Evaluation of Criminal Offenses and Law Enforcement in Chicago (2019 - 2021)

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Abstract

Effective law enforcement is the backbone of our rule of law, designed to minimize crime over time and across geographies. The costs of law enforcement failure range from rising crime rates to loss of trust in public institutions and ultimately infiltration of the state. This case study uses real data on crime in Chicago from 2019 until 2021 to identify patterns in crime, to measure law enforcement efficiency and to suggest possible tools to improve it. The case study illustrates the strong seasonality of crime. The majority of crimes in Chicago are committed between May and September, typically in the latter half of the day. Driving factors of seasonality are crimes of the type theft and battery. The efficiency of the Chicago police during these years is considered to be rather low. However, the metric used must be treated with caution as it is very limited by data availability.

1 Data

This evaluation of criminal offenses is based on data of real crimes in Chicago from 2019 until 2021 taken from the city's open data portal.[1] I consider all crimes with the exception of murders where data relates directly to each victim and consequently is not publicly available. The data set consists of 680,583 criminal offenses and related observations for the following list of variables:

Variable	Definition
ID	Unique identifier for the record
Case.Number	Unique to the incident
Date.Time	Date and Time when the incident occurred
Updated.On	Date and Time the record was last updated
Block	Address, same block where the incident occurred
IUCR	Illinois Uniform Crime Reporting code
Primary.Type	Primary description of IUCR code
Location.Describtion	Description of the location where the incident occurred
Arrest	1 if an arrest was made
Domestic	1 if domestic-related, Illinois Domestic Violence Act
Beat	Smallest police geographic territory
District	Police district where the incident occurred
Ward	City council district where the incident occurred
Community	Community area where the incident occurred
X/Y.Coordinate	Geographical location info where the incident occurred
Crime.Severity	1 if violent

Although the *Case.Number* should be unique, the data set on the city's open data portal contains duplicates for *Case.Number*. Since the differences between crimes with the same *Case.Number* are rather negligible, I assume that the deviations are minor recording errors. Some cases appear to be duplicated by accident and other might have been updated without deleting an earlier version as suggested by the associated timestamp *Updated.On*. I remove redundant observations. For each *Case.Number* only the unique observation with the latest *Updated.On* timestamp is kept.

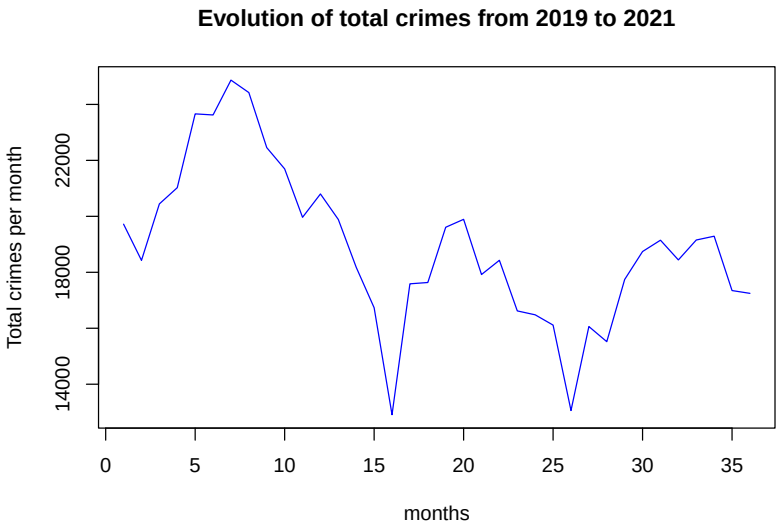
The data also contains many *NA*, especially in the columns describing the location of the incident. If a location parameter is missing, I use the most precise way available to infer it. With *Longitude* and *Latitude* the *X/Y.Coordinate* can be derived and vice

