Visualising NYC Fire Department resource with an analysis of fire incidents

Simon Horton & Chun-Hung Lee
Department of Computer and
Information Science
Fordham University
NYC, USA
sh43,cl2@fordham.edu

***Abstract*— With the rise of population density in major cities it is important to understand if there sufficient emergency response resources in major cities to service the needs of the population. The main objective of this report is to understand the density of reports, distribution of fire stations and the ratio for different boroughs of New York city, New York. The aim o looking at the different boroughs is to see if there is any difference between the boroughs both in terms of density of fire stations, incidents and the types of major fire incidents across the different boroughs. This will be visualized by using python libraries for the departments and Tableau for the incident visuals. During the process there will be no adjustments to the data only applying simple filters to ensure that it is as true to source as possible. It will look at a single period to give consistency and reduce the number of datapoints from around 10million.**

Keywords*— *Data Visualization, Tableau, Python, Fire Stations, New York

I. Introduction

With the growing density of urban populations [1] across the last 50 years it is important for major cities to assess if they have adequate resources to deal with the population increases and the demands of the current urbanization of the world. While the growth is higher for South America and Asia [1] There has still been significant growth in North America that warrants investigation.

While it is imperative to have the resources to tackle major incidents it is clear that major incidents have decreased significantly with the emphasis on safety standards and building practices. It is a reduction of around 50% over the last 50 years [2].

While outside of the scope of this research, it can be seen that there are significant regulations in place in terms of fire safety in NYC. This can be from building sites such as §28-301.1 [3] outlining requirements for safety on sites such as no smoking and access to fire extinguishers through to keeping sprinkler lines from freezing. Is more regulation a help or a hindrance? That is something discussed at length in other fields of research.

This research will look at publicly available datasets from NYC government [4] [5] [6] with the aim of showing the distribution of fire related incidents across the 5 boroughs across NYC. The research will focus on 2022 as this was the last time the firehouse data was updated and it is expected to be a return to normal after the Covid-19 pandemic lockdowns had finished and the city was back to normal.

It is expected that the distributions of fire stations will be similar across the 5 boroughs when related to population rather than land area. As there are more multi-occupancy buildings in Manhattan, businesses and tourist areas it is likely that Manhattan will have the most fire stations by land area.

The research will use a collection of tools for the analysis of each dataset. For the firehouse data [5] Python will be used with the Folium library to create an interactive map of the firehouses along with MatPlotLib to plot additional analysis of counts and areas of firehouses. Tableau will be used to analyze the incidents dataset [4] to create dashboards and time series analysis.

II. Related Work/Background

Emergency service resource allocation represents a critical challenge in urban planning and public safety management. Previous research on urban emergency services has increasingly focused on understanding the spatial distribution of fire stations and their relationship to incident response. Visualization techniques have emerged as powerful tools for analyzing the complex interactions between fire station locations, incident frequencies, and urban characteristics. Studies have particularly emphasized the importance of mapping and quantitative analysis in assessing emergency resource allocation.

The New York City Fire Department (FDNY) presents a unique case study for such analysis, given its diverse borough structure and varied urban landscape. Researchers have been interested in understanding how factors such as population density, land area, and economic significance influence the placement of fire stations. The integration of EMS services since 1996 has further complicated the analysis of emergency resource distribution.

Methodological approaches to emergency service resource visualization have evolved with technological advancements. Tools like Python, Tableau, and Geographic Information Systems (GIS) have enabled more sophisticated spatial and temporal analyses of emergency incidents. These methods allow for comprehensive examination of response times, incident types, and geographical variations that were previously difficult to comprehensively assess.

III. DATA

While there is access to 3 datasets in the introduction it has been restricted to the firehouse and incident data for this project in order to keep it manageable. It is likely that the demographic data will be able to add additional information and insights to the project, but it is currently beyond the self-imposed scope of this project.

The firehouse data [5] features the listing of the firehouses and is detailed in the table below.

