IBM Data Science Capstone Project

Opioid Addiction Treatment in Boston MA

1. Introduction

1.1 Background

There is a crisis of opioid addiction across America and the situation only appears to be getting worse. This epidemic began with a significant increase in prescribed opioid medications for pain management in the 1990's. More recently, deaths from opioid overdose have increased sharply over the past few years following the introduction of Fentanyl, a powerful synthetic opioid [1].

1.2 Problem

Boston is the state capital and largest city in Massachusetts. It's also the Massachusetts city with the greatest amount of incidents of opioid overdose [2] and this problem is likely to continue to increase [1]. A recent study projects that the annual number of deaths by opioid overdose will increase from 33,100 in 2015 to 81,700 in 2025, a 147 percent increase [1]. This being the case, it seems prudent to explore what treatment options are available in Boston, where they are located, and what can be strengthened, in light of a probable increase in need for these services.

1.3 Current Model for Addiction Treatment

The current model of opioid addiction treatment ideally begins with physical detox, possibly following an emergency department admission for intoxication or overdose. This is often followed by Medication-Assisted Treatment (MAT) using Methadone or Buprenorphine, which ideally coincides with a progression from a CSS, to a TSS, and ultimately to a Halfway House. Details for these forms of treatment are given below [3]:

Acute Treatment Services (ATS or Detox)

Length: 3–7 days

Detox is the medical supervision of withdrawal from opiates. This is necessary to manage the sometimes life-threatening withdrawal effects of detox. These facilities are inpatient units that provide 24hr evaluation and management of withdrawal symptoms.

Medication-Assisted Treatment (MAT)

MAT includes the use of medication often coupled with counseling and other supports. Medication also can reduce cravings and withdrawal symptoms. This is a long-term treatment engaged in throughout CSS, TSS, and Halfway House placements.

Clinical Stabilization Services (CSS)

Length: ~14 days

Clinical Stabilization Services (CSS) provide short-term inpatient treatment, stabilization, and referral services for clients who don't qualify for medically monitored detoxification or who have already completed a detoxification program. Stabilization programs include a comprehensive assessment, individual and group counseling, health education, some medical support, and planning for longer-term support services.

Transitional Support Services (TSS)

Length: 2-4 weeks

Transitional Support Service (TSS) are short-term residential programs that accept clients from detoxification, clinical stabilization services (CSS) programs, or from the community if there isn't a risk for physical withdrawal. In order to enter a TSS program, the person must plan to enter a long-term program, such as a Halfway House.

Halfway House

Length: 4-6 months.

Halfway houses are licensed and overseen by the Massachusetts Department of Public Health. The goal of treatment is to help the person gain a deeper understanding of addiction, recovery, and the practical skills needed to live addiction free. These provide a drug free living environment, case management services, and recovery support meetings in the house and in the community where members can find mutual or "peer" support.

1.4 Plan and Interest

I will explore the number of these facilities around Boston and their location and proximity to each other. Location is important for two major reasons. First, ease of access is important and people in treatment need to be able to access services easily, so as to not become discouraged and increase the risk of relapse. For example, it would be helpful for MAT clinics to be located near halfway houses because the person in recovery needs to visit these facilities on a daily basis. A long daily commute can add stress to an already stressful process and take time away from other important areas of treatment. Furthermore, many people in recovery have financial difficulties and it may be difficult logistically to travel. Secondly, it is known that having the support of family and friends through this process is important and can help prevent relapse, so it would be ideal to have supports nearby [3]. In consideration of an expected continued increase in addiction problems and overdoses [1], I will also explore whether there seem to be any gaps in treatment options and what could be recommended for the future. This will likely be of interest for not only the medical community, as there will be a need for increased services in the near future, but also to the families of those suffering through addiction.

