How Did the COVID-19 Pandemic Affect Crime In Chicago? A Data Analysis Approach to Crime Data Correlations

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1 INTRODUCTION

The COVID-19 pandemic called for global shutdown in the year 2020, heightening a sense of isolation, fear, and anger among billions of people. With the ongoing friction of shutting down businesses and mask mandates, less people were able to carry out their normal lives. Interestingly enough, crime decreased at a rate of 37% worldwide after stay-at-home issues were ordered [1]. According to the American Law Institute in 1962, crime has been defined as an "offense by the Model Penal Code or any other statute of this State, for which a sentence of imprisonment is authorized" [2]. However, cities like Chicago that accounted for half of the U.S. homicides for 2016, create speculation if the pandemic had an effect on their crime rate as well [3]. Understanding the connections of densely populated cities with crime behavior is imperative to help identify potential motives and prevent further crime from occurring in the future. As machine learning models and data analysis methods mature in the computational landscape, applications in criminal studies have utilized their techniques. A recent study was conducted to analyze crime in South Africa following a linear regression model. This model was designed to help predict crime across all nine provinces dependent on the population, number of police stations, and types of crimes committed. A separate study observed 2013 crime statistics in the state of Mississippi by utilizing linear regression, additive regression, and decision stump algorithms. The goal of this work was to categorize which cities of Mississippi were more likely to have certain crimes occur and how many crimes happened based upon population. Therefore, for this work, an array of data analysis techniques was constructed to correlate crime trends in Chicago during the pandemic. Understanding connections such as locations where crimes were committed, types of crimes, and times in which they occurred can be a helpful resource for understanding how global phenomenon can impact large cities. This information can be used for future events to help mitigate the crime occurring in the city of Chicago.

2 RESEARCH QUESTIONS

2.1 How have arrests changed over the course of the pandemic?

Analyzing the rate of arrests will provide us insight into the changes in police activity during the pandemic. There are a number of factors that could change the proportion of crimes that lead to an arrest. Firstly, the nature of how crime is committed could change. We will hopefully see trends related to this with an analysis of how arrest rates change

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for a few different kinds of crime. Second, covid restrictions could make policing more difficult. As the pandemic has progressed, restrictions have been loosened, so judging how lasting the change is can tell us more about this. Finally, attitudes towards enforcement may have changed, especially given recent unrest surrounding the question of policing. Added temporal analysis will also help us with this question.

2.2 How has domestic crime changed over the course of the pandemic?

Domestic violence crime is a rising concern for the city of Chicago due to the significant disparities between occurrences, police reports, and arrests. In 2019, there were 193,800 domestic related calls made to the Chicago Police Department and 24,400 calls made to the Illinois Domestic Hotline [9]. Of those recorded calls, situations where police interference was conducted, only 10,095 domestic related arrests occurred [9]. These statistics are alarming since many domestic cases are not carried out and many offenders do not foresee consequences for their actions. In addition, on average only 47% of domestic cases are reported to the police due to the complex nature of domestic situations [10]. Therefore, domestic incidents are a category of crime that is unique and must be investigated to understand its trends and relevancy towards life-altering world events.

During the COVID-19 pandemic, the city of Chicago instituted a stay-at-home order in March that lasted until the city re-opened in June. With the uncertainty of the virus, massive job loss, and being ordered indoors, tensions were expected to arise among many people. Therefore, it is imperative to ask, how did the pandemic affect domestic violence cases? One may question the connections to trends during the year 2020 and how other future world events may affect this crime. Consequently, of the crimes committed in 2020, which of those crimes were domestic cases and how many domestic arrests were conducted? If the proportions of these cases shifted, it would question whether the pandemic played a relevant role in criminal actions. Lastly, what was the distribution of domestic cases across the districts of Chicago in 2020 in comparison to previous years? If cases are occurring in hot spots of Chicago, perhaps better reinforcements can be instituted to combat the domestic crime activity.

2.3 How has the location of crime changed over the course of the pandemic?

This task aims to analyze the criminal activities in Chicago city districts before and during the Covid19 pandemic. Specifically, we compare the activities from 2016 to 2021. The data related to these periods are taken via segregating the main dataset file. Two main features are utilized in this task: primary type that represents the criminal activities and the district representing the city's coded neighborhoods according to the Chicago police categorization. The district feature shows 23 districts scattered into three areas: Central, North, and South. Those districts, as we will see later, have almost a similar trend of data across all the years, except the district coded 31, which, for some reason, does not present the same trend. It shows a minor number of crimes,and during any statistical operation, it reflects an unconventional rate. Hence we consider it a data outlier and exclude it from our analytics.

3 METHODS

3.1 Preprocessing

This dataset was retrieved from Kaggle. We pulled a subset of police reports starting January 1st, 2015 and ending on November 6, 2021. We also selected a subset of available features: [unique key, date, block, iucr, primary type, description, location description, arrest, domestic, fbi code, year, district]. The data was provided unordered, but was sorted into files by year.

3.2 Arrests

To analyze the change in the proportion of arrests over time, we must decide how to divide our data temporally. We chose to count the proportion of arrests to crimes per month, as this created a manageable data set that still had enough points to perform regression. A weekly analysis may have been more statistically robust, at the cost of manageability. In hindsight, I would have chosen this. The first analysis was curve fitting to these monthly proportions. This was done with the SciPy Optimize library, with the objective function set to $ax + bx^2 + c$. This fitting was done for months before the first lockdown in March 2020, after the first lockdown, and over the entire dataset. To decide if a significant change was present, we compared the curve of months before the lockdown to the curve over the entire dataset to decide if there was a noticable change in trajectory.