TABLE I. FIREHOUSE AVAILABLE DATA

Field Name	*Example*	*Type*
FacilityAddress	42 South St	Text
Borough	Manhattan	Text
Postcode	10005	Int
Latitude	40.70	Geo
Longitude	-74.00	Geo
Community Board	101	Int
Community Council	1	Int
Census Tract	7	Int
BIN	1000867	Int
BBL	1000350001	Int
NTA	East Village	Text

So, it is possible to map the locations of the firehouses across NYC and pin them with the name of the station and or address locations. This inclusion of the latitude and longitude means that they can also be mapped precisely rather than by an address or zip code that would put them in a rough area.

There is an opportunity to also map the areas that the firehouses cover given the NTA value but this is not done in this project.

The Borough field will enable to test the hypothesis outlined in the introduction such as fire stations per land area, population and incidents. Although this information is not included in the dataset it is possible to find the population and land area for the different boroughs of NYC.

The second dataset is the incident reporting to NYFD [4] and covers information from 2005-2023. As the NYFD has also covered EMS services since 1996 [7]. This means that there are incidents that relate to medical emergencies as well as those of fires which is what the paper looks to analyze.

With this in mind the information is presented with the full range of incidents in the visuals as well as filtered for those relating to fires. It is also filtered down to 2022 for most of the visuals as this corresponds to other data present in the research. There is the opportunity to analyze over a 15 year period but that will be discussed in the further work section.

The data available is listed in the table below.

TABLE II. FIREHOUSE AVAILABLE DATA

Field Name	*Example*	*Type*
starfire_incident_id	2100404460110002	Int
incident_datetime	04/01/21 1:00	date
alarm_box_borough	Bronx	text
alarm_box_location	446	Int
alarm_box	5th Ave & 112 ST	text
incident_borough	Bronx	Text
Zipcode	11691	Int
Policeprecinct	9	Int
Citycouncildistrict	2	Int
Communitydistrict	103	Int
Communityschooldistrict	1	Int
Congressionaldistrict	12	Int
alarm_source_description_tx	Phone	text
alarm_level_index_description	Initial Alarm	text
highest_alarm_level	First alarm	text
incident_classification	Automotive Fire	category
incident_classification_group	Structural Fire	Category
dispatch_response_seconds_qy	50	Int
first_assignment_datetime	04/01/21 1:00	Datetime
first_activation_datetime	04/01/21 1:00	Datetime
first_on_scene_datetime	04/01/21 1:00	Datetime
incident_close_datetime	04/01/21 1:00	Datetime
valid_dispatch_rspns_time_indc	N	Boolean
valid_incident_rspns_time_indc	Y	Boolean
incident_response_seconds_qy	110	Int
incident_travel_tm_seconds_qy	120	Int
engines_assigned_quantity	1	Int
ladders_assigned_quantity	2	Int
other_units_assigned_quantity	3	Int

From the table it is possible to identify various areas that can be used to test hypotheses identified in the introduction. It can be categorized by borough, can be filtered for date and the different type of incidents can be analyzed.

It should be noted that there are null and missing values throughout this dataset. In terms of addressing this it is not something that will be addressed in this paper. Analysis shows that there is <0.1% of values missing so it should not have an impact on the analysis.

IV. DATA VISUALS

This section will explore and attempt to explain the visuals used to test and validate the proposed hypothesis. It will be broken down into the fire station analysis in python and then the Tableau section that focuses on the incidents.

A. Firehouse analysis

The first point to consider is the total number of clicks compared to the number grades achieved.