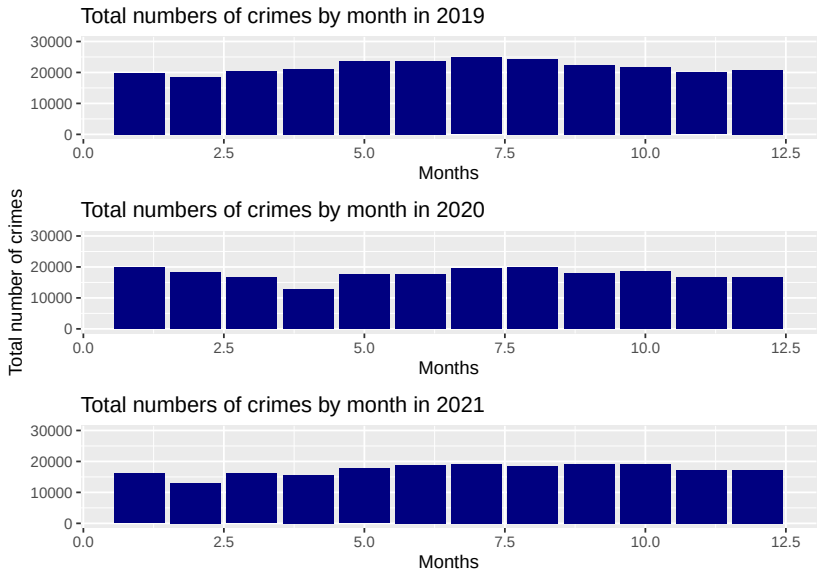
[1] https://data.cityofchicago.org/Public-Safety/Crimes-2001-to-Present/ijzp-q8t2/about_data

versa. By using the R application "Geocode" it is possible to obtain *X/Y.Coordinate* for a given specific address (*Block*).

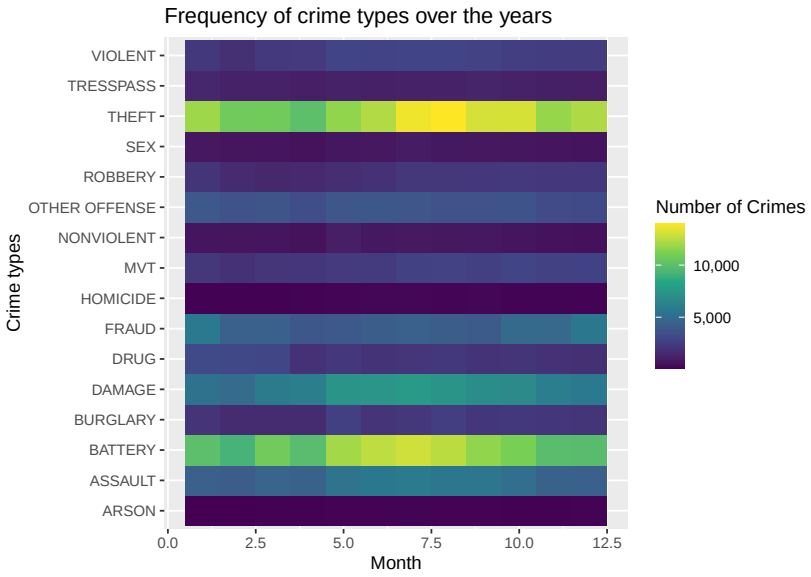
2 Evaluation of Crimes

Looking at the data from a broad perspective, there is an overall decrease in the number of crimes in Chicago from 2019 to 2021. What is striking is a sharp drop at the beginning of 2020, probably influenced by the COVID pandemic. In each of these three years, the number of offences seems to follow a pattern of fluctuation indicating some kind of seasonality.