After curve fitting to both the aggregated data and data sectioned by type of crime, we generated a list of the farthest outliers to the curve across all months, in order to see if the change was only over the strictest period of lockdown. If this is the case, we would expect months in mid-2020 to appear as influential outliers. Outliers were determined according to the same squared error function $(x_i - x_{expected})^2$ used in curve fitting, which was done by minimizing the sum of squares error. $\sum_{i=1}^{n}(x_i - x_{expected})^2$

3.3 Domestic

The domestic analysis data was viewed through three different avenues: yearly percent change of domestic crimes, proportions of domestic crimes and arrests, distribution of domestic crime across Chicago districts. Columns were selected from the Kaggle dataset based on relevancy to each individual analysis as follows: 'date', 'domestic', 'arrest', and 'district'. Data sets were collected from 2015-2021 to provide a lense of what domestic trends were observed leading up to the pandemic, start, and during the ongoing event. After filtering each column of interest into a list, dictionaries were created to sort data for each avenue. For example, 'date' and 'domestic' were selected as 'date' being a key and 'domestic' as a value to segregate data association for analysis. Such tasks were performed for other avenues concerning the 'arrest' and 'district' category.

To understand the correlation among the total number of cases, domestic cases, and domestic arrests, an intersection had to be made. After filtering 'True' domestic cases with their associated date, a value search was evaluated to uncover dates in which a domestic crime occurred and the offender was arrested. For evaluating domestic case counts for each individual district, a similar intersection was conducted to find the date, district, and if there was a domestic case. The percent change for yearly domestic cases was calculated by subtracting the number of cases of the following year from the initial year and dividing out the initial year multiplied by 100. For visualization, percent change and district distribution were represented by bar graphs and domestic proportions were represented through pie charts.

3.4 Location

Four analyses have been conducted in this task. These include analyzing the crimes per district, area and calculating the crime percent change between two consecutive years during the chosen period (2016-2021). We compute the percent change based on the following equation[1].

$$Crime\_Percent\_Change = \frac{x_i - x_{i-1}}{x_{i-1}} * 100 \quad (1)$$

[1] Available at https://www.percentage-change-calculator.com/calculate.php

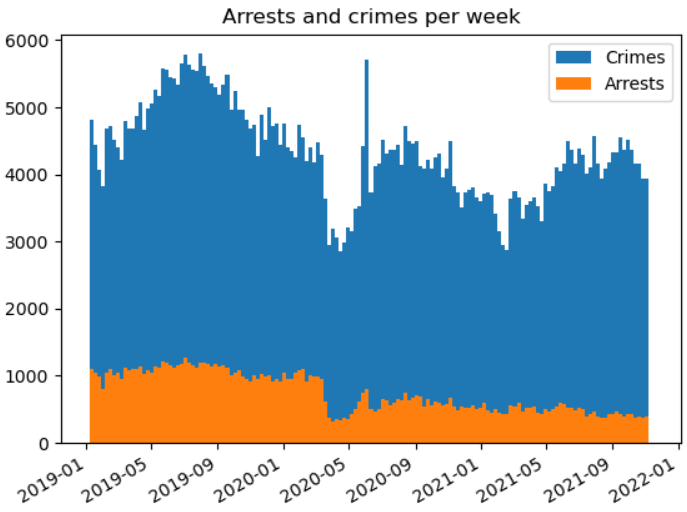

Fig. 1. Weekly crimes and arrests.

4 RESULTS

4.1 Arrests

In figure 1, we see how crime rates and arrests change over 2019 and 2020. In figure 2, we see how the proportion of arrests to crimes changes over time, along with the best fit curves for each period of interest. The direction of the curve is changed, indicating that there is a meaningful decrease in the rate of arrests. Referencing appendix B, we see a similar trend across many crime types, with a more dramatic decrease in a select few, such as public peace violations, which are likely related to political unrest in the summer. However, we see some types that do not change. These seem to be ones with arrest rates close to 1 or 0, where the nature of the crime makes an arrest either very difficult (eg. car theft) or inevitable, such as in the case of crimes where knowing of the crime implies knowing the perpetrator (eg. liquor law violations). Some trends warrant further investigation with the help of domain experts - violent crimes' arrest rates seem to decrease on average, with the exception of sexual assault. Our later analysis of domestic crimes may provide more insight into this trend.

When we look at the trend in arrest proportion, we notice that the decrease seems to persist until the present. Isolating the months that are the larger outliers shows that the largest outliers are actually pre-pandemic, confirming that the change in trends is not the effect of a few large outliers during the strictest months of lockdown. When we look at the outliers on a type-by-type basis, as in Appendix A, we see similar results. Notable exceptions are Prostitution and Interference with public officers, as well as one extreme outlier for Public Peace violations in March 2020.

4.2 Domestic

The percent change was calculated of domestic crime cases in Chicago from years 2015-2021 [Figure 3]. Of the case counts recorded, the largest number of domestic crime cases that occurred were in 2018 with 44,009 total domestic cases.