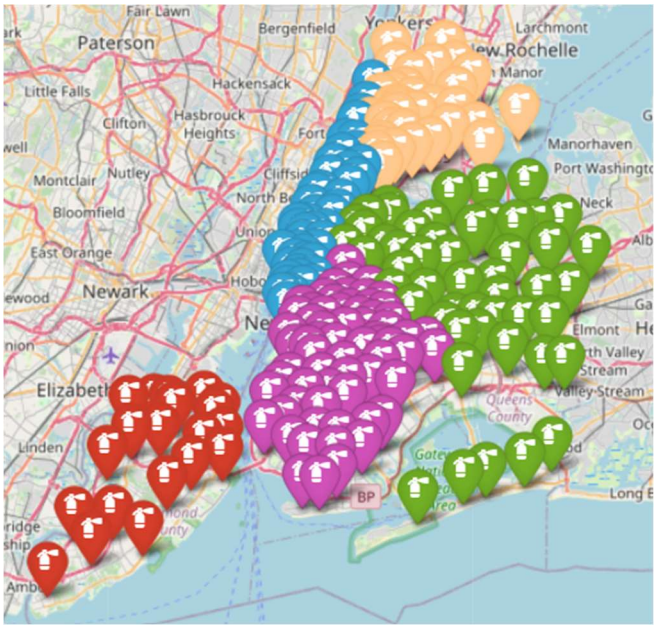

Fig. 1. Mapping of all fire stations in NYC

This map shows the density an locations of the fire stations across NYC. It can be viually seen that Manhattan has th highest densiy of fire stations, Brooklyn visualy appears to have the most. Staten Island appears to have the fewest and the least density. Each borough is shown in the appendix. They show that Queens also appears to be quite sparse given the size of the borough.

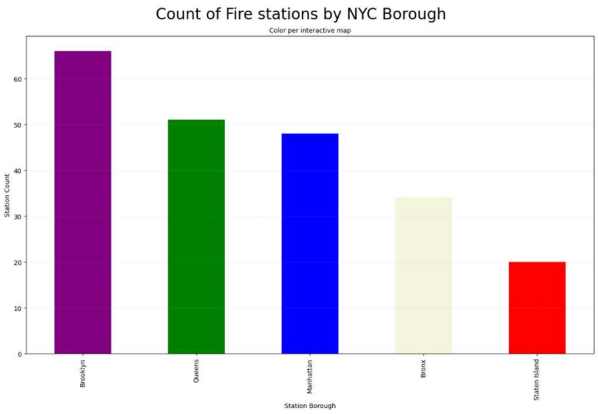

Fig. 2. Bar chart count of the stations.

Figure 2 is a summary of the count of fire stations showing that Brooklyn (66) has the most and Staten Island (20) the least. Queens (51) and Manhatten (58) have similar amounts and the Bronx (34) is lower.

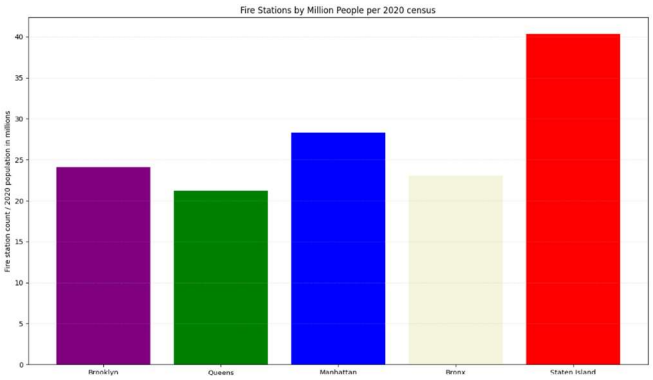

Fig. 3. Barchart of fire stations per Millon people

Figure 3 shows that based on population most boroughs have a similar number of stations per million people in the 20 range with Manhattan (28) being the highest and Queens (21). As Staten Island has a much smaller population compared to the other boroughs (~400k) [8] it is not surprising that they have the most per population.

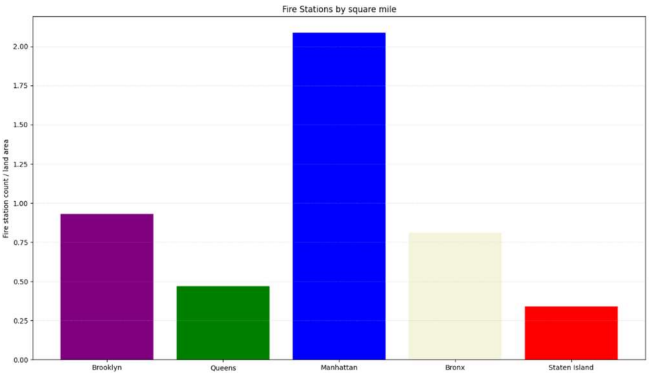

Fig. 4. Barchart of fire stations per land area SQ Miles

Figure 4 shows that based on land area Manhatten has the most fire stations per square mile which is is one of the hypotheses that was outlined in the introduction. This is not surprising given that they contribute ~73% of the GDP for the city [9]. When taking the 5 counties from the data to get the total GDP for the city.

