Characterizing 311 System Reactions to a Global Health Emergency

Duygu Pamukcu
Virginia Tech
duygu@vt.edu

Christopher W. Zobel
Virginia Tech
czobel@vt.edu

Abstract

Communities are complex, multi-dimensional systems that react to crises in a variety of different ways. Based on the municipal services provided to a community, 311 calls can be used as indicators of the different dimensions of that community's reaction to a crisis situation. To improve Citizen Relationship Management, municipalities can analyze and even augment their 311 systems to capture specific types of information about an ongoing crisis. New York City did this by adding specific category types and descriptors to their 311 system, in response to the evolving COVID-19 pandemic. This paper provides an initial look at the 311 data for New York City and the variety of community behaviors that it is able to capture as a reaction to the pandemic and the associated actions taken by the authorities to respond to the situation.

1. Introduction

Municipalities are responsible to their citizens for ensuring and maintaining necessary public services, even during emergencies [1]. Such municipal services as maintaining traffic signal systems, road conditions, electric power systems, and water systems are essential parts of the normal functioning of society. Any disruption to those services due to an emergency, such as a natural disaster or a disease outbreak, may negatively impact the continuity of the service provision and thus the municipality must have the capability to prepare for, respond to, recover from and adapt to that disruptive event. This combined set of capabilities is often referred to as *disaster resilience* [2].

The continuous monitoring and evaluation of operations are important in order to support learning from past responses and to improve service performance for future emergencies [3]. Effective communication between citizens and public service providers depends on information sharing at all governmental levels, particularly during emergencies [4]. The combination of timely and accurate data with the implementation of effective communication procedures then helps to establish the success of public services and citizen satisfaction.

For several decades, governments have been implementing e-government practices to improve service delivery and provide more efficient and transparent public administration [5]. For example, local governments often incorporate Citizen Relationship Management (CiRM) systems to facilitate data collection and information exchange and to respond to the expectations of citizens [6]. The effective use of such technologies enables citizen access to government, improves the responsiveness of governments, and holds them more accountable to their constituents [7].

The 311 non-emergency call system in the United States is a part of the CiRM implementation for a number of local governments, particularly in the more urban areas of the country. In contrast to the better known 911 system, which was built to respond to emergencies, the 311 system allows for a municipality to receive *non-emergency* service requests from citizens through various modes of access. Recent studies have been paying attention to the potential value of using 311 call systems to support emergency mitigation and response because they contain a large amount of historical and timely data on non-emergency service requests [2]. 311 data also have been used as a source of data for characterizing and measuring the multi-dimensional resilience of a community, by combining the volume and timing of different types of service requests related to severe storms into indicators of the disasters' impacts on the municipality [1,2,3,8]

Recently, however, the world has been experiencing a different, and more widespread, kind of disaster. COVID-19, a novel coronavirus disease, has presented a serious threat to global health. The outbreak has been closely monitored by the Centers for Disease Control and Prevention (CDC) in coordination with the World Health Organization (WHO) and other partners in order to assist countries with resisting and responding to the situation. The CDC committed itself to stopping the spread of coronavirus disease and took the responsibility of analyzing and incorporating new

information quickly into guidance for the actions of the organizations, health departments, health care providers, and the public [9]. Nevertheless, due to its rapid spread, the COVID-19 pandemic has caused disruptions in the normal functioning of almost all services such as health, education, production, transportation, and tourism. Many countries have declared restrictive orders, including lockdowns, travel bans, stay-at-home orders, and social distancing regulations.

Given the prior research on the value of CiRM implementations in service quality, and the use of 311 data to leverage the functionality and resiliency of municipal services during emergencies, this study seeks an answer to the following research questions:

RQ1: Can the data from existing municipal service systems, such as 311 systems, be used to characterize the impacts that a pandemic has on a community, in support of responding more effectively to that crisis?

RQ2: Is there value in expanding municipal service systems to collect new information specific to an ongoing crisis?

With these questions in mind, the following paper discusses various types of information that can be derived from a 311 non-emergency request system in order to understand fluctuations in citizens' behavior and in the responsiveness of service providers during such a public emergency. In particular, we present an analysis of New York City's 311 system in this context. Based on the variations in the public's reactions to the changing levels of health threat and municipal orders, and the city's subsequent adjustments to the system, we discuss the opportunity for better understanding the impacts of such a disruptive health emergency so that they can be responded to more effectively.