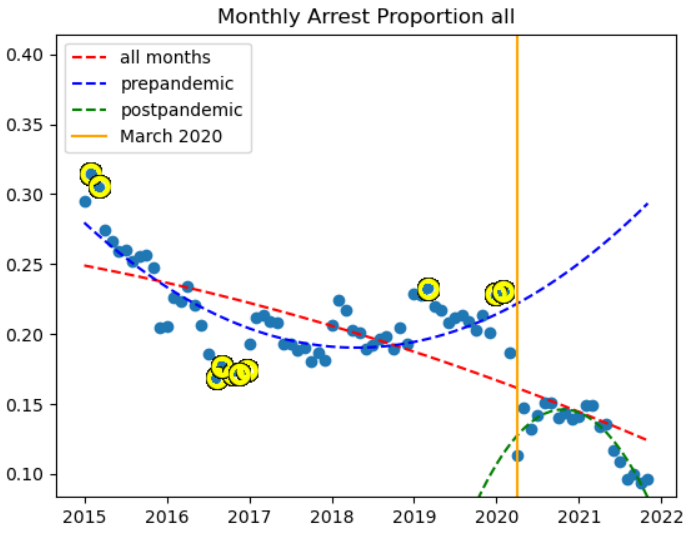

Fig. 2. Monthly proportions of arrests.

When observing overall trends in case counts, the largest increase occurred 2017-2018 with the largest fall 2018-2020, a -9.4% decrease. Speculation as to why the 2018 domestic cases are the highest could correlate to legislation passed in the city of Chicago. In 2018, the Victims of Crime Act (VOCA) expanded services to victims with a $1 million dollar grant for the city of Chicago [10]. Such aid included additional medical access and social services for victims in need. By allowing greater access, it can be speculated that more reports could have been filed due to knowing that the victims would be taken care of in recovery and transition. Unfortunately, in addition to the lower domestic crime in 2020, more than 30,000 domestic calls were received by the Illinois hotline [11]. This trend is up 16% from the year 2019. Although on the surface it seems domestic crime decreased, it is likely less individuals reported domestic cases due to being trapped at home with the offender.

Proportions related to domestic crimes and domestic arrests relative to overall crime counts were calculated [Figure 4]. The year 2020 the most domestic crimes occurring proportionally of the years that were recorded, at 15.6%. This statistic equates to 32,976 domestic cases occurring in 2020 out of 211,388 total cases. Of the 2020 domestic crimes, only 3,170 total arrests were made. It should be noted that the year 2021 has not concluded and therefore such analysis may need to be revised in the future. A larger proportion of 2020 domestic cases may be connected to the government issuing a stay-at-home order for the city of Chicago for two and half months. The continuing trend of low arrest rates could depend on a lot of factors. The complexities behind if an offender is arrested in a domestic case rely on: officer and victim request, previous charges on the offender, and if the case is considered a family unit [12].

The distribution of domestic cases across districts in the city of Chicago were considered to track potential correlations relative to the pandemic [Figure 5]. Across the years of 2018-2020, the highest reports of domestic crime occurred in district 6. The number of domestic cases occurred sequentially: 2,168 domestic cases, 2,558 domestic cases, and 2,569 domestic cases. From this report, there is no significance difference in case variance across districts or within each

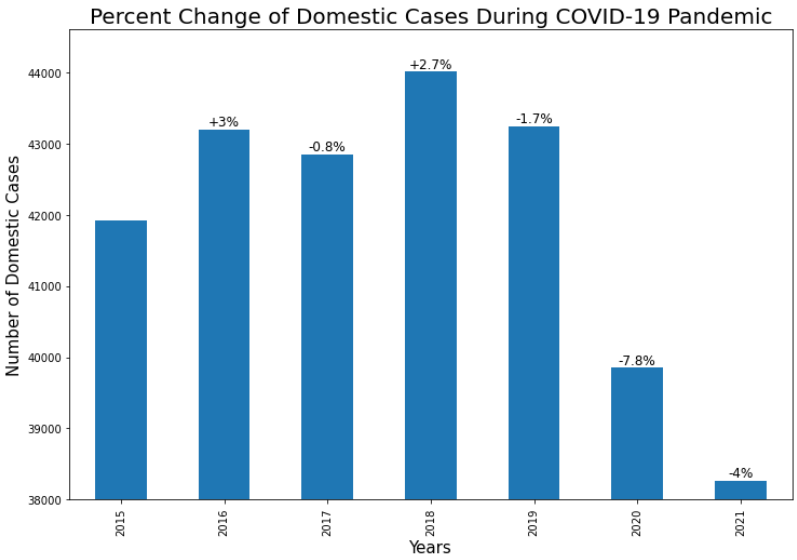

Fig. 3. The percent change of domestic case counts over the years of 2015-2021.