B. Incident Analysis

This section will focus on analysis of the reported incidents. As the dataset has ~10m reports over an 18 year period the focus will look at 2022 that is a time outside of Covid-19 restrictions and ties in with the data used for the fire station analysis.

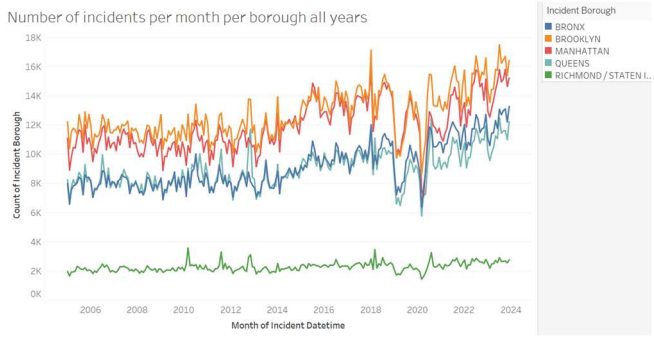

Fig. 5. Bar chart all incidents per year per borough

To verify the claim above that the time selection is viable figure 5 shows that 2019-2021 were not aligned to the overall trend during the Covid-19 pandemic.

Analysis of the incidents verify the earlier mentioned fact that the NYFD is responsible for the medical and EMS incidents. These are therefore included in the data as seen in figure 6 below.

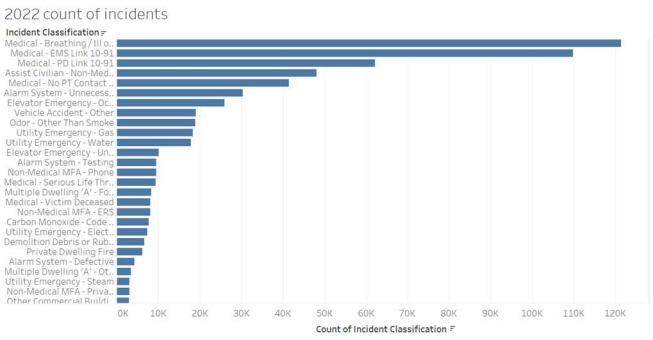

Fig. 6. All reported incidents 2022

Figure 6 shows how many incidents were reported across the NYC area in total around 650k a year with over 50% being medical emergencies.

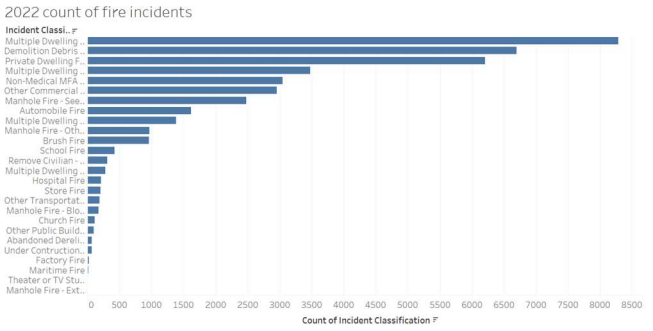

Fig. 7. All reported fire incidents 2022

Figure 7 filters down the incidents to fire related incidents only and shows there were 40k incidents relating to fires being under 10% of the total number of reported incidents.