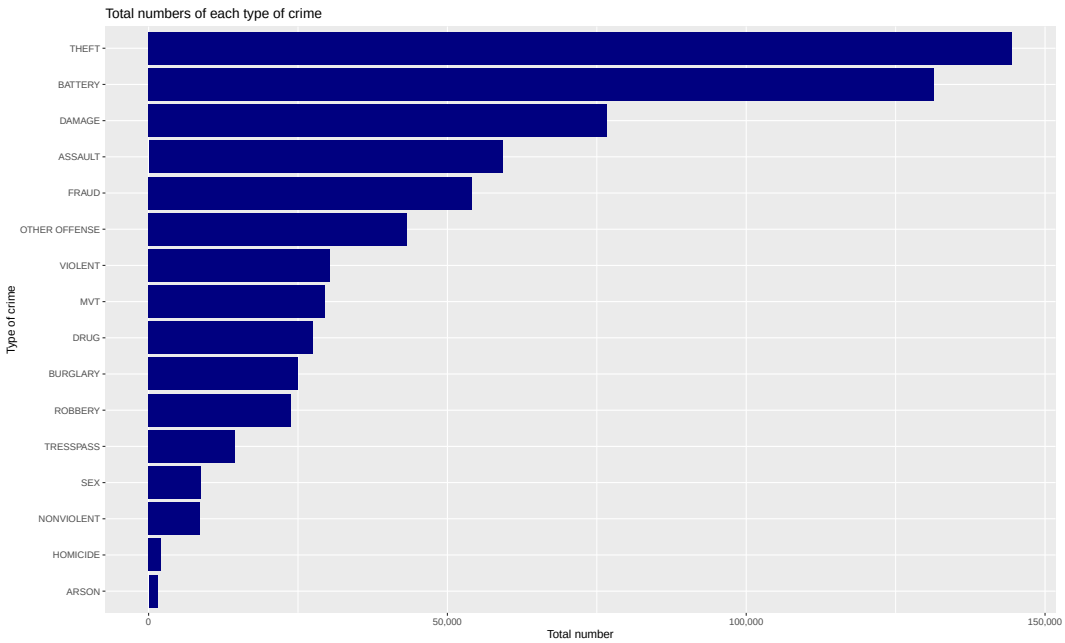




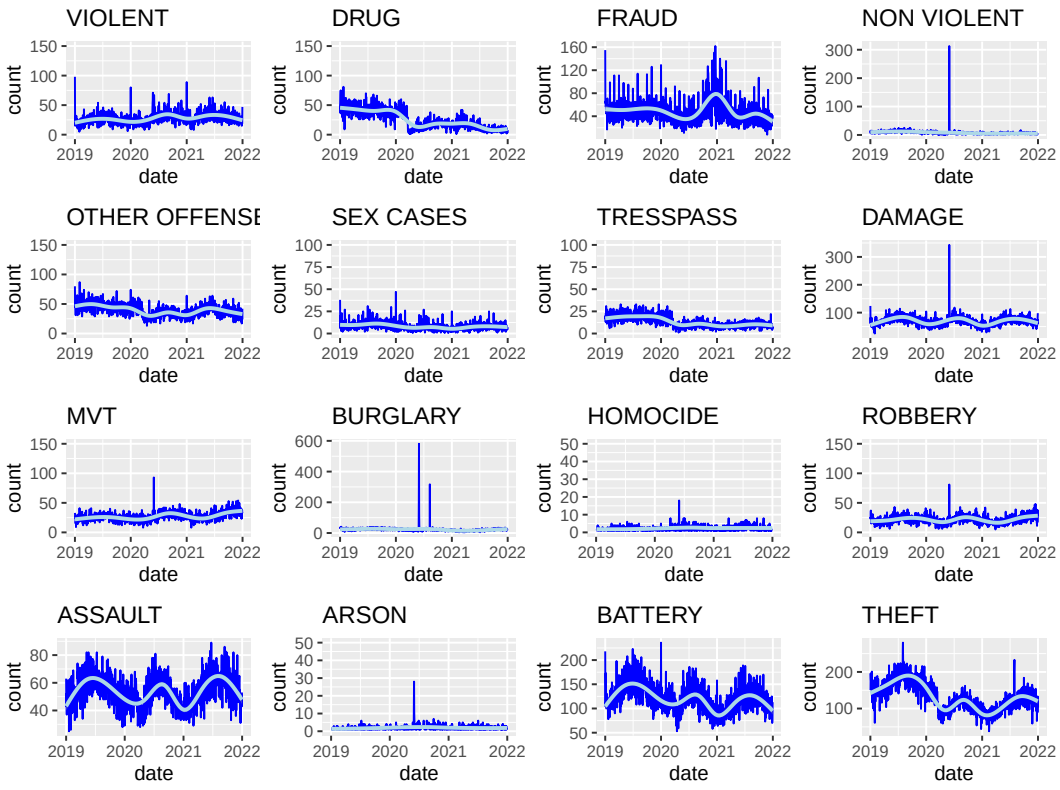
There is indeed a seasonality to crime in Chicago. Most crimes are concentrated between May and September in all three years. In particular, the offences of "Theft" and "Assault" increase significantly during the summer and appear to drive this seasonality in total crime.