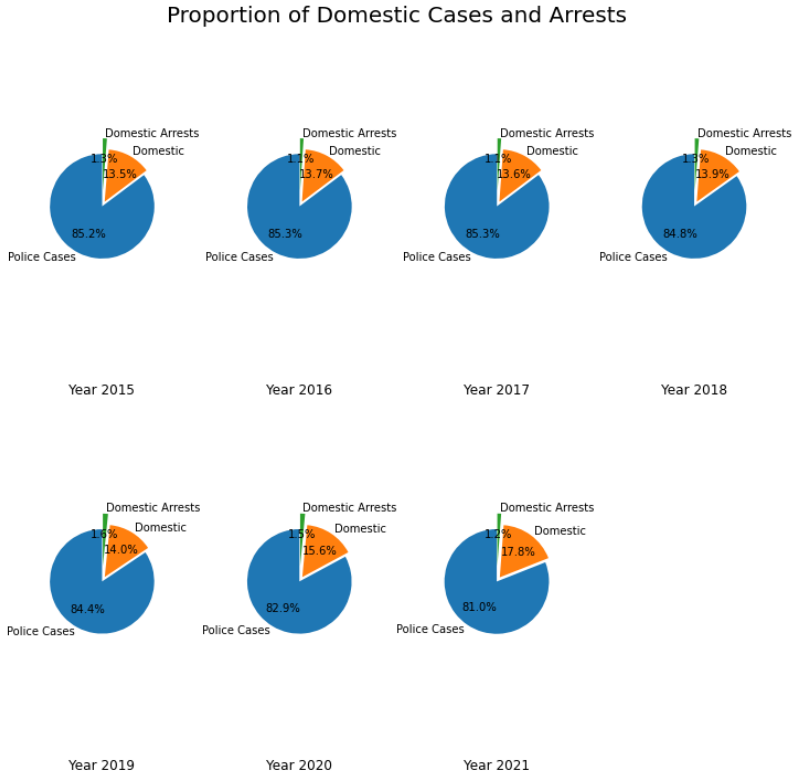

Fig. 4. Proportions of domestic crime counts and domestic arrests conducted out of overall crime reported for years 2015-2021.

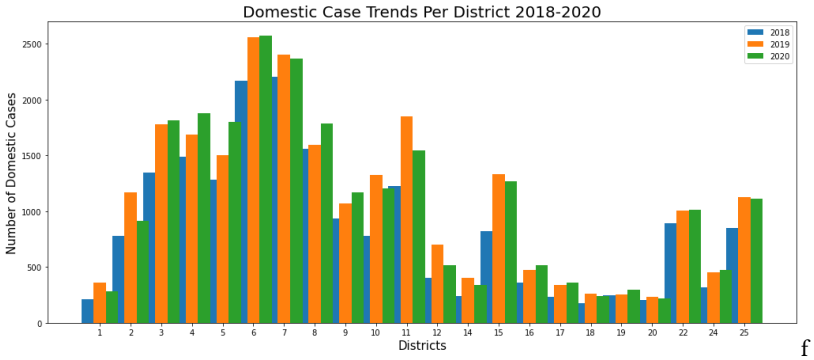

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Fig. 5. Proportions of domestic crime counts and domestic arrests conducted out of overall crime reported for years 2015-2021.

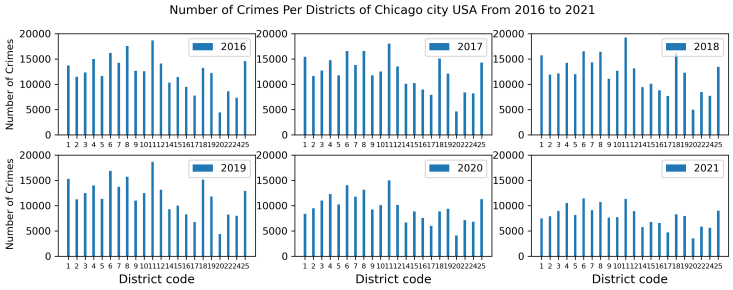

Fig. 6. Number of crimes per districts of Chicago city

individual district. It is noted that a consistently lower number of domestic cases are reported in districts 18-20. District of Chicago is known as the Gresham area which has one of the highest reports of criminal activity and a lot of densely populated residences. For districts 18-20, they reside in the metrpolitation and tourist-like areas of the city that have fewer residences and are less likely to report incidents of domestic crime.

4.3 Location

Figure 6 shows the number of crimes per district in Chicago from 2016 to 2021. The number of crimes is declined to become around half during the pandemic time (2020 and 2021). An example of this can be seen in district # 11 that has crime activities about 20000 before the Covid19 and becomes slightly more than 10000 in 2021.

Grouping the Chicago districts into regions, the crime rate is analyzed from 2016 to 2021. Although this analysis may not reveal the impact of the crime numbers during the pandemic, it intends to explore if the crime pattern in these regions has been changed. Figure 7 demonstrates the crime rate per region during the chosen interval. It shows that the crime rate maintains a similar trend with having the Central Chicago region the most crime rate till 2019. After that, the South Chicago area has the largest crime rate. The north region maintains the lowest crime rate before and after the pandemic, with about 28 percent.