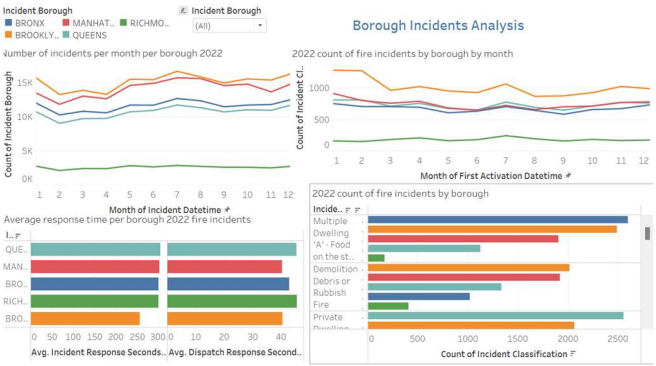

Fig. 8. Dashboard for incidents by borough

Figure 8 shows a Tableau dashboard created for the analysis of incidents, fire incidents, response times and monthly incidents to test the hypothesis. It is eveident from the dashboard that most fire incidents occur in January for all boroughs apart from Staten Island where the most fires occur in July. In terms of overall incidents July seems to be the peak month.

The surprising observation to come out of this is that the average respone times for all boroughs bar Brooklyn is around 300 seconds or 5 minutes. When this is analysed at a worse / maximum it shows a different picture

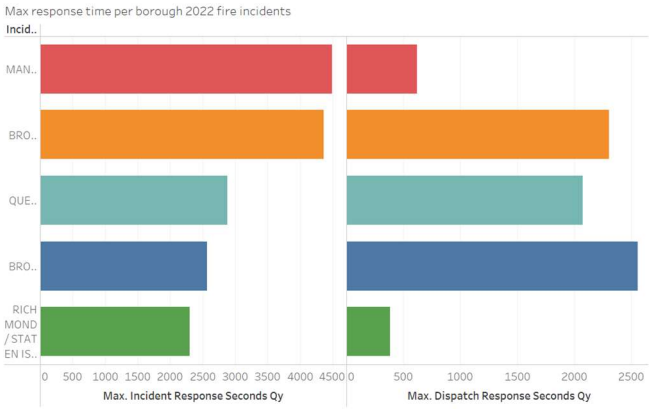

Fig. 9. Max incident response times

Figure 9 shows here that the longest respone time was in manhatten whereas the longest dispatch response was in Bronx. Manhattan seems to have dispatch respond quickly and there will be many factors contributing to these single incidents that will not be analysed in this paper.

V. Conclusion & Future Work

This research provides a comprehensive visualization and analysis of the New York City Fire Department's resources and incident distributions across the five boroughs. Our findings reveal critical insights into fire station deployment and emergency response patterns that challenge and confirm initial hypotheses.

The spatial analysis of fire stations demonstrated significant variations across boroughs. Manhattan emerged with the highest number of fire stations per square mile, aligning with our initial hypothesis about the borough's unique urban characteristics. This distribution reflects Manhattan's economic significance and dense urban landscape, contributing approximately 73% of the city's GDP.

Incident analysis uncovered nuanced patterns in emergency services. Contrary to expectations, medical emergencies comprised over 50% of FDNY responses, with fire-related incidents accounting for less than 10% of total reported incidents. Seasonal variations were notable, with January emerging as the peak month for fire incidents in most boroughs, except Staten Island.

Response time analysis provided insights into operational efficiency. While average response times consistently hovered around 5 minutes across boroughs, maximum response times and dispatch speeds revealed significant variations. Manhattan demonstrated particularly

interesting patterns, with quick dispatch responses but occasional extended incident response times.

Potential avenues for future research include:

- Longitudinal Analysis: Expanding the study to a comprehensive 15-year dataset to explore long-term trends in urban emergency response.
- Demographic Integration: Incorporating detailed socioeconomic data to develop more nuanced understanding of incident distributions and resource allocation.
- Advanced Geospatial Mapping: Developing more precise service area analyses for firehouses to enhance resource optimization strategies.
- Predictive Analytics: Exploring machine learning techniques to anticipate potential incident hotspots and optimize station placement.

The study demonstrates the power of data visualization in understanding urban emergency services, offering a framework for more effective public safety resource management.