2. Data

This project made use of the following data sources:

Location Data for Boston

Web scraping was utilized to pull zip code, city, and county data from the https://www.zip-codes.com/state/ma.asp website. This was cleaned and reduced to show only zip codes and cities within Boston, or Suffolk County. Another website was used to get all of the latitude and longitude coordinates by zip code (https://gist.githubusercontent.com/erichurst/7882666/raw/5bdc46db47d9515269ab12ed6fb2850377fd869e/US%2520Zip%2520Codes%2520from%25202013%2520Government%2520Data).

Addiction Treatment Services in Boston

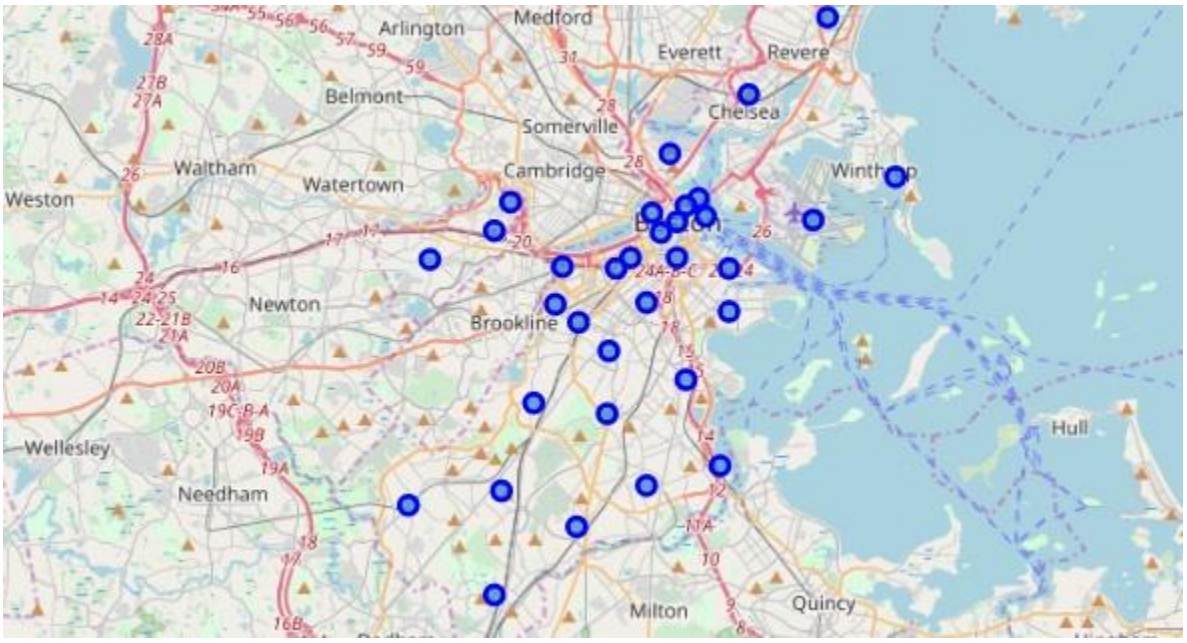
Foursquare's API will be used to pull all Emergency Department data for Boston. Emergency Department names and latitude and longitude will be called from the API.

Further addiction services locations are not available on Foursquare's API, so it was necessary to create a dataset with this information. A list of addiction services was used from MOAR (Massachusetts Organization for Addiction Recovery) at https://docs.wixstatic.com/ugd/8256b8_c57f31e039d547cbb67e13fb84c6ceed.pdf. These facilities were searched for on Google maps for zip codes, latitude, and longitude.

3. Methods

3.1 Data Preparation

Data scraping was used to pull zip codes, cities, counties, and zip code type for all zip codes in Massachusetts. Since Boston was the focal point of this project, all counties other than Suffolk County were dropped from the data frame. Also dropped was “zip code type”, as this isn’t necessary for this project. Next, a csv file was imported with all coordinates (latitude and longitude) for each zip code in the USA. This was merged with the Boston dataframe. Such that all Suffolk County zip codes were retained and coordinates were added for each. The resulting data frame had four columns; zip code, city, latitude, and longitude. There were 33 zip codes in total for Suffolk County. Shown below is a map with all Boston zip codes.



