Legacy of Natural Disasters on Municipal Services

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Abstract—Natural calamities can have long-term consequences but extrapolating and disentangling such consequences from the environment in which they occur can be difficult. The absence of metrics of natural disasters' full and actual impact is a significant factor for examining their impact on welfare outcomes. This is crucial for guiding the development, formulation, and implementation of alleviation policies. Using data from Sandy 311 calls data set, this paper investigates the long-term consequences of such disasters and how the municipal services played an integral part in the recovery process. This study visualizes information with respect to different questions that can arise while taking a look at the data.

Index Terms—Information Visualization, Service Request Data, 311 Data, Data Visualization, Disaster Response

1 Introduction

Natural catastrophes can have life-changing consequences for those who are lucky enough to survive them. It can have an influence on a neighborhood, a city, a state, or even a whole country. Even if human settlements are mostly unscathed, natural catastrophes can have massive environmental consequences. The severity of the effect, as well as the amount of readiness and resilience of the subject impacted, all have a role in how successfully the impact of a catastrophic event is absorbed.

Natural disasters have always been a part of existence, even before the contemporary world's industrialization [1]. For example, there are reports of Native Americans migrating away from coastal Florida in order to avoid seasonal storms. Many weather-related natural catastrophes have increased in frequency and intensity as a result of the industrialization of many civilizations throughout the world and the effects human industrial activities have brought to the environment.

Once a natural disaster is hit, the next important step for the community is the recovery process [2]. All assets utilized in the response and recovery activities are within the responsibility of the local government, regardless of where they came from. With the help of the state and federal governments, local administrations must plan and prepare for this responsibility.

This paper mainly focuses on discussing the legacy of natural disasters on municipal services. We did research on the impact of natural disasters on non-emergency lines such as 311. 311 is a unique telephone number that is used in several Canadian and American towns. Non-emergency municipal services can be accessed by dialing this number [3]. The 3-1-1 phone line serves as a single center for residents to access a range of city services. Its purpose is to deflect routine questions and non-emergency community issues away from the 9-1-1 line, which is only for emergencies.

We used Hurricane Sandy as our sample case for this study. On the evening of Oct. 29, Sandy struck New York, and the city got 8,054 calls specifically related to the storm. The storm's long-term implications are yet unknown. Sandy is regarded as the fourth most costly hurricane in US history, with over 600,000 homes damaged in New Jersey and New York. New York City's administration estimates that 19 billion dollar in damage was caused to the city alone [1].

We looked at the data from the Sandy 311 calls to see how much anxiety there was about Hurricane Sandy over time. Hurricane Sandy was the source of 15.6 percent of 311 calls in the first two weeks after the storm. The number of queries declined from 87,209 in 2012 to 25 in 2020. In 2012, the bulk of calls were for general Hurricane Sandy information, while in 2020, assistance with property repair was requested. The long-term effects of Hurricane Sandy in New York City are still being felt almost eight years later, in 2020. Hurricane Sandy victims' requirements have evolved over time, from broad information about closures, property devastation, and urgent disaster help to legal, financial, and mental health assistance [1]. In order to give resources and plan for future catastrophes, disaster response policymakers must understand the changing requirements of populations.

Using the Sandy 311 calls data set, we try to visualize the data which gave us more insights about the patterns and intensity of the calls made after the unfortunate incident. In the next section, we provide an overview of related works and the methodology used in our study. Here, we explain in detail, the origin of our data set and its features. Section 4 shows the visualizations and the meaningful results we drew from them. In the final part, Section 5, we elaborate on the possible work or study that could be done on this matter in the future.

2 Related Works

Since the establishment of the Baltimore, Maryland 311 call center in 1996 [3], research has increasingly focused on the use of the non-emergency line immediately following disasters.

In 2007 Schellong and Lagenberg studied the use of the 311 system in Miami-Dade County during hurricane Wilma,

finding that the successfully implemented 311 system enabled the county to better respond to citizen's needs. [4]

In 2016 O'Brien looked at Boston's 311 system and its utilization in instances of informal social control, the theory that neighborhoods with an internal and informal social contract that discourages acts of vandalism or other asocial behavior from individuals within the neighborhood. Focusing on the ability of users to create accounts when making 311 systems through applications, O'Brien found that neighborhoods with a high concentration of 311 accounts and requests, had lower instances of crime and delinquency. [5]

In 2017, Xu et al focused on predicting increased demand for sanitation service requests in Chicago. Using geo-coded 311 service requests, the authors focused on creating a model that could be used for neighborhood planning and 311 resource allocation. [6]

In 2018, Wheeler looked at the impact of resolving 311 service requests on crimes in Washington D.C. by finding a small but meaningful reduction in neighborhood level crime when infrastructure and sanitation related 311 service requests are resolved. [7]