Plotting the aggregated data for the three years of each crime category shows that the crime type "Theft" dominates followed by "Battery"and "Damage".



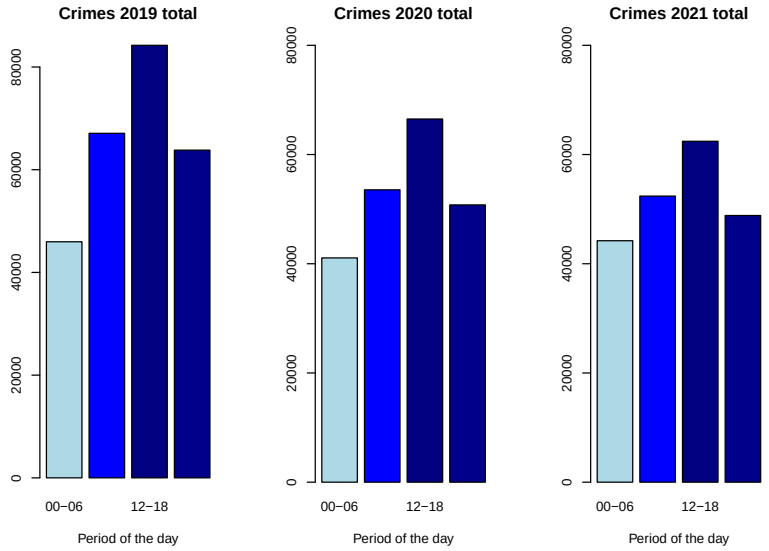
Further analysis of the evolution of the type of crime over the three years reveals a more nuanced pattern of variation. The pattern of "Assault", "Battery", "Theft", "Damage", "Robbery", "MVT" and "Other offence" seems to match the annual fluctuation pattern of all crimes: most crimes occur in the warm periods of the year. A possible explanation could be that temperature-sensitive criminal activity is quite dominant and has a significant impact on overall crime trends in Chicago.