Foursquare’s API was then used to pulls data for all Boston area Emergency Departments, their zip codes, cities, and latitude and longitude’s. After inspection, it became clear the category ID for Emergency Room (4bf58dd8d48988d194941735) incorrectly included a couple of dentist offices and some duplicate information, such as separate entries for ambulance bays. The data was cleaned, such that only rows remained for actual emergency departments in Boston without duplicates. This dataframe was then merged with the previous dataframe including coordinate information for each zip code with 7 resulting columns: ZIP code, latitude, longitude, facility name, facility latitude, facility longitude, and facility category.

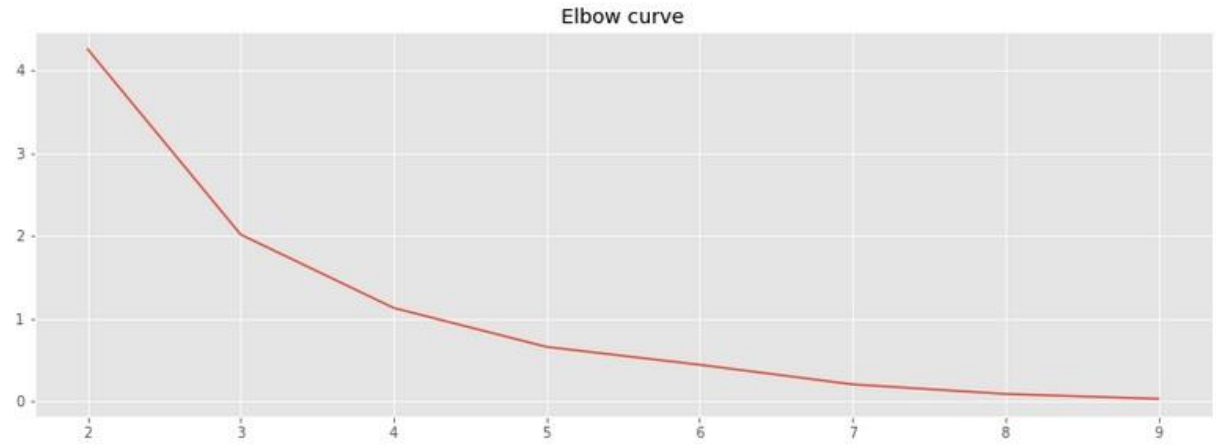
Because Foursquare does not have location data for other addiction services, it was necessary to create a csv file with this information gathered from the internet. A thorough search was conducted for Boston area addiction services, including halfway houses, ATS detoxes, MAT clinics, TSS, and CSS programs. Google Maps was used to gather specific latitude and longitude

coordinates for each entry. This data frame was then concatenated with the previous data frame resulting in 7columns (ZIP code, latitude, longitude, facility name, facility latitude, facility longitude, and facility category) and all 6 facilities (ED, ATS, MAT, Halfway House, CSS, and TSS). The resulting dataframe is shown below:

	ZIP	LAT	LNG	Venue	v_lat	v_lng	v_category
0	02119	42.324029	-71.064858	Hope House	42.330585	-71.074463	Halfway House
1	02116	42.350579	-71.076397	Men & Women's Sober Living & Recovery House	42.352383	-71.064130	Halfway House
2	02127	42.334992	-71.039093	Cushing House	42.336591	-71.055968	Halfway House
3	02127	42.334992	-71.039093	Answer House	42.336187	-71.044349	Halfway House
4	02130	42.309174	-71.113835	Sullivan House	42.308332	-71.101316	Halfway House
5	02130	42.309174	-71.113835	Portis Family Home	42.325400	-71.111755	Halfway House

3.2 Data Analysis

First, we conducted some exploratory analyses looking at frequencies of the specific facility types and what zip codes they are located in. This was done by plotting a bar chart using matplotlib and then sorting facilities by frequency for each zip code. Following this, we created a new dataframe with only the zip codes and 4 most common facilities for each zip code. We chose to show the 4 most common facilities because the exploratory analysis revealed that all zip codes had between 0 and 4 total facilities each, so it would not be informative to look at more. We then plotted an "elbow curve" graph to determine what the optimal number of clusters should be (range of k: 1-10). The elbow curve revealed a fairly smooth curve, showing that the data may not be heavily clustered.