We analyze the crime percent change in Chicago districts based on Equation 1 between two successive years in the time range of 2016-2021. The crime percent could be either an increased change, presented as a positive ratio, or a decreased change, presented as a negative ratio. Figure 8 shows the crime percent change in the districts. The percent

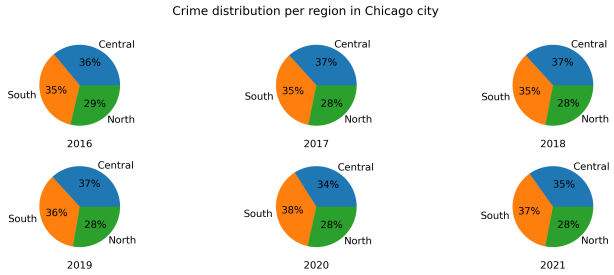

Fig. 7. Crime distribution per region in Chicago city

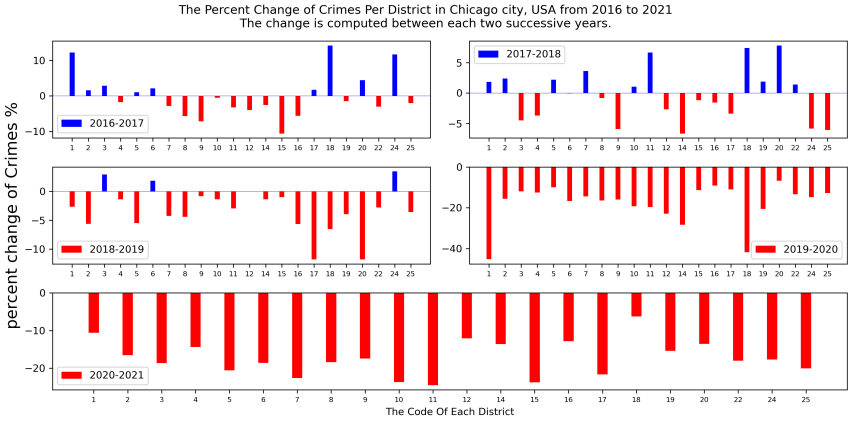

Fig. 8. The percent change of crimes per district in Chicago city

change ranges from 10 to -10 before the pandemic; however, there is a decreasing trend only in the crime rate in 2020 and 2021 exceeded the 40% in some districts in 2020.

We also computed the average percent change per area, as plotted in Figure 9. It is clear that there is a noticeable decrease in the crime rate during the pandemic, with about 25% in the Central Chicago area in 2020 (2019-2020). The north and south regions maintain a similar trend in percent change in 2021 and 2021.

5 CONCLUSION

From the conducted analyses, we notice a noticeable decline in the criminal activities in Chicago city during the Covid19 pandemic. Therefore, it could be noteworthy to investigate as a future work the factors that led to the decline of crimes in this city during the pandemic.

Regarding the work of the police over the pandemic, we see an overall decrease in the number of reported crimes that lead to arrest, and see that that decrease has continued to the present date.We do not have an obvious reason for why the changes in arrests changes seem to persist. This fact, along with the ambiguity of which crimes see a change, highlights the need for context beyond the data and insight into the details of police work.

Overall, domestic related crime cases decreased significantly at -7.8% from 2019-2020. Although crime reports decreased, likely more crime occurred due to the 16% hotline call increase from the previous year. Proportionally, the

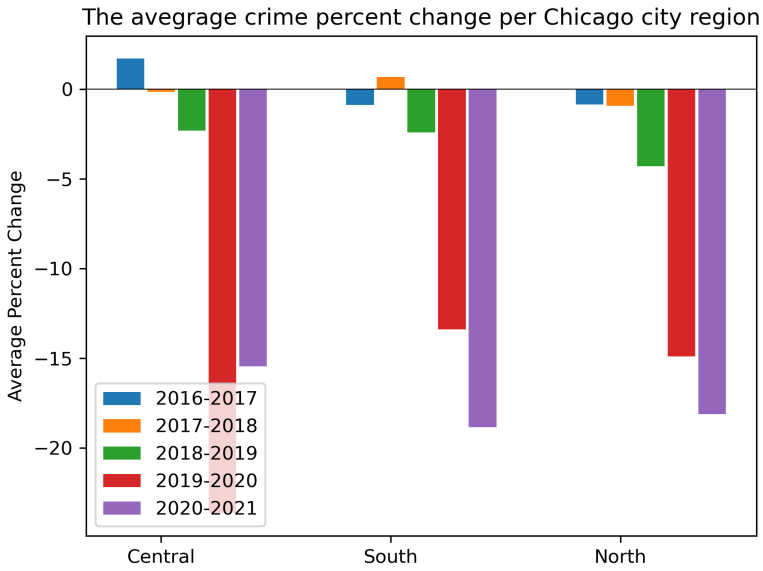

Fig. 9. The average crime percent change per Chicago city region

year 2020 had the highest number of domestic incidents accounting for 15.6% of total cases recorded for that year. This is not an unexpected finding due to the stay-home-orders instituted nationwide. However, there is a continuation of small arrest rates averaging around 1% due to the complex nature of police intervention in domestic situations. Statistically district 6 of Chicago has the highest rates of criminal activity and reports the highest number of domestic cases. This district is a densely populated residential area in comparison to metropolitain tourist areas such as districts 18-20. It is recommended that the city of Chicago create a better system of domestic reporting due to over half of incidents being left unreported. This roadblock creates difficulty in predicting when and where future domestic crimes can occur. Also, creating more accessibility to help for domestic victims residing in problematic areas such as district 6 would help address the consistent trends occurring over the years.

Overall, this exploration of the data has highlighted a clear trend of decreasing crime reports, but raises questions about the true cause for this change that, upon investigation, could lead to concrete improvements in urban systems of policing and justice.

