

# Modeling Toronto Hospital Network Coverage Expansion

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February 10, 2020

## 1. Introduction

### 1.1 Background

Toronto was the second fastest growing metropolitan area in the United States and Canada in 2018 ([Ryerson University Research](#)). Such growth requires infrastructure expansion prediction and according planning.

### 1.2 Problem

This project aims to predict optimal placement of hospital facilities based on emergency incident statistics.

### 1.3 Interest

Toronto city Council would be interested in the results of this research since it can be used in [The Official Plan](#) of city development.

## 2. Data sources and pre-processing

### 2.1 Data Sources

Dataset for research will be obtained from three sources:

- Wikipedia: [List of postal codes of Canada: M](#)
- Toronto Open Data Portal: [Paramedic Service Incident Data](#)
- Nominatim service, for geo data: Python [geopy](#) library
- Foursquare API for hospitals location data, [site](#)

### 2.2 Data Pre-processing

Service Incident data (2010-2019) will be cleaned and used for incident prediction for the next decade. Hospital location data obtained from Foursquare will be used to analyze current coverage and prediction of new facilities placement.

## 2.3 Data Linkage

Service Incident data structure:

ID	Dispatch_Time	Incident_Type	Priority_Number	Units_Arrived_At_Scene	Forward_Sortation_Area
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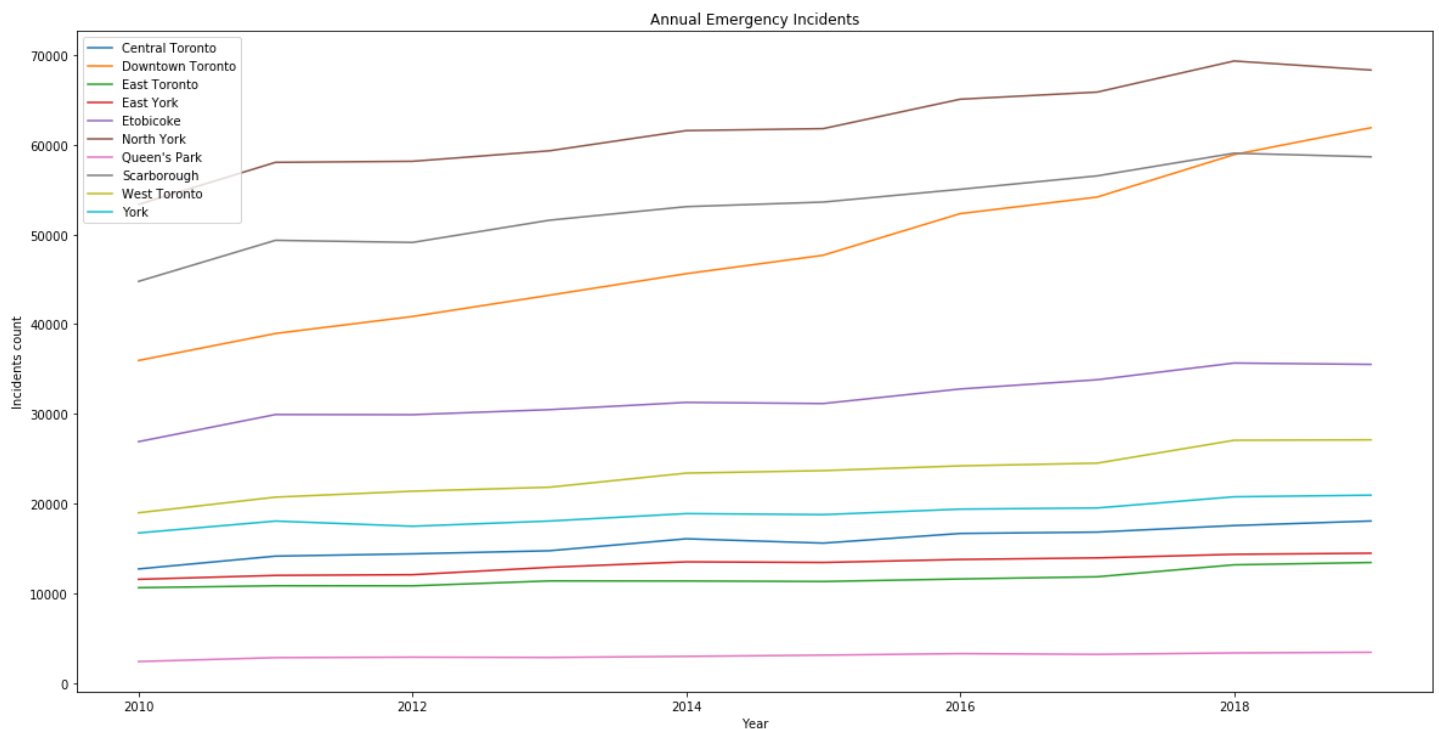
Data clustered in 10 clusters for every year in 2010-2019. We are interested in 'Forward\_Sortation\_Area' which is Post Code and 'Units\_Arrived\_At\_Scene' to get aggregated values for each Borough annually.

