increase in crime rate; however, this might be a compounding factor of thunder frequently occurring with rain.

But why is clear weather related to higher crime rates? Further, why is fog and snow related to lower crime? We know specific weather events are correlated with certain temperature ranges (e.g. it's rarely 80F and snowing). Figure 4 analyzes the crime rates by temperature buckets.
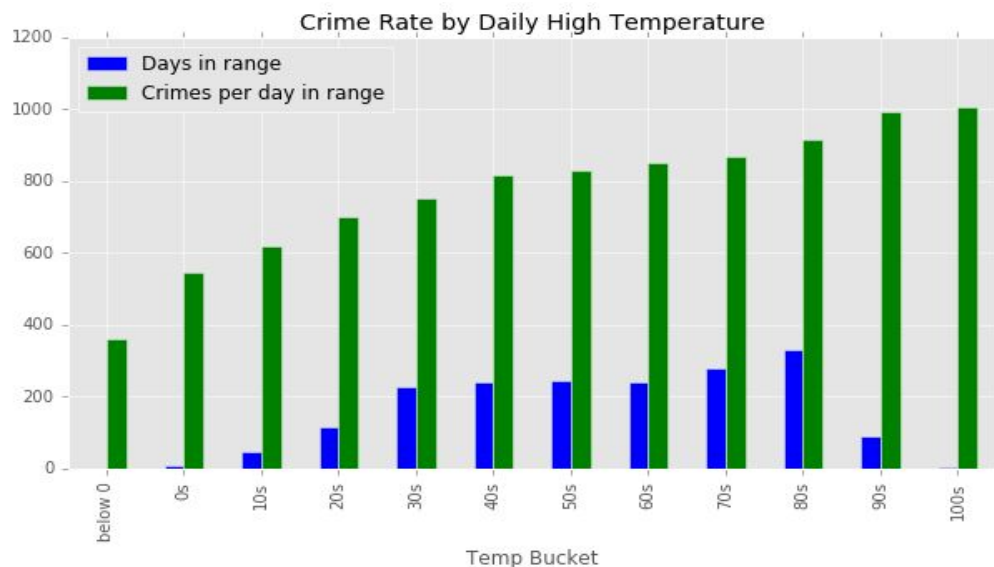

Figure 4. Average Crimes Per Day by Temperature Bucket

There is a nearly linear relationship between the number of crimes committed per day and the high temperature for that day. Figure 4 looks at the average crime per day and still shows a positive relation. This negates the possibility that there are more warm days on which to have criminal activity thus crime is more likely due to opportunity.