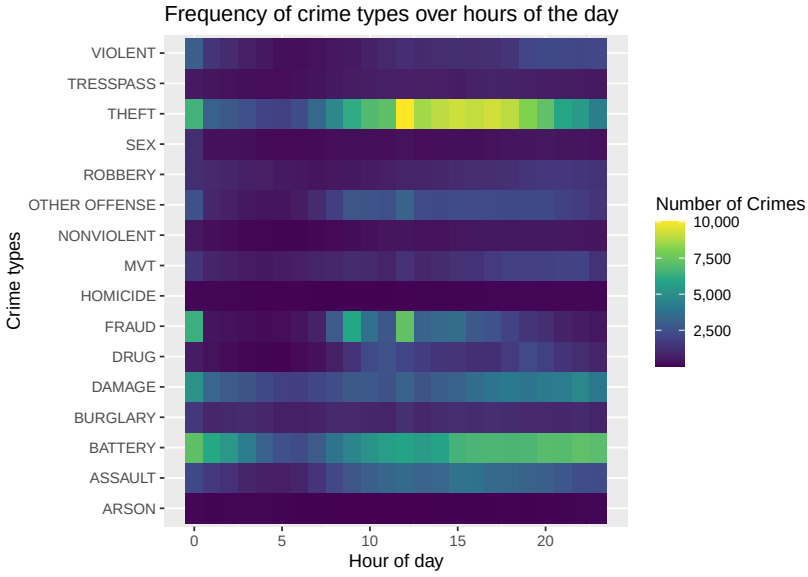


Overall, violent crimes seem to fluctuate more strongly than non-violent crimes. "Burglary", "Sex crimes", "Homocide" and "Argon" appear to remain constant. There is a negative trend for crimes related to "Drug" and "Tresspass". A key moment seems to be 2020 and the beginning of COVID. "Fraud" reached a massive peak in 2021, most likely due to a revival of an old time crime: cheque fraud.

Through the more nuanced analysis of crime trends in Chicago, an extreme value is revealed in the data. In the summer 2020, many crime types spike. This phenomenon is explained by the fact that in the summer of 2020, Chicago police used excessive force to violate the human rights of Black Lives Matter activists.

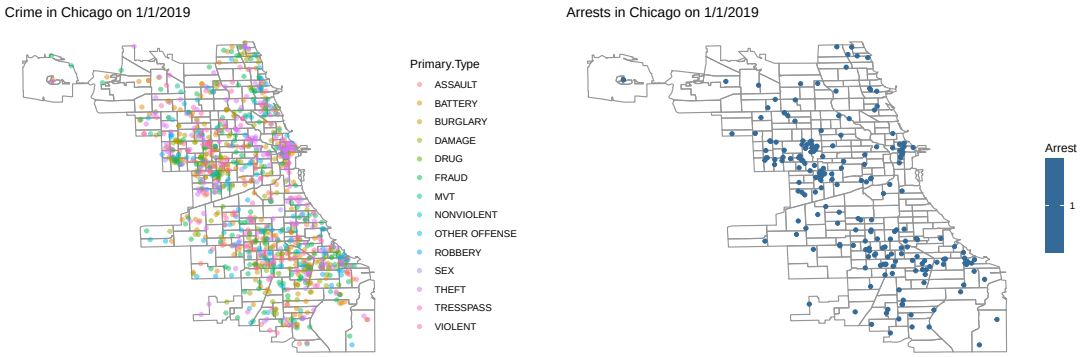
Looking at the distribution of crime incidents over the day, we can see that crime is more frequent in the second half of the day, between 12 and 18 o'clock. In fact, the heat map shows that most "Thefts" occur between 12 and 18 o'clock.





In order to observe crime trends in relation to their location, I construct a detailed police beat map with the exact locations of all crimes and arrests in Chicago on a selected day. The map uses colour to distinguish between different types of crime. In this way, the different types of crime that each police beat has to deal with can be

captured quite accurately. Areas with a lot of crime but very few arrests could be an indication of low police effectiveness.