The rest of the paper proceeds as follows: First, we provide a background on the use of 311 call systems in the United States. We then explain the theoretical background of the use of communication technologies in local government service practices, and we describe the details of the 311 system in New York City. This is followed by a discussion and analysis of the 311 service requests that were received during the health emergency. We then finish the discussion with a close look at two particular descriptors that were created in order to help generate specific data that would be directly relevant to the COVID-19 emergency.

2. Municipal 311 call systems

311 Call Systems were initially created to alleviate congestion in the 911 system resulting from high numbers of non-emergency calls. The intent was to ensure that the 911 call system was only used for true emergencies. With this in mind, the Federal Communications Commission established 311 as a unique telephone number for non-emergency local government service requests in 1997 [7].

The 311 Call System serves many communities in Canada and the United States and has been used to collect, update, and report information provided by citizens about a wide range of municipal service needs. The system not only offers timely access and up-to-date information for such citizens, but it also enables government bodies to receive the requests and provide feedback in a more efficient manner. In effect, the 311 service takes on a centralized role in the process of information sharing, organizational adaptation, citizen guidance, multi-jurisdictional government, and cross-boundary collaboration [4].

Enabling multiple modes of access to the 311 system allows a standardized format for requests which can ease the sharing of 311 data between providers. The idea of enabling public access to 311 service data was based on the importance of collaboration between public agencies, nonprofits, and private agencies, and it was first implemented in Washington, D.C. Many cities that are using the 311 call system now offer free access to their service data.

2.1. Citizen Relationship Management implementations in 311 call systems

The term Citizen Relationship Management (CiRM) is drawn from the more commonly known concept of Customer Relationship Management (CRM), which originated as a profit-driven private sector business strategy [4]. CiRM systems are software applications that provide a considerable amount of data and information about citizen problems and demands. They generally provide multiple modes of electronic access to the government via the internet, email, and text messages, as well as call centers and web-based citizen service centers. In this way, local governments increase the possibility of self-service, thus decreasing costs and improving the availability of public services [6].

CiRM provides a new and promising area of research, and it offers potentially valuable contributions to both theoretical and empirical studies [4]. This is related to the fact that implementation of effective communication procedures is necessary for the success of public administration and citizen satisfaction. Call centers and web-based citizen service centers currently represent the most common forms of public sector CiRM systems that allow information exchange and encourage the participation of both citizens and public service providers.

The concept of *absorptive capacity* (ACAP) has been mentioned as a means of expressing an organization's ability to acquire, assimilate, transform,

and exploit information and knowledge concerning citizens' needs [4]. Citizens represent a valuable resource for assessing ACAP in public sector services, in terms of support for planning and measuring the success of those services. The literature notes the potential of improving the perception of service quality and the performance assessment of citizens if they have a positive public service experience via the use of CiRM services [8].

Generally speaking, 311 systems incorporate CiRM as part of their call center functionality. CiRM applications are used to track interactions with residents in a local government on an ongoing basis and allow for more effective data and information management. They enable technologies that focus on citizens' needs and complaints and motivate them to participate in their government [10]. Such technologies provide practical ways to improve citizen participation in government and ensure a more successful response to their needs and requests. The corresponding implementation of 311 non-emergency call systems thus has great potential [7].

CiRM systems in the United States have primarily been implemented by metropolitan areas as they attempt to become more efficient, effective, and citizen-central. Such applications have evolved into multi-channel systems offering a broad range of services and functions that can handle citizen requests using a single contact platform. It is in this way that 311 systems improve governmental service delivery: they offer citizens in these metropolitan areas the opportunity to participate in decision-making processes thanks to the use of web and mobile applications, which facilitate quick and easy access to the city government [11].

With this background in mind, our particular focus in this paper is on the 311 non-emergency call system in New York City. The next section provides a brief introduction to that system and discusses the specifics of the data that is collected each time that an individual service request is made.