References

[1] V. S. M. R. Hannah Ritchie, "Urbanization," Our Data World, September 2018. [Online]. Available: https://ourworldindata.org/urbanization. [Accessed 22 November 2024].

[2] Firefighter Health and Safety, "Where Firefighters are in high demand," firefighters and ems fund, 10 October 2019. [Online]. Available: https://www.fireandemsfund.com/where-firefighters-are-in-highest-demand/#:~:text=According%20to%20the%20Bureau%20of,cities%20across%20the%20United%20States.. [Accessed 2024 November 21].

[3] NYC Buildings, "Construction Site Fire Safety," NYC Buildings, 2024. [Online]. Available: https://www.nyc.gov/site/buildings/safety/construction-site-fire-safety.page. [Accessed 22 November 2024].

[4] Fire Department of New York City (FDNY), "Fire Incident Dispatch Data," 22 January 2024. [Online]. Available: https://data.cityofnewyork.us/Public-Safety/Fire-Incident-Dispatch-Data/8m42-w767/about_data. [Accessed 22 November 2024].

[5] Fire Department of New York City (FDNY), "FDNY Firehouse Listing," 8 April 2022. [Online]. Available: https://data.cityofnewyork.us/Public-Safety/FDNY-Firehouse-Listing/hc8x-tcnd/about_data. [Accessed 22 November 2024].

[6] Department of Youth and Community Development (DYCD), "DYCD Participant Demographics by Zip Code," 14 November 2023. [Online]. Available: https://data.cityofnewyork.us/Social-Services/DYCD-Participant-Demographics-by-Zip-Code/hebw-6hze/about_data. [Accessed 22 November 2024].

[7] E.-P. a. M. E.-P. B. J. M. D. M. E.-P. Mark Peck, "A Short History of New York City's Emergency Ambulance Services," Jems Training, 1 December 2022. [Online]. Available: https://www.jems.com/major-incidents/a-short-history-of-new-york-citys-emergency-ambulance-services/. [Accessed 22 November 2024].

[8] D. R. G. e. al., "POPULATION ESTIMATES FOR NEW YORK CITY AND BOROUGHS," 1 July 2023. [Online]. Available: https://www.nyc.gov/assets/planning/download/pdf/planning-level/nyc-population/population-estimates/current-population-estimates-2023-June2024-release.pdf?r=1. [Accessed 23 November 2024].

[9] Federal Reserve Bank of St Louis, "Current Dollar Gross Domestic Product by County: New York," 1 January 2023. [Online]. Available: https://fred.stlouisfed.org/release/tables?rid=397&eid=1063765. [Accessed 2024 November 23].

VI. Appendix

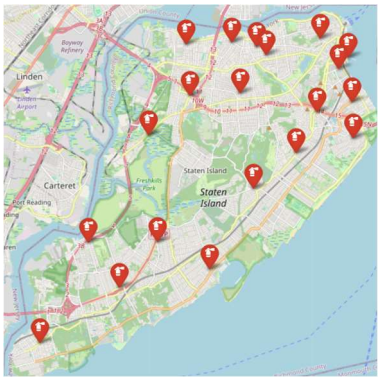

Fig. 10. Staten Island map

Fig. 11. Manhattan Map

Fig. 12. Queens Map

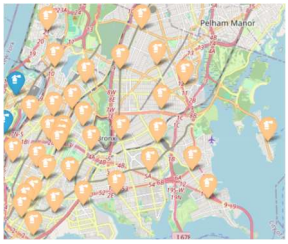

Fig. 13. Bronx map

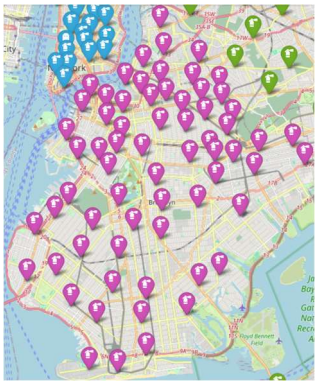

Fig. 14. Brooklyn Map