Using 'Forward\_Sortation\_Area' this data will be linked to Borough data for analysis. Foursquare API will be used for retrieving current hospital facilities which also will be assigned to Boroughs.

## 3. Exploratory Data analysis

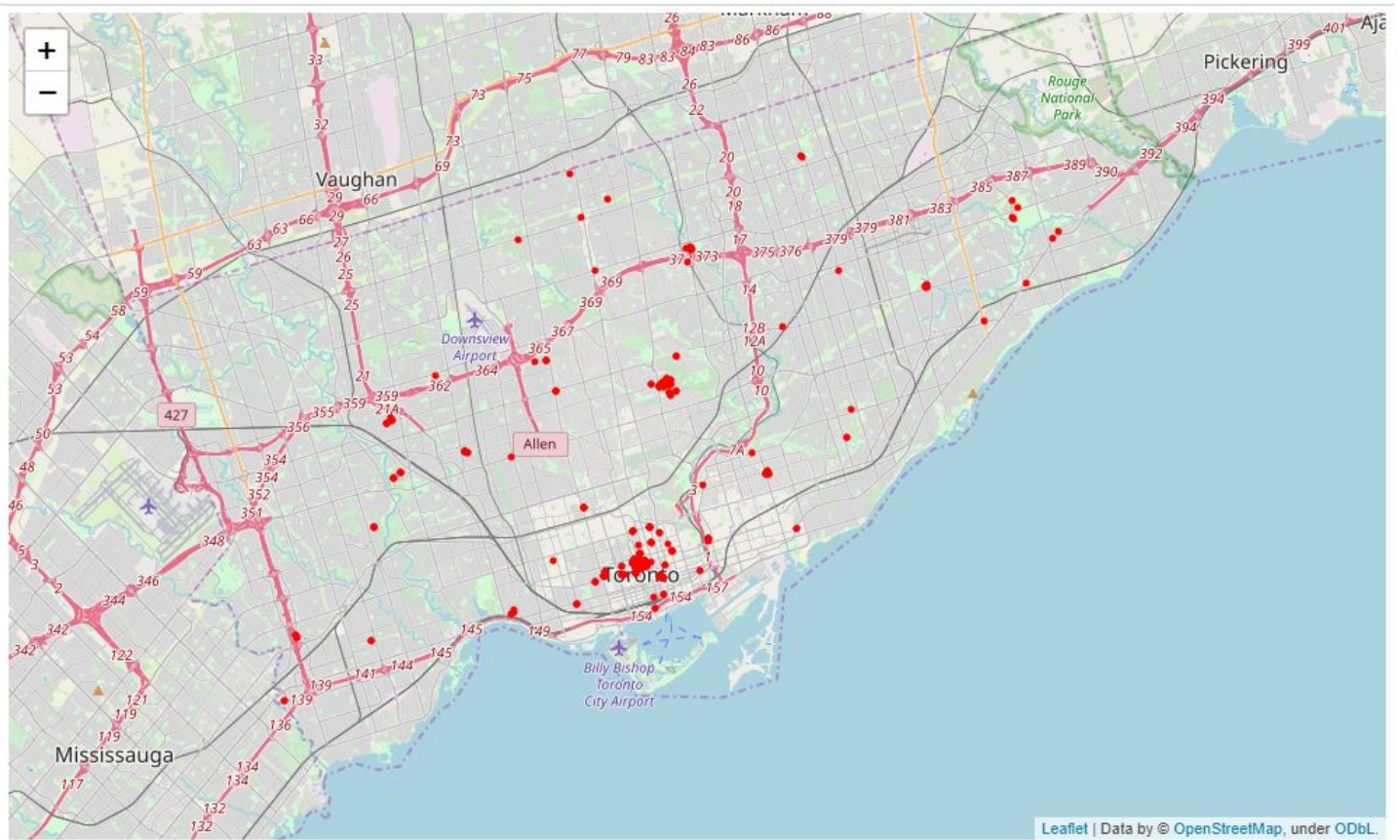
### 3.1 Prediction of emergency incidents count for the next decade