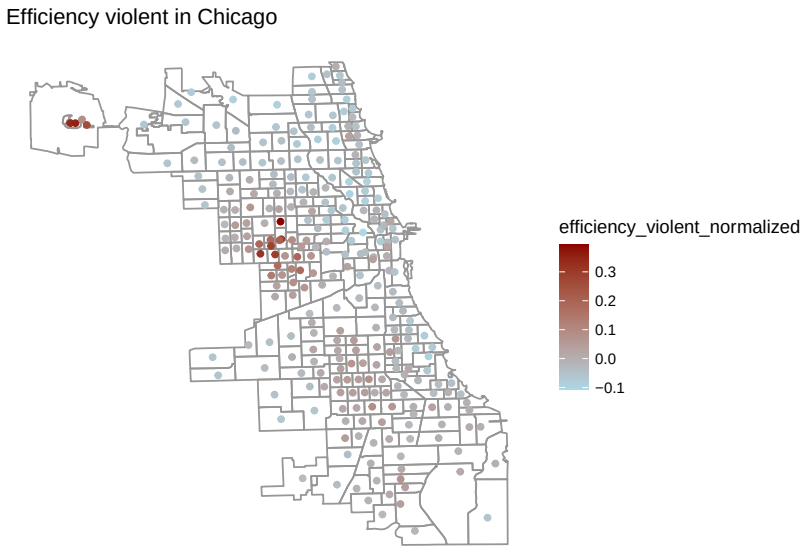
3 Evaluation of Law Enforcement

One possible measure of police effectiveness could be the ratio of arrests to total crime. The number of arrests made by the Chicago Police Department is used as a proxy for police activity. Arrests are a measurable outcome of police work. The number of arrests and crimes is calculated per beat, per day for the number of crimes or arrests within the last 30 days. The last 30 days are considered to eliminate the effect of possible outliers caused by a random event or an unusually high number of crimes on a particular day. Even though the quota of arrests relative to crimes gives some indication about the efficiency of the Chicago police, it does not account for which type of crimes actually lead to an arrest. To involve the severity of crimes the different types of crimes are separated into two types: violent and nonviolent crimes. Violent crimes are more likely to lead to an arrest. If a violent crime does not have an arrest as a consequence, it is an indication of low police efficiency.

The efficiency calculated for each police unit beat gives a value between 0 and 1 as an output. A police efficiency of 1 indicates a very high efficiency and 0 indicates a very low efficiency. Having the value of efficiency for each beat allows to take the average overall efficiency of the Chicago police for the years 2019, 2020 and 2021. For the efficiency regarding all crimes, the value of the arrest crime rate is 14.32% and for violent crimes the value of the arrest crime rate is 12.86%. This indicates a very low overall efficiency for violent crime. The efficiency for violent crime is even lower than

for all types of crime, although violent crime should lead to more arrests.

In order to make a comparison between the different police units across the city, I create a map showing the efficiency of the Chicago police for violent crime, where the efficiency for violent crime per beat is normalized by subtracting the average arrest rate per violent crime.



Police efficiency based on violent crimes
Red = efficient, Blue = inefficient

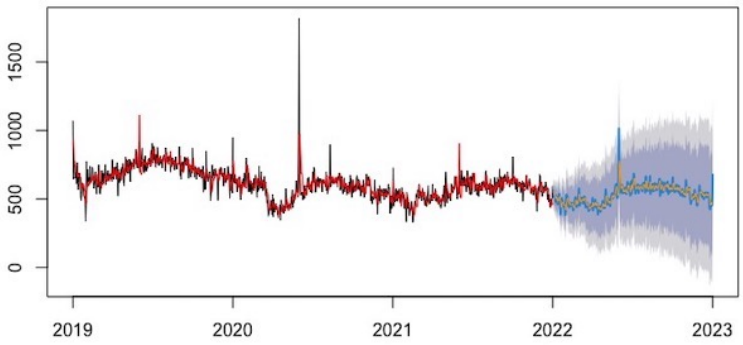
This map illustrates significant differences in the efficiency of police units across the city. Beats with higher efficiency cluster around the centre of Chicago and in the north-west beats of the city.