In 2020, Madkour and Tokgoz looked to predict surges in 311 utilization following a disaster, focusing on Houston, Texas. The authors suggested that by predicting surges in 311 calls, departments could prioritize closing issues in anticipation of a surge, thereby allowing for a better response time during a disaster. [8]

Outside of academic research, 311 call analysis has been of public interest through journalism efforts such as Wired's 2010 analysis on one hundred million NYC 311 calls [9] and the 538 analysis on the long tail of Hurricane Sandy's visualization through 311 calls. [10]

Based on the results of previous research, it is our belief that appropriate 311 responses in the wake of a disaster can reduce crime and increase resident satisfaction. In order to provide a reasonable turn around on requests, a municipality must be prepared for a surge in requests related to the scale of the disaster.

3 Methodology

3.1 Data Gathering

The 311 Call Center dataset used for our study was extracted from the NYC OpenData website. [11] NYC OpenData is a free public data site published by New York City agencies and other partners. The authors of "The (Very) Long Tail of Hurricane Recovery" used the 311 call center dataset and downloaded the logs of over 36 million calls placed to 311 from the days before Sandy's arrival, in the fall of 2012, through September 8, 2017, where nearly 80,000 calls were directly related to the storm [10]. Wolfe's and Roeder's analysis, the 538 authors of "The (Very) Long Tail of Hurricane Recovery," inspired our own investigation into the 311 calls relating to Hurricane Sandy. From the 311 Call Center Inquiry dataset, we extracted the entries regarding Hurricane Sandy to create visualizations out of the data. The dataset contains information on all agent-handled calls to the city's 311 information line: topic, date, time, and more.

3.2 Data Features

The NYC OpenData website hosts a preview on the city's website for the 311 calls from 2010 to 2017. Upon reviewing the 311 Call Center Inquiry dataset, the dataset has nine columns and 86.3 million entries.

The spreadsheet is composed of different features. The following list is the features in the 311 Call Center Inquiry dataset:

- Unique ID: Unique identifier for each call.
- Date: Date the call was received.
- Time: Time the call was received.
- Date and Time: A combination of the date and time columns.
- Agency: Acronym of agency associated with the specific topic.
- Agency Name: Complete agency name.
- Inquiry Name: Topic the call center representative used to resolve the customer's inquiry.
- Brief Description: Brief description of the topic.
- Call Resolution: How the call ended or was resolved.

4 Data Visualization

In this project, we used the NYC open data tool to visualize and analyze the Sandy 311 calls data set. Visualizations focused on plotting two facets of the data: Inquiries by department and Inquiries over time. In all visualizations, a standard color legend is used wherein Hurricane Sandy-related inquiries are represented in orange and other NYC 311 inquiries are represented in blue. Inquiries were identified to be related to Hurricane Sandy if the brief description contained the text 'Sandy'. The data, tools, and visualization were chosen to utilize the process referenced in the Empirical Studies in Information Visualization: Seven Scenarios paper. [12] This process not only aided in identifying the best data to evaluate but it helped visualize the data accurately.

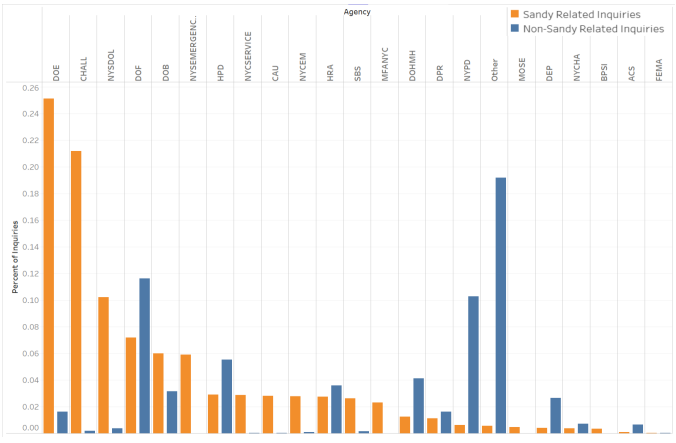

Fig. 1: **NYC Inquiries from 2012-2020 by Department:** a comparison of Hurricane Sandy vs general inquiries by Agency. This figure plots the percent of Hurricane Sandy related calls routed to a particular department against that department's share of all other 311 calls emphasizing atypical 311 volumes to certain departments