When we examine crime rates within a 10 degree range (or temperature bucket), the relationship between weather events and crime rates becomes clearer (figure 5). Similar to figure 3, figure 5 shows the response of the crime *rate* in the presence of a given weather event.
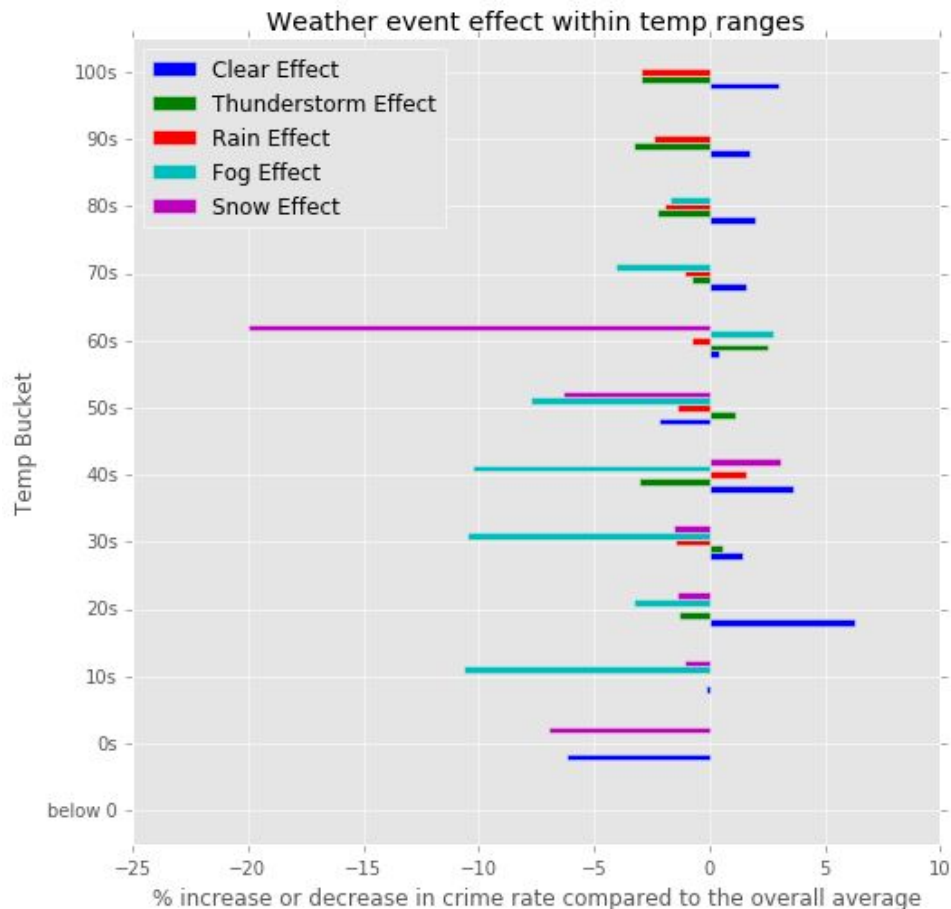

Figure 5. Crime Rates by Weather and Temperature Buckets

After controlling for temperature, the surprising correlation between rain and thunderstorms with higher crime disappears and we see a plausible explanation. Thunderstorms generally happen during warmer weather, which is shown to relate to higher crime (figure 4). Clear weather, our hypothesized increaser of crime, does indeed seem to have a consistently positive correlation with an increase in crime rate across all temperature ranges for which we have a significant amount of data (very few days fall into the 0s and below 0 categories).

Due to its visual prominence, we specifically investigated the significant negative spike for snow in the 60's. There was a single day in the dataset that recorded both snow and a high temperature in the 60's. That day had a significantly lower *average* temperature than most other days in the 60's. It could be argued that using the average temperature would have smoothed out the effects somewhat. However, most people and weather reports discuss the

day's temperature in terms of the day's maximum temperature. We decided to stick with that convention, even though it leads to discussing conundrums like "a snow day in the 60s."

Thus far the relationship between temperature and crime has become readily apparent. Temperatures definitely fluctuate with seasons. But is this temperature fluctuation enough to support the strong annual cyclical pattern shown in figure 2? Figure 6 shows seasonal crime rate by day of month.
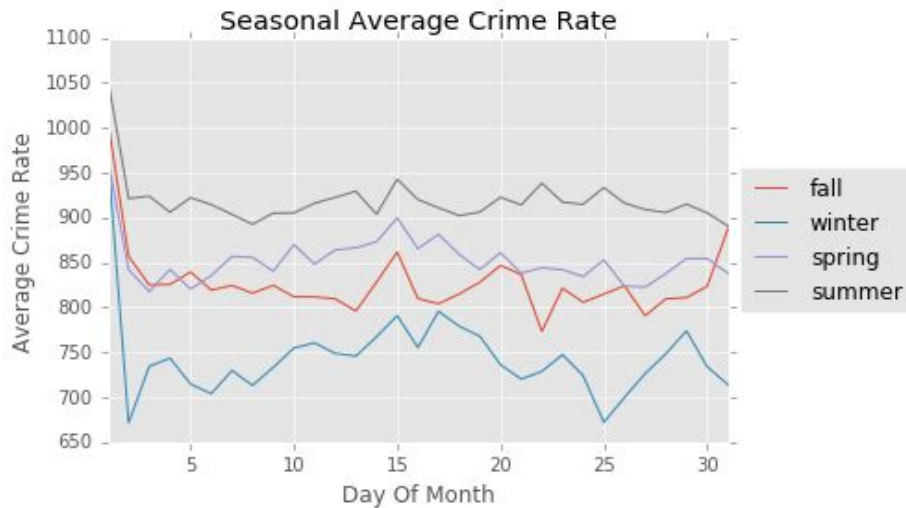