There are limitations to the analysis. It should be borne in mind that efficiency is proxied by arrests per crime. Since arrests indicate a higher level of police activity, this activity may be driven by a higher number of police stations in a given beat. As there were no data points for police stations in the datasets provided, efficiency is not weighted by the proportion of police stations in this analysis. The next step in a more advanced analysis would be to compare the efficiency weighted with the number of police stations in a particular beat. Another critical point to consider is that as much as an arrest indicates active policing, it does not necessarily mean that the police were inefficient in a particular case if no arrest was made. Furthermore, efficiency for violent crime depends on the definition of the type of crime. The categorization of the crime

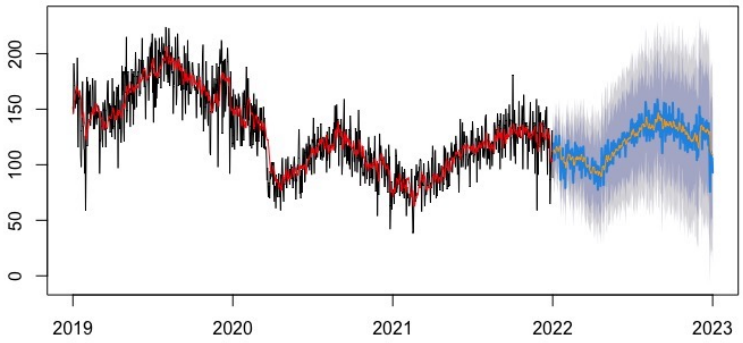
severity dummy is based on the assumption that an arrest must follow a violent crime. However, it is not known whether this is actually the case for all crimes included in the analysis.

4 Improvement of Law Enforcement

To improve law enforcement, crime prediction could play a fundamental role in considering when and where police officers are needed. The prediction of future crime in this case study is limited to the total number of crimes and the number of "Theft" occurring in the future. The crime type "Theft" was chosen for analysis because it appears to be an important driver of overall crime trends. The package "Rcrimeanalysis" is used to predict the total number of crimes and the total number of crimes of the primary type "Theft".

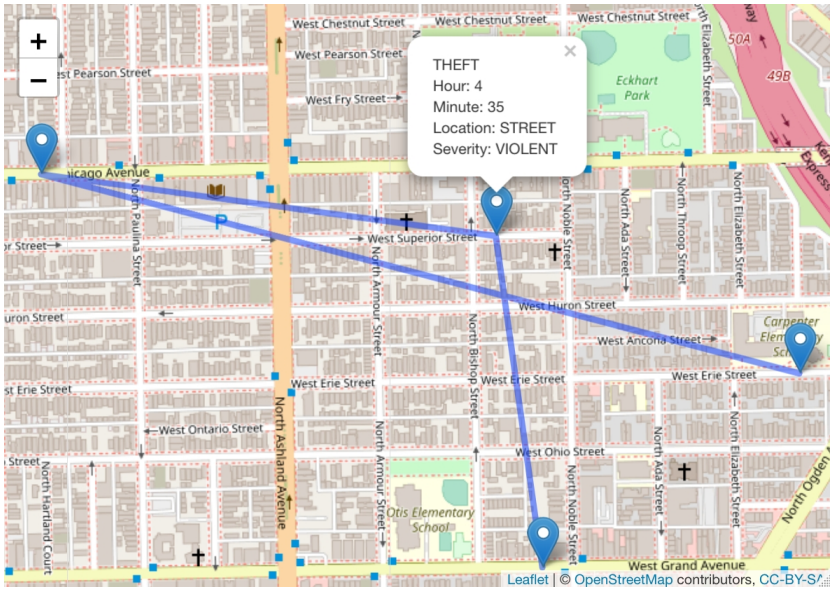


Total crimes in the past 30 days.
Prediction based on the 3-year history of crimes



Total crimes of primary type "Theft".
Prediction based on the 3-year history of crimes

Enforcement could also be improved through more strategic route planning. Assuming that the police are informed in time of the location where crime is currently taking place, the R-code suggests the optimal police route for an individual police unit on a given day. Providing police officers with the optimal route could save them important time and lead to greater efficiency. In addition, the map provides a first overview of the situations the officers will face.



Efficient route planning in beat 1215 on 01/01/2019

A comparison with data on the actual routes taken by police officers on a given day, patrolling or responding to calls for service, could provide further lessons for improving the efficiency of the Chicago Police Department's law enforcement.