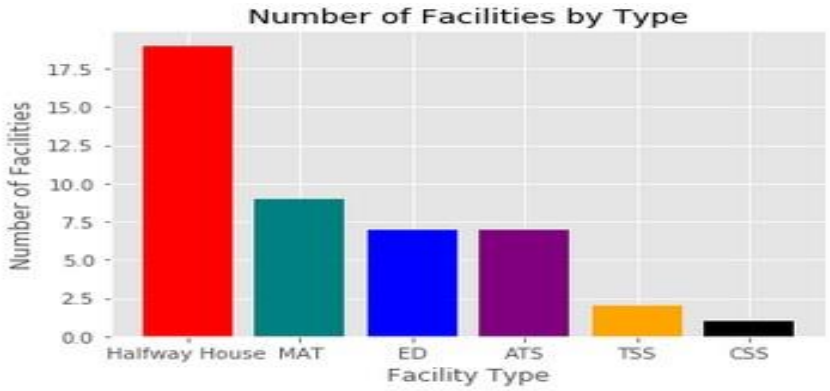
The above elbow curve shows a fairly gradual decline after 3 clusters and could be interpreted in numerous ways. This being the case, a second method was used to determine optimal cluster size and Silhouette scores were computed revealing the best cluster size as '7'. Finally, a K-Means clustering algorithm was run using scikit-learn. This was followed by adding a "cluster" column

to the dataframe and dropping all rows with NaN values. The clusters were then visualized over a map of Boston using Folium.

4. Results

4.1 Exploratory Analysis

A bar chart was constructed showing total counts by facility. It's apparent from this visualization that there are a number of ED's, MAT clinics, and many Halfway Houses, but there are very few CSS and TSS facilities.