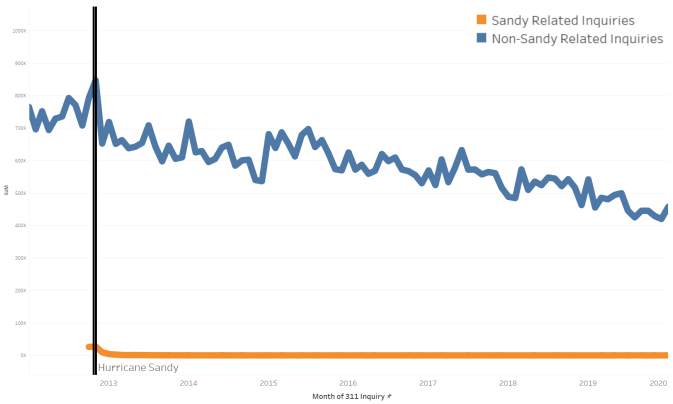

Fig. 2: **NYC 311 inquiries from 2012 to 2020**: a comparison of Hurricane Sandy call volume against total NYC 311 call volume. This figure plots two key series of time data: the total monthly NYC 311 call volume and the Hurricane Sandy 311 call volume. As a point of reference, the vertical black bar illustrates Hurricane Sandy.

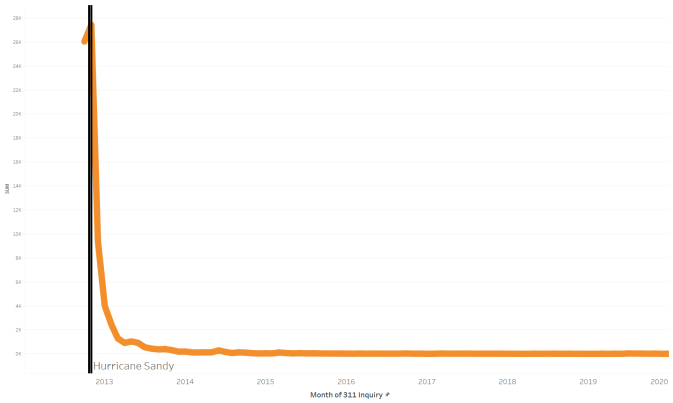

Fig. 3: **Hurricane Sandy 311 Inquiries 2012-2020**: Focused on just the Hurricane Sandy 311 Inquiries, this figure shows the fluctuations in Hurricane Sandy related calls that are otherwise obscured in Figure 2 The inquiries peak in November 2012 with 27,423 calls. The lowest number of calls were received in February 2019 where only 3 inquires were made.

When developing Figure 1: NYC 311 Inquiries from 2012 to 2020, there were many elements we took into consideration such as the size, color, sharing, and distancing. The data itself was comprised of a vast number of individual data points (over 86 million rows) and seemed to have little correlation to the human eye. By looking at all the calls including non-Sandy-related calls we could filter the data out into two separate parts, group by date, and then compare the resulting sub-datasets to give us Figure 1. Many additional elements, however, still needed to be considered to ensure that the data would not be misinterpreted or misunderstood. This was achieved by creating a uniform color scheme throughout the paper so the reader only must decode the first visualization and the rest would come naturally. Uniformed spacing was then used throughout the graph, a grid created, and the white space on the y-axis above 26% removed. These modifications all helped improve understanding and response time of a user when first decoding the visualizations. The authors were able to witness this ourselves when we applied the Seven Scenarios process, the application of which we describe in the section below.

Using the same methodology with color scheme and spacing when developing and analyzing Figure 2 and Figure 3, we created a two-part type of graph. The data represented in Figure 2 was too massive to be able to show concisely without losing elements. Figure 3 helps with this analysis by showing a zoomed-in graph of the Hurricane Sandy 311 Calls and truly shows the uptick in calls that were just for that specific data versus every call within 311 data.

These visualization techniques minimize common errors and pitfalls, helping users to easily understand the visualization. Due to the timeline and constraints of the study, we were unable to perform user feedback and user analysis of the charts for Evaluating User Performance and Evaluating User Experience. However, when we created the visualization, we did a preliminary study among the authors of the paper to get a sense of where we stood answering the basic questions for Evaluating User Performance and Evaluating User Experience. When Evaluating User Performance, we asked, “What are the limits of the human visual perception and the cognition for specific kinds of visual encoding or interaction techniques” [12] and we asked, “How does one visualization or interaction technique compare to another measured by human performance?” [12] When Evaluating User Experience we looked at how we saw the visualization and got the “feedback opinions” [12] of each member.

4.1 Tools

These visualizations were created within Tableau public post initial data exploration in the NYC Open Data Tool. The NYC Open Data Tool provides useful features to explore and visualize large NYC specific data sets. Allowing users to manipulate the data through filtering, summarizing, and combining datasets, users can also create interactive data visualizations via some of the most common data visualization techniques including:

- Pie charts
- Bar charts
- Timeline chart
- Histograms
- Scatter plots

The NYC Open Data Tool also natively includes NYC specific localization data allowing the plotting of data within NYC police districts, voting districts, and boroughs. This allowed for rapid data investigation to discover trends before the final, more readable visualizations are created off line through Tableau.