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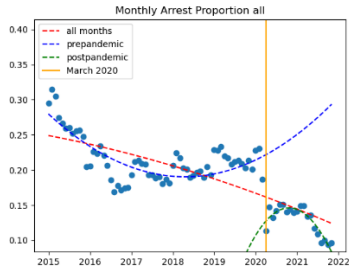
Appendix A: Outlier months for each type of crime

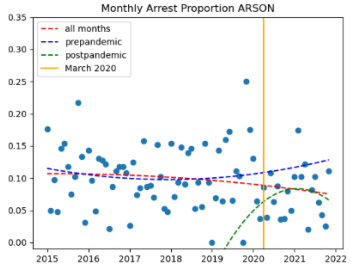
Type	sse	Top 10 outliers (month-yy)									
all	0.071	Feb-15	Feb-20	Jan-20	Aug-16	Mar-15	Oct-16	Nov-16	Sep-16	Mar-19	Dec-16
ARSON	0.1863	Nov-19	Oct-15	Jan-19	Oct-19	Feb-21	Jul-16	Dec-19	Jun-19	Jan-17	Dec-15
ASSAULT	0.042	Feb-20	Feb-15	Aug-16	Jan-19	Jul-19	Jul-15	Dec-19	Jun-19	Aug-19	Jan-20
BATTERY	0.0296	Feb-20	Jan-20	Feb-15	Dec-19	Jul-16	Aug-16	Nov-16	Jul-17	Jan-15	Mar-15
BURGLARY	0.012	Apr-20	Nov-21	Oct-21	Mar-20	Feb-19	Dec-19	Nov-18	May-16	Sep-20	May-21
CONCEALED CARRY LICENSE VIOLATION	0.2362	Dec-16	May-15	Sep-17	Nov-17	Sep-21	Aug-16	Jan-17	Apr-20	Mar-18	Jan-21
CRIMINAL DAMAGE	0.0064	Feb-15	Dec-16	Oct-16	Feb-20	Aug-16	Jan-20	Mar-15	Sep-19	Jul-16	Nov-16
CRIMINAL SEXUAL ASSAULT	0.0653	Jun-15	Jan-15	Mar-17	May-20	Nov-19	Sep-17	Jan-19	Aug-18	Jan-20	Feb-15
CRIMINAL TRESPASS	0.3373	Feb-20	Apr-20	Jun-20	Nov-19	Jul-16	Aug-16	Mar-19	Sep-16	Jan-20	Feb-15
DECEPTIVE PRACTICE	0.0097	Aug-18	Nov-16	Nov-15	Nov-19	Aug-15	Aug-19	Sep-20	Jan-16	Dec-19	Apr-20
GAMBLING	0.1729	Jun-21	Oct-21	Sep-21	Jul-21	May-21	Apr-21	Mar-21	Nov-20	Oct-20	Sep-20
HOMICIDE	0.6848	Jan-17	Apr-18	Mar-15	Jan-20	Oct-21	Feb-16	Nov-18	Nov-21	Dec-17	Oct-20
INTERFERENCE WITH PUBLIC OFFICER	0.1236	Jun-21	Jul-20	Mar-21	Mar-20	Jul-21	May-20	Jan-21	Dec-16	Jul-19	Jun-19
INTIMIDATION	0.5983	Dec-16	Jan-16	May-15	Jul-15	Apr-16	Mar-16	Jun-17	Jul-16	Sep-16	Oct-21
KIDNAPPING	0.4041	May-20	Apr-17	Jun-15	Feb-20	Dec-20	May-18	Mar-17	May-21	Jul-18	Dec-16
LIQUOR LAW VIOLATION	0.0054	Nov-15	Mar-16	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15
MOTOR VEHICLE THEFT	0.0119	Apr-18	Aug-15	Jul-20	Jun-18	Jan-17	Nov-15	Nov-19	Oct-18	Dec-16	Apr-16
NARCOTICS	0.0154	Aug-21	Jul-21	Nov-21	Feb-21	Jan-21	Dec-20	Mar-21	Nov-20	Oct-20	Sep-20
NON-CRIMINAL	0.9523	Feb-17	Apr-18	Mar-17	Jul-18	Aug-18	Jan-16				
OBSCENITY	3.9469	Nov-20	May-19	Sep-16	Dec-15	May-21	Jul-21	Mar-15	Apr-18	Jul-17	Apr-15
OFFENSE INVOLVING CHILDREN	0.0656	May-20	Oct-19	Mar-15	Jan-17	Aug-19	Apr-18	Nov-21	Feb-15	Dec-18	May-17

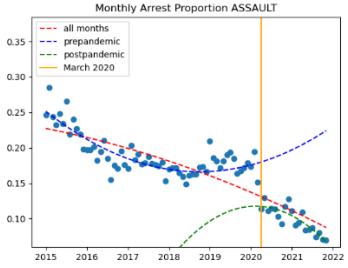
Appendix A: Outlier months for each type of crime