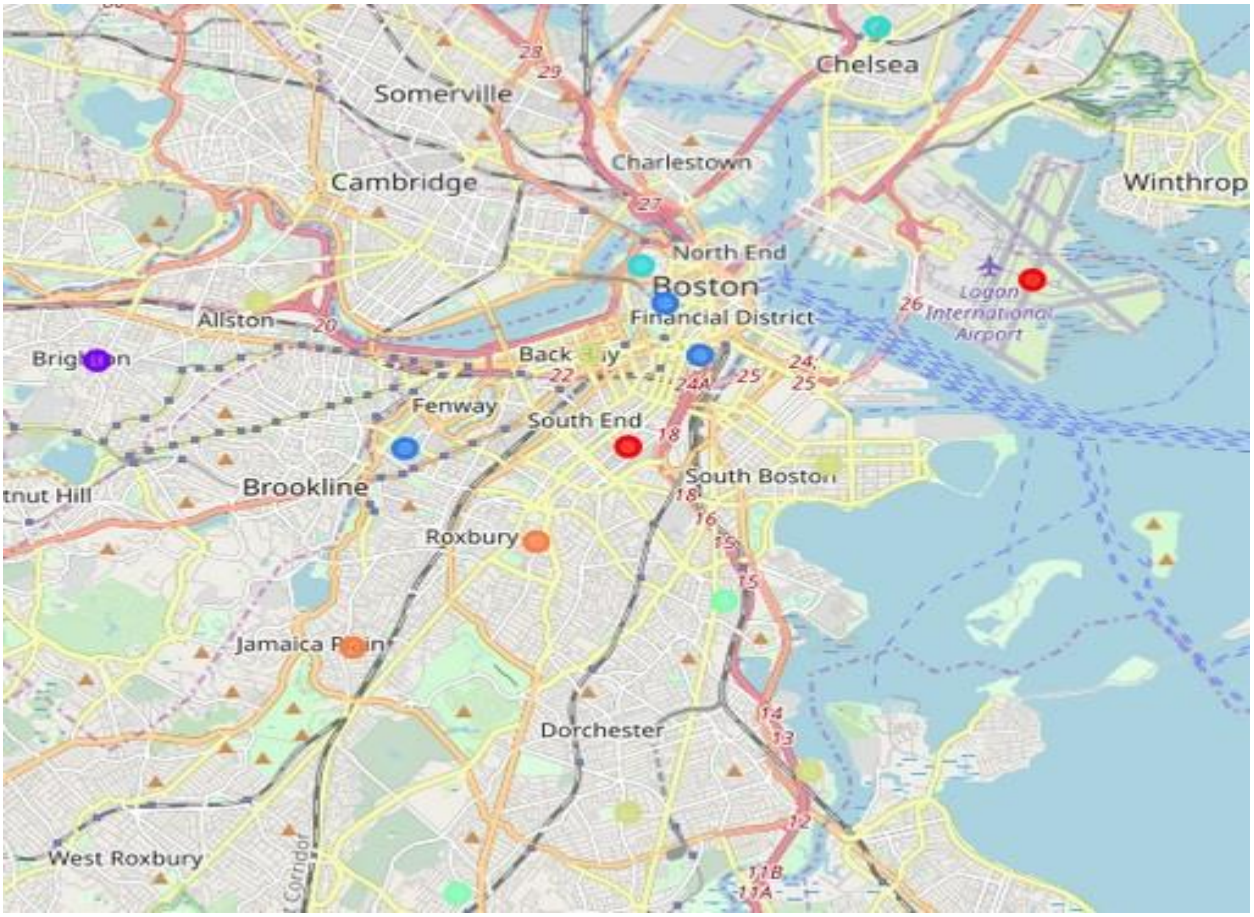


Below is the frequency by zip code chart. We can see that there are17 zip codes with at least 1 facility. This means that out of the 33 total zip codes for Suffolk County, there are 16 zip codes in the Boston area that have no facilities whatsoever.

	ZIP	ATS	CSS	Emergency Room	Halfway House	MAT	TSS
0	02108	0.000000	0.00	1.000000	0.000000	0.000000	0.000000
1	02111	0.000000	0.00	1.000000	0.000000	0.000000	0.000000
2	02114	0.000000	0.00	0.000000	0.000000	1.000000	0.000000
3	02115	0.000000	0.00	1.000000	0.000000	0.000000	0.000000
4	02116	0.000000	0.00	0.000000	1.000000	0.000000	0.000000
5	02118	0.125000	0.00	0.125000	0.375000	0.375000	0.000000
6	02119	0.250000	0.25	0.000000	0.500000	0.000000	0.000000
7	02122	0.000000	0.00	0.000000	1.000000	0.000000	0.000000
8	02124	0.000000	0.00	0.000000	1.000000	0.000000	0.000000
9	02125	0.000000	0.00	0.000000	0.666667	0.000000	0.333333
10	02126	0.000000	0.00	0.000000	0.500000	0.000000	0.500000
11	02127	0.000000	0.00	0.000000	1.000000	0.000000	0.000000
12	02128	0.000000	0.00	0.000000	0.666667	0.333333	0.000000
13	02130	0.571429	0.00	0.000000	0.285714	0.142857	0.000000
14	02134	0.000000	0.00	0.000000	1.000000	0.000000	0.000000
15	02135	0.333333	0.00	0.333333	0.000000	0.333333	0.000000
16	02150	0.000000	0.00	0.000000	0.000000	1.000000	0.000000

4.2 K-Means Clustering

Below are the 7 clusters visualized over the map of Boston:



Results show that Emergency Departments tend to cluster near the center of the city in Cluster 2 (Blue). Medication Assisted Treatment (MAT) seem to be in Clusters 0 (Red), 1 (Purple), and 3 (Teal). ATS detox facilities appear mainly in Cluster 6 (Orange) around Jamaica Plain. Halfway Houses are mainly in Cluster 5 (Yellow) and are shown to be spread out widely throughout the map. TSS facilities make up Cluster 4 (Green) and are mainly south of the city. There are no CSS facilities prominent for any cluster, which seems reasonable considering there is only 1 facility in the area.