Figure 6. Average Daily Crime Rate by Day of Month, distinguished by Season

On average, figure 6 shows a similar trend amongst all seasons but with mean daily crime rates highest for summer and lowest in winter. If season were more dependent than temperature, we would expect to see different slopes to each seasonal line. Instead, each season has closely related crime rates almost to the day.

To fully flesh out monthly cycles, we also examined crime in relation to lunar cycles. If month is unrelated, perhaps lunar cycles is more significant. Figure 7 has violin plots of crime counts by specific lunar events.
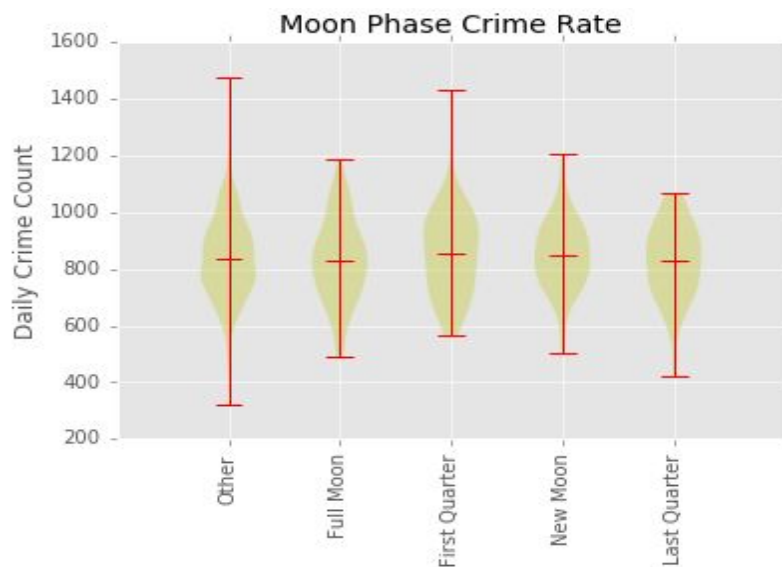

Figure 7. Lunar Cycles on Daily Crime Count

The origin of the word lunacy does not apply in our data: the moon illumination has barely noticeable impacts on crime counts. Based on previous studies, such as the Full Moon and Crime study published in the British Medical Journal, we were curious if specific lunar events would cause an impact on crime. The Full Moon and Crime study found that "the incidence of crimes committed on full moon days was much higher than on all other days, new moon days, and seventh days after the full moon and new moon." We suspect that the small sample size of that study resulted in skewed results.