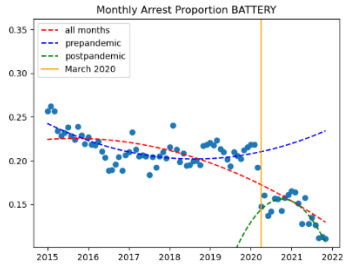
OTHER NARCOTIC VIOLATION	4.8592	Nov-18	Aug-19	Mar-17	Dec-16	Jun-15	Aug-20	Sep-15	May-21	Mar-21	Jan-16
OTHER OFFENSE	0.0993	Apr-20	Jun-20	Jan-20	Aug-16	Feb-20	Jul-20	Mar-15	Oct-16	Jul-16	Nov-19
PROSTITUTION	0.0156	Aug-20	Mar-20	Sep-21	Aug-21	Jul-21	Jun-21	May-21	Mar-21	Feb-21	Jan-21
PUBLIC INDECENCY	0	May-21	Feb-21	Jan-15	Jan-21	Feb-15	Mar-15	Nov-20	Apr-15	Dec-17	Apr-18
PUBLIC PEACE VIOLATION	0.7314	May-20	Nov-21	Dec-18	Jun-20	Oct-19	Nov-19	Jul-19	Sep-19	Sep-20	May-19
ROBBERY	0.0226	Feb-15	Apr-21	Oct-21	Jan-20	Nov-21	Mar-19	Jan-17	Dec-16	Apr-19	May-19
SEX OFFENSE	0.1735	Oct-17	Nov-20	Jan-15	Jan-16	Apr-15	Mar-20	Aug-15	Oct-19	Apr-17	Dec-18
STALKING	0.8622	Jan-15	Jan-19	Nov-19	Aug-19	Sep-20	Feb-15	Aug-15	Oct-17	Mar-18	Nov-15
THEFT	0.0168	Jan-20	Feb-20	Feb-15	Jul-16	Sep-16	Nov-19	Apr-20	Oct-16	Jan-19	Dec-19
WEAPONS VIOLATION	0.1585	Apr-20	Feb-20	Jan-17	Apr-19	Sep-16	Jan-16	Feb-21	Feb-17	May-16	Mar-17