5 Discussion

5.1 Findings

As show in Figure 1, the calls related to Hurricane Sandy are mostly directed towards the department of education (DOE), the state department of labor (NYSDOL), and City Hall(CHALL). Looking specifically at the DOE volume, 25%

of calls related to Hurricane Sandy were routed to the DOE, typically DOE inquiries only represent 1% of 311 inquiries. The Borough President of Staten Island (BPSI) agency also received a strong increase of calls, though only 182 inquires were received related to Hurricane Sandy, those calls represent 48% of the total 311 call volume for the BPSI agency. Similarly the 2,980 Hurricane Sandy related 311 calls routed to the New York State Emergency Management Office (NYSEMERGENCYMG) account for 99% of all NYSEMERGENCYMG inquiries. We can account for the NYSEMERGENCYMG and NYSDOL inquiry surges as atypical call volumes where a local municipality must interface with broader state resources, something that only occurs during State Emergencies. The increased volumes for CHALL and DOE however, show that Hurricane Sandy caused a surge in unique types of calls that the city does not typically see. During a natural disaster, the citizens of a city have specific needs that that may go unmet if not planned for.

As evidenced by Figure 2 and Figure 3, Hurricane Sandy related call volume was not constrained to the immediate the time period surrounding the Hurricane's landfall and thus the atypical agency inquiries continue in the months and years to follow. Figure 2 first shows that even during Hurricane Sandy, there were still just as many non-Sandy calls to 311. This leads to the insight that resources should not be shifted away from the other departments to help with the departments outlined above. Instead it demonstrates a need to bring in additional help beyond what is seen during usual times. Secondly, Figure 2 shows that even as 311 inquiries via phone began to trail off between 2019 and 2020, possibly due to the implementation of the 311 app, Hurricane Sandy related inquiries continued to come in via phone at a relative consistent rate of a handful a month.

Figure 3 highlights Hurricane Sandy's lengthy recovery. While there is a massive peak right after the hurricane hit, representing the maximum monthly call volume of 27,423 calls received in the month of November 2012, the calls do not cease completely within the few months following the hurricane. The calls continue for years including 79 received in 2020, the last year of this data set. This indicates that the unusually powerful hurricane left devastation that has taken years to overcome.

5.2 Future Work

This case study's main goal was to analyze the data provided by the 311 Hurricane Sandy calls and help understand the full scope of the currently known impact. There were, however, some limitations to our study.

One limitation was the geographical or local regions from which the calls came. Our study focused on the number of calls that came into each department over several years and the long-term volume. The primary data set used for this study did not include location of the caller nor did it include service location. Understanding locational data, as in where the calls came from, we could see if there was a trend based on different locations. We could also see if that trend continued through the years or if another trend appeared. This could help with understanding future storm resources and other funding-related issues. To address this limitation, future work could attempt to join the NYC 311 Call Center Inquiry dataset [11] with the 311 Service Requests from 2010 to Present dataset. [13]

The second limitation was the time of the study. As mentioned in the Data visualization section of the paper, we were unable to perform a group study to get a good consensus of the visualization that represented the data correctly and if the data we chose was correct. Fully utilizing the Seven Scenarios process [12] would have allowed the data chosen and the visualization created to have a more statistical and mathematical backing therefore ensuring that the visualization showed clear and concise visualization.

Even with these pitfalls, we can still take what we currently found and build this study to a larger scale. Once we understand the frequencies of the calls, we could map out which departments had the resources to handle each specific call and understand where the resources for help vs where they needed more help were. Understanding where resources for a storm-related incident are required, we could create predictive models and target both locations and agencies which need those resources the most. This approach could then help pave a path for other cities to handle incidents like seen in NYC in 2012.

6 Conclusion

The catastrophic disasters that Hurricane Sandy caused can be felt today by the people, by the cities, and by industries. Quantifying the data to get the exact amount of damage and cost of that damage is extraordinarily difficult and might not be known for years to come. The Sandy 311 Calls allow us to have an insight into the history of non-emergency calls that were made during and after the storms hit. By mapping out the data we were able to understand the patterns and intensity of the calls that were seen. We saw this through graphing out the Number of Inquiries by the NYC Agency, plotting NYC 311 Inquiries 2010-2020, and taking a closer look into the hurricane sandy specific call inquiries. The main takeaway was that when looking at these three different visualizations we saw that people were still dealing with issues that have yet to be resolved almost a decade after the Hurricane hit NYC. While it might be heart-wrenching to see the damage done, getting the full picture through the years will help our future selves prepare and predict what needs to be done before another catastrophic event like this occurs.

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Appendix A
Interactive Figures

All figures referenced in this paper are available in interactive form through Tableau public.

- Figure 1: https://bit.ly/311AgencyDistro
- Figure 2: https://bit.ly/311TimeLine
- Figure 3: https://bit.ly/Sandy311Timeline

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