Emergency incident data was prepared and displayed as graph:



### 3.2 Emergency facilities location visualization

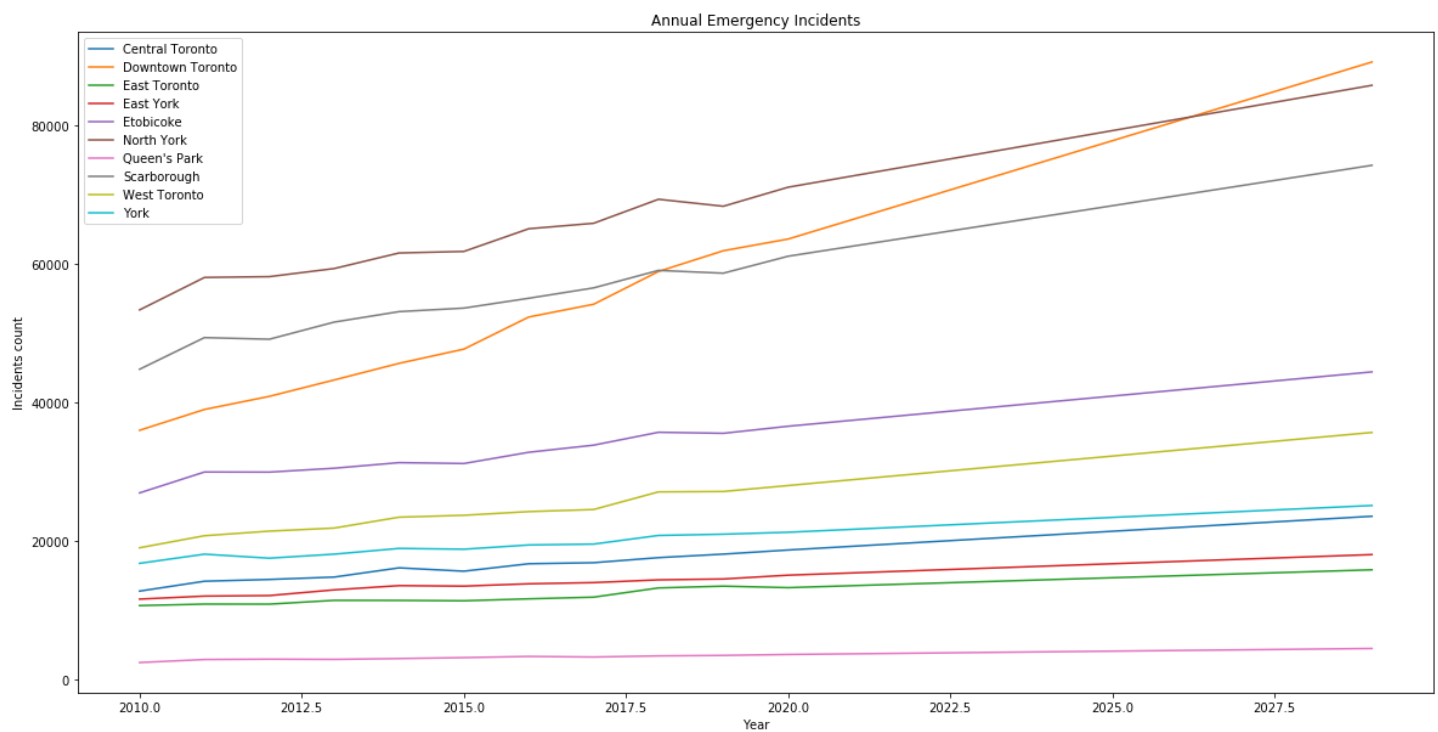
Emergency facilities location data retrieved from Foursquare and placed on map:



## 4. Predictive Modeling

### 4.1 Regression model

As a result of emergency incidents graph observation we can use Linear Regression to predict values for the next decade. Predicted values are displayed as graph:



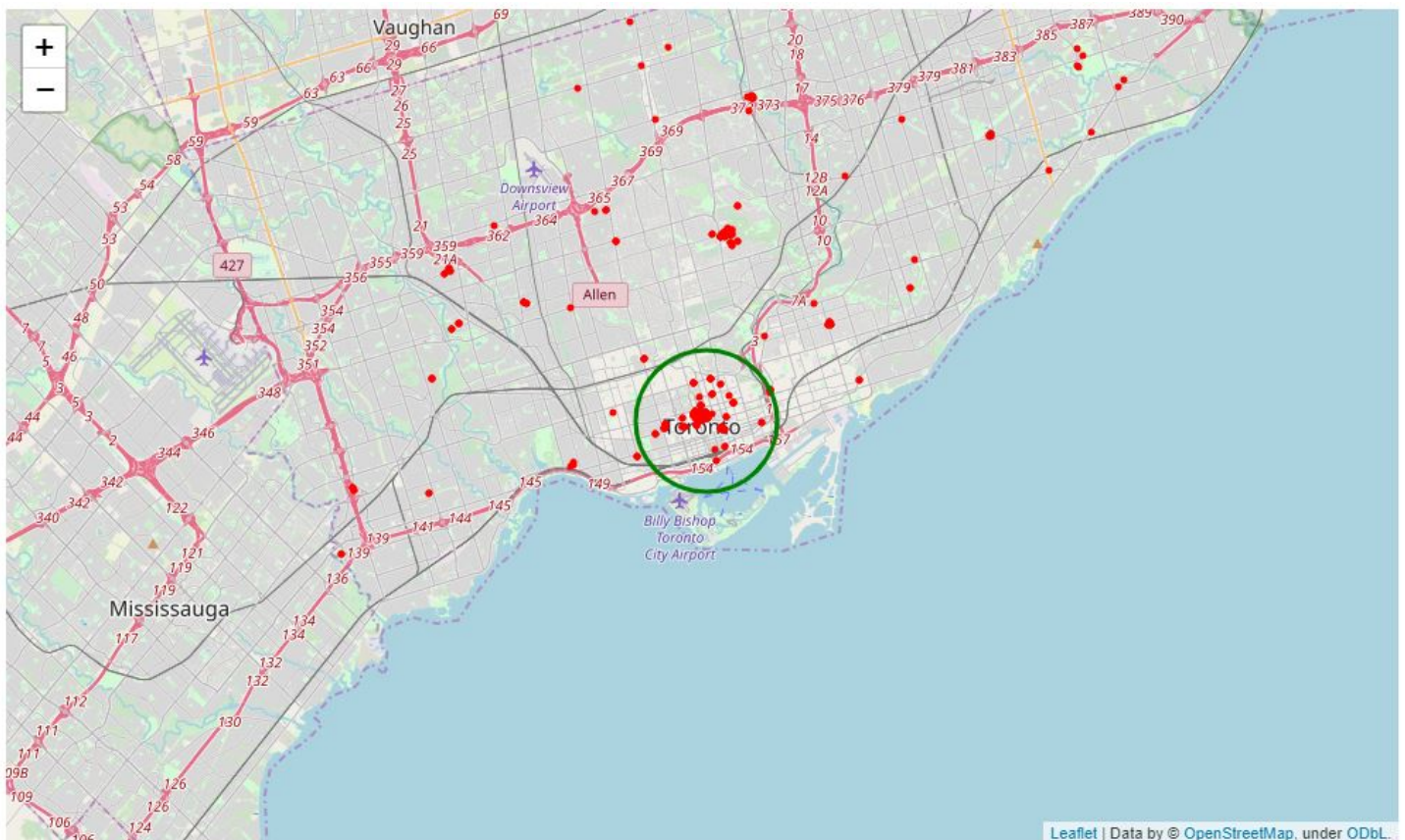
Major predicted incident growth is observed for Downtown Toronto borough. Predicted value for 2029 will outgrow all other boroughs.

## 5. Conclusions

This study analyzes Toronto emergency incidents for the past decade and intended to predict their growth for the next decade. Study results show that Downtown Toronto predicted value for 2029 will outgrow all other boroughs. This growth can be the outcome of city urbanization.

General outcome of this research is a recommendation for Toronto City Council to plan city infrastructure accordingly to cover Downtown Toronto with emergency services coverage.

When planning changes to city infrastructure we should keep in mind that Downtown Toronto has most of emergency facilities, as displayed on the graph below:



## 6. Further project development

This study can be extended by traffic analysis and emergency services capabilities to plan city infrastructure changes.