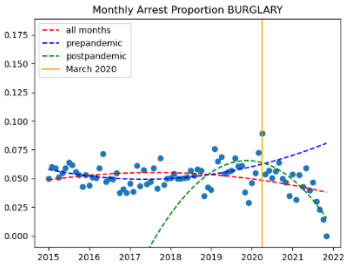
Appendix B: Arrest trends by crime type

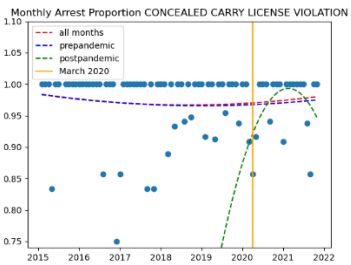


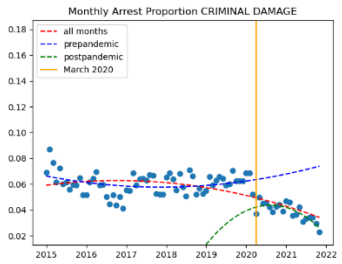


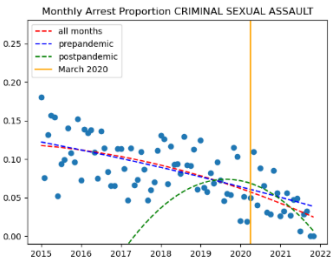


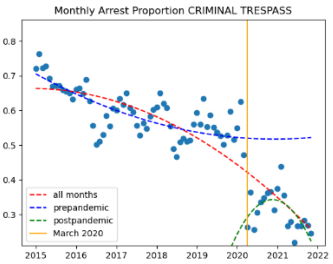


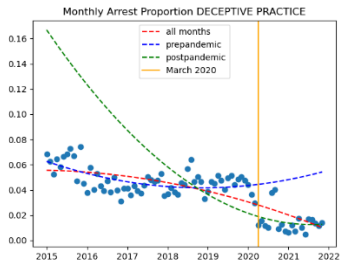


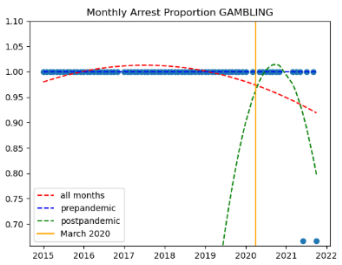


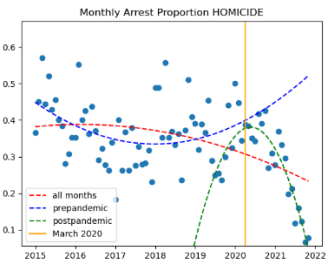


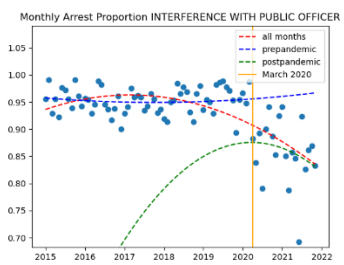


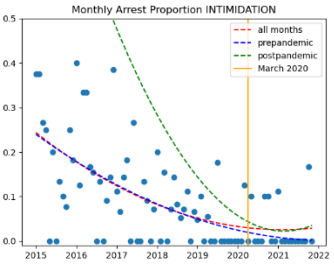


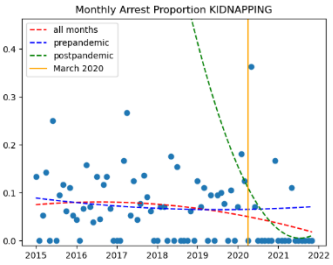


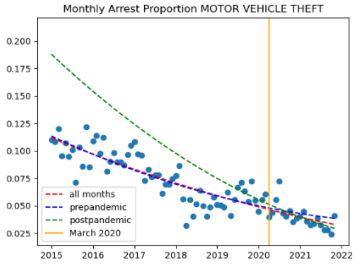


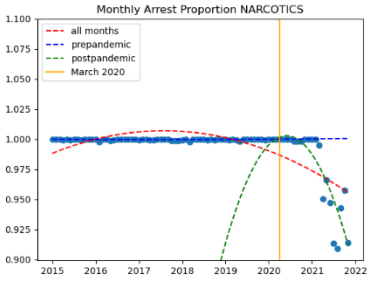


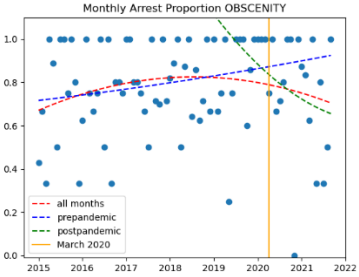


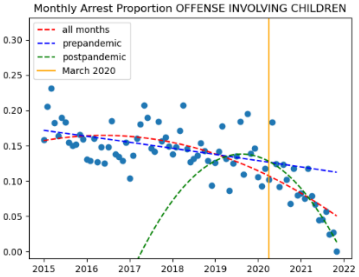


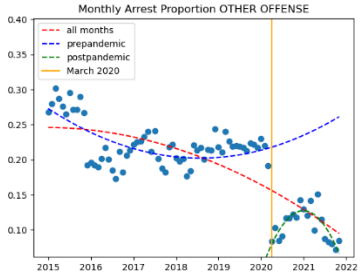


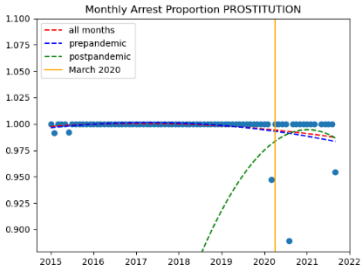

Monthly Arrest Proportion MOTOR VEHICLE THEFT
all months
prepandemic
postpandemic
March 2020

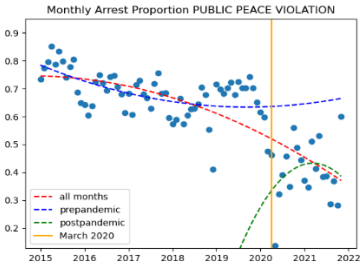

Monthly Arrest Proportion NARCOTICS
all months
prepandemic
postpandemic
March 2020

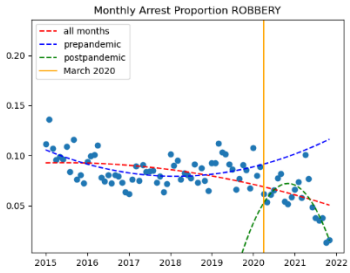

Monthly Arrest Proportion OBSCENITY
all months
prepandemic
postpandemic
March 2020

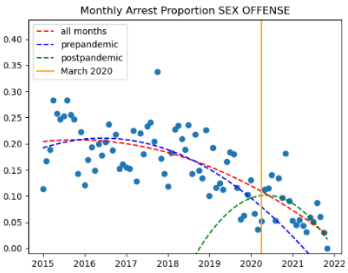

Monthly Arrest Proportion OFFENSE INVOLVING CHILDREN
all months
prepandemic
postpandemic
March 2020

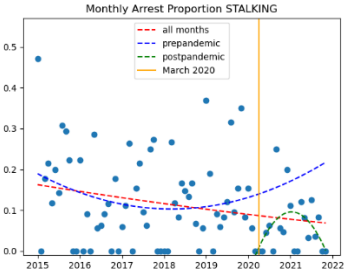

Monthly Arrest Proportion OTHER OFFENSE
all months
prepandemic
postpandemic
March 2020

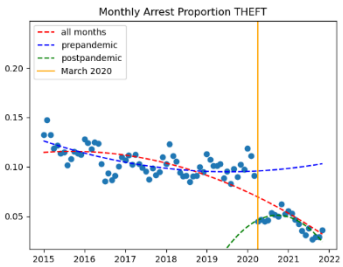

Monthly Arrest Proportion PROSTITUTION
all months
prepandemic
postpandemic
March 2020

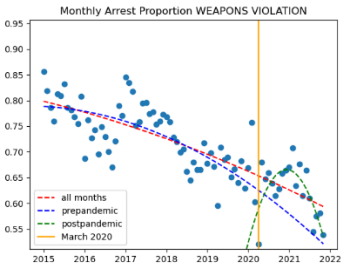

Monthly Arrest Proportion PUBLIC PEACE VIOLATION
all months
prepandemic
postpandemic
March 2020


Monthly Arrest Proportion ROBBERY
all months
prepandemic
postpandemic
March 2020


Monthly Arrest Proportion SEX OFFENSE
all months
prepandemic
postpandemic
March 2020


Monthly Arrest Proportion STALKING
all months
prepandemic
postpandemic
March 2020


Monthly Arrest Proportion THEFT
all months
prepandemic
postpandemic
March 2020


Monthly Arrest Proportion WEAPONS VIOLATION
all months
prepandemic
postpandemic
March 2020