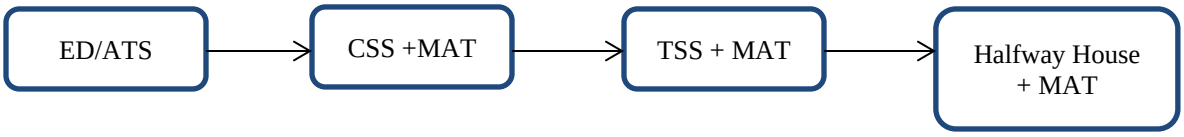
5. Discussion

There are a few key insights gained from the present results. The Emergency Departments are mostly centered around the heart of Boston. There are numerous facilities and many are considered top-tier teaching hospitals connected with medical schools. There are many Halfway Houses and these are spread out throughout the city. There are also numerous MAT clinics mainly spread out around the inner city, Chelsea, and in Brighton. This might pose a problem for those who live south of the city, where ease of access would be lower with fewer options for

public transport. The ATS facilities are mainly in Jamaica Plain. Indeed, more than half (4 out of 7 total) of the ATS facilities are in Jamaica Plain (02130). Both CSS and TSS facilities are very scarce with only 1 and 2, respectively. All three are located south on the map. On closer inspection, the CSS and one of the TSS facilities appear to be for females only. This leaves only one TSS and zero CSS for males. This seems to be Boston's biggest gap in treatment for addiction and if the relapse rate for addiction is 40-60% [4], it seems like a crucial gap to fill. The TSS and CSS facilities are structured intermediate treatment programs designed to help a person transition from physical detox to a more stable and less structured living environment. They provide important supports and treatment plans during a period of time when the chance of relapse is quite high. According to a report in 2015, the state of Massachusetts has about 860 total ATS beds and only 297 CSS and 339 TSS beds available [5]. This means that a significant amount of people are being discharged from the ATS facilities without adequate support, thereby increasing the risk for relapse.

6. Conclusion

The current model for addiction treatment in Boston moves along a progression as such:



The reasoning behind this progression is to first help the patient get through the physical withdrawal in the Emergency Departments and the ATS facilities before moving on to highly structured and supportive programs, such as CSS and TSS, and finally to a less structured residential placement in a halfway house. The patient is likely engaging in MAT throughout this process.

The results of the study show two main problems that could be addressed. First, since the patient is likely engaged in medication-assisted treatment (MAT) throughout the process, it would be helpful to have these clinics spread out more evenly. A good location for another MAT might be south of the inner city, perhaps in Dorchester. Second, there are not many CSS or TSS facilities, particularly for men. Because these serve as important bridge programs between detox and residential placement when the risk of relapse is quite high, it is highly recommended to add more of these facilities. Since the existing facilities are all south of Boston proper, it might be prudent to set other facilities in the inner part of the city or around the Brighton/Allston area.

7. References

1. Website: https://www.massgeneral.org/News/pressrelease.aspx?id=2351

2. Website: https://www.mass.gov/files/documents/2019/05/15/Emergency-Medical-Services-Data-May-2019.pdf

3. Chalana, H., Kundal, T., Gupta, V, & Malhari, A. (2016). Predictors of relapse after opioid detoxification during 1-year follow-up. *Journal of Addiction*, 7620860. doi:10.1155/2016/7620860

4. Website: https://www.drugabuse.gov/publications/principles-drug-addiction-treatment-research-based-guide-third-edition/frequently-asked-questions/how-effective-drug-addiction-treatment

5. Website: https://www.mass.gov/files/documents/2016/08/nr/csat-access-to-substance-use-disorder-treatment-in-mass.pdf