While examining the seasonal impact on crime for figure 6, we noticed an unusual spike in criminal activity with the first of the month. To examine, we looked at the crime rate on the first of the month compared to the crime rate for the remained of the month (figure 8). Similar to figure 3, bars going to the right indicate an increased percent of crime.
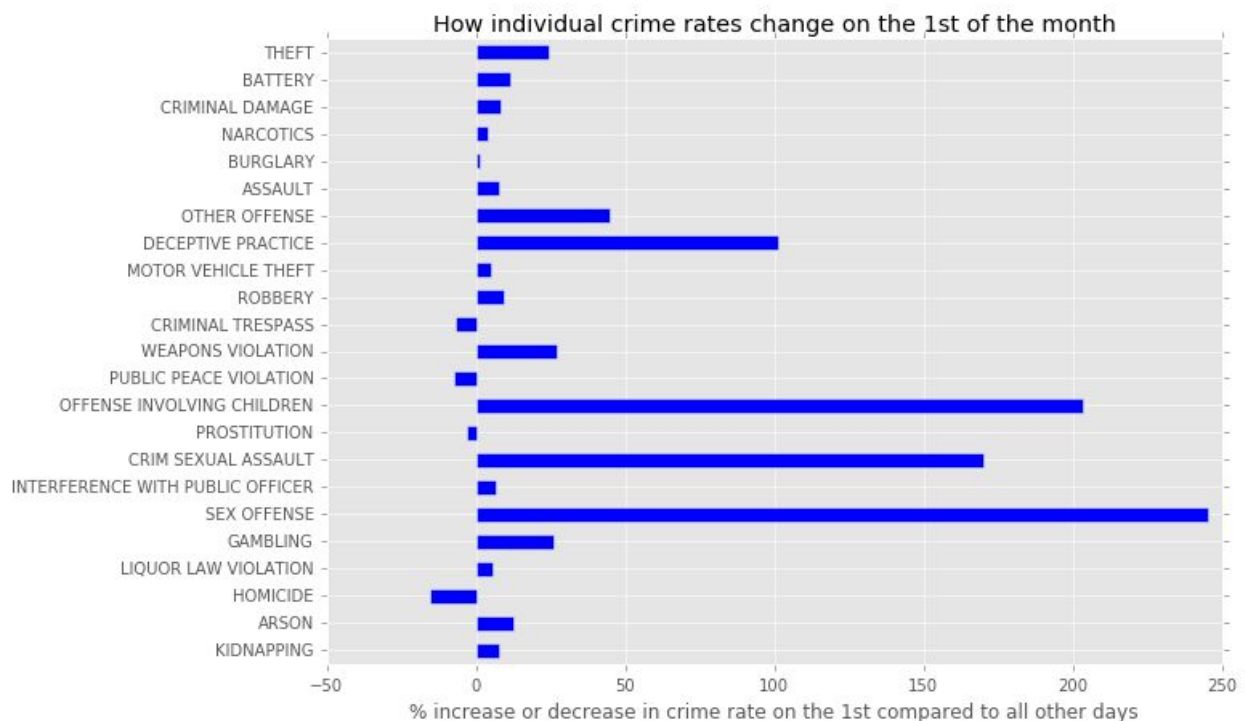

Figure 8. Crime Rate on the First

The spike on the first is not associated with weather as every month and season shows a similar trend (figure 7, 8). Not shown is that New Year's Day (Jan 1) had the greatest spike in criminal activity. We're suspecting this may be a factor of how data is entered. The Chicago police may routinely enter backlogged records on the first. Alternatively, the default date for a report without a specific date of occurrence may be the first. In either case, we're suspecting a human-error correlation rather than a criminal trend. We've emailed the Chicago PD to learn more about how this data set was created but did not receive a reply in time to include with our analysis.

We were curious if other specific dates were related with higher crime rates. Figure 9 shows average crime rates on and around four holidays: Christmas, Thanksgiving, New Year's Eve, and Easter. The crime surrounding New Year's Eve is exclusive of New Year's Day since we noticed it as an anomaly from analyzing figure 8.
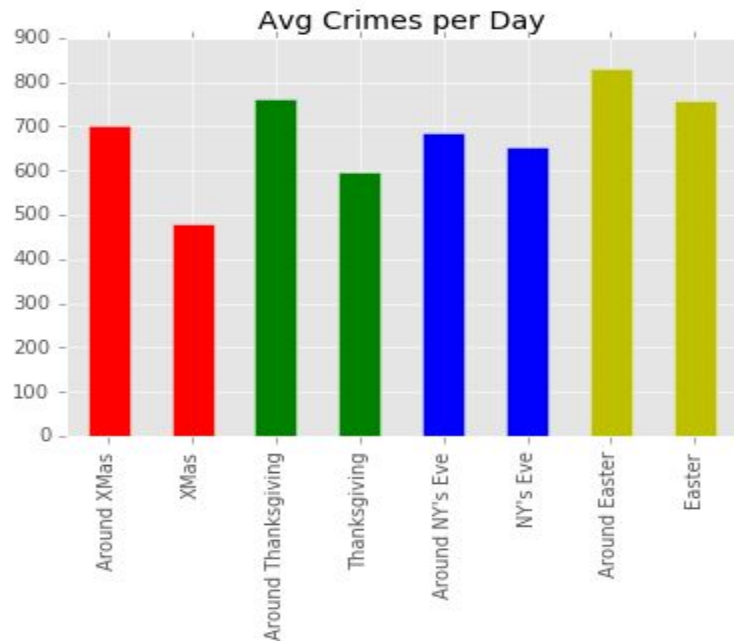
Figure 9. Average Crimes Per Holiday

For each holiday we examined, the average crime rate on the holiday is noticeably lower than the days surrounding the holiday. We again can neither contribute this to time nor weather. Instead, we suspect the date-related change is a result of how data is entered. The Chicago police department likely has fewer officers on duty on holidays. Reduced headcount means fewer officers to patrol and make arrests, which would artificially decrease reported crime rates. Alternatively, paperwork may be pushed off until the next business day when there's more officers on-duty to cover both entering paperwork and responding to criminal reports.

CONCLUSION

From our analysis, we conclude that there is a positive relationship between temperature and crime rates. While negative weather events, when corrected for temperature variation, do correspond to a dampening of the crime rate, the role played by temperature alone is much more significant. More rigorous statistical analysis is necessary to better understand the extent to which these factors influence crime rates.

We also learned that crime-related media coverage is not proportional to the prevalence of various crimes. Crime rates are down overall and major crimes like murder only make up a small proportion of criminal activity in Chicago. If the news reported crimes in the same proportion that they were committed, a third of the crime-related news would be on minor thefts and battery. Granted, a crime such as murder has greater social impacts than the more minor types, but it's useful to have a view of the big picture.

For further analysis, we would like to delve deeper into cross relationships between our variables and possible alternative situations. Are certain crimes more sensitive to weather and temperature patterns than others? Is global warming a potential sign that crime will increase? Does crime in locations with higher average temperatures follow the same trend we discovered in Chicago? And how statistically significant is the relation between crime and

temperature? The trend around holidays is of particular interest - do holidays where families stay together show a different trend than holidays that are more party-centric or have less observance?

We would also like to compare smaller crime types that did not fit the mold. For example, deceptive practice, sexual assaults, and crimes involving children do not have a clear downward trend. These crimes have a much smaller sample size which may mask their real downward trend. In any case, the comparison of crime types over time and nationwide may lead to greater insights into future crime rates.

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Newman, Elana; Tiegreen, Sara. 02-18-2009. "Violence: Comparing Reporting and Reality". http://dartcenter.org/content/violence-comparing-reporting-and-reality

Full Moon and Crime

Thakur CP, Sharma D. Full moon and crime. *British Medical Journal (Clinical research ed).* 1984;289(6460):1789-1791.

DATASETS

Our raw data is saved in a google drive (https://drive.google.com/open?id=0B_PnWx1pRhmzNWxYNDVjWjBNcnc).

Weather

Description: Daily report from Jan-1-2011 to Dec-31-2015 on temperature and weather events

Columns: Date, Mean Temperature (F), Mean Visibility (Miles), Max Wind Speed (MPH), Mean Wind Speed (MPH), Max Gust Speed (MPH), Precipitation (In), Cloud Cover, Events

Source: www.wunderground.com/history

Chicago_Crime

Description: Daily report from Jan-1-2011 to Dec-31-2015 on criminal activity in Chicago

Columns: Date, Primary Type, Description

Source: https://data.cityofchicago.org/Public-Safety/Crimes-2001-to-present/ijzp-q8t2

Lunar

Description: Daily report from Jan-1-2011 to Dec-31-2015 on solar and lunar events such as eclipses and season changes.

Columns: Date, IlluminatePercent, Phase, SeasonEvent

Source: http://aa.usno.navy.mil/data/index.php (Dates of Primary Phases of the Moon, Fraction of the Moon Illuminated, and Earth's Seasons - Equinoxes, Solstices, Perihelion, and Aphelion)