2.2. The New York City 311 System

New York City (NYC) has one of the most comprehensive non-emergency call systems for linking its citizens to a variety of municipal services. NYC311 was formally established in 2003 and has successfully implemented 311 Citizen Service Management as part of the City's CiRM strategy, with the help of a consultant agency and use of e-government applications [12]. In order to improve the accessibility, transparency and accountability of the City government, the 311 data is made available for public use through the NYC Open Data initiative (https://opendata.cityofnewyork.us/).

Currently, citizens can connect to the NYC311 System via website, text message, phone call, skype call, social media or smartphone app. The NYC 311 system allows citizens to submit photos through the 311 app or the website [13], and it has 50 language options in the online service and 175 language options in the phone call service. In addition, NYC 311 offers Video Relay Service (VRS), Text Telephone options for citizens who are deaf, hard of hearing, or speech-impaired.

Every 311 call record consists of attributes that include the time and date of the request, the specific agency that was called, the complaint type, the street address, the borough, how and if the request was resolved, the resolution date, and the latitude and longitude of the incident, as shown in Table 1. The values of most of the attributes, such as Agency Name, Complaint Type, and Descriptor, are drawn from a pre-defined list of options.

Table 1. Selected 311 request attributes

Attribute Name	Description
Unique key	Unique identifier
Created date	Date and time the record was created
Closed date	Date and time the record was closed
Agency name	Specific agency name
Complaint type	Category of complaint type
Descriptor	Detailed description of complaint
Incident zip	Zip code of incident location
Incident address	Street address of incident location
City	City of incident location
Borough	Borough of incident location
Due date	Date and time the request is due
Resolution description	Description of call resolution update
Latitude	Latitude of incident location
Longitude	Longitude of incident location

3. 311 system reactions during the COVID-19 health emergency

The COVID-19 pandemic was confirmed to have reached the United States in January, 2020. After the first CDC warning was given on February 25th, COVID-19 subsequently spread to all 50 U.S. states by the end of March. All affected states established policies to try to mitigate the impacts of the disease, including lockdowns, travel bans, stay-at-home orders, and social distancing regulations. In many cases, additional local restrictions were announced, based on the spread of the virus and the risk in the area.

As a result of this crisis, U.S. cities with 311 call

systems observed a significant change in non-emergency complaint volume and frequency. It was reported that the increase over time in the proportion of 311 calls that were related in some way to COVID-19 was comparable to the exponential rise in google search results for the term "Coronavirus" [13]. In New York City, residents were asked to report social distancing violations through the 311 website, mobile app, or teleservices so that the city would be aware of those violations and be able to react quickly. As a result, the City boosted its 311 capacity in order to handle the larger number of calls that were expected from the thousands of additional citizens seeking help during the emergency [14].

As the situation progressed, news articles began to express the dramatic changes in call volumes that were occurring. By the end of the first week that citizens were able to provide the information, for example, the NYC311 service recorded 4000 complaints related to social distancing violations [15]. In addition, by the third week of April, the NYC police department had received around 14,000 complaints about gatherings in stores and parks, on streets and around residential buildings [16]. The complaints were not just related to people congregating, however. When prices in stores started to increase after restrictions were announced, the mayor of New York City encouraged citizens to call 311 to report stores raising prices on staples by more than 10%. New Yorkers subsequently registered more than 4500 "Consumer Complaints" in the NYC 311 system by mid-March, due to this price gouging [17].

In addition to the complaints directly related to COVID-19, there were reports that the NYC311 System experienced significant fluctuations in many preexisting citizen complaints. For example, more people began about their noisy neighbors. In March, for example, the NYC 311 system recorded a 42% increase in loud television complaints compared to the previous year [18]. This was also seen in other cities, such as Philadelphia, where 311 complaints surrounding recycling and trash pickup quadrupled in just a few weeks [19].

In order to respond more effectively to the COVID-19 crisis, NYC 311 was connected to the COVID-19 clinician hotline that was established by NYC Health + Hospitals (NYC H+H). The COVID-19 clinician hotline allowed New Yorkers to assess COVID-19 related concerns, and provides clinical and informational guidance to citizens, motivating them to use emergency medical services only if they are truly needed [20]. The service was provided to every citizen, regardless of their insurance status, income, or immigration status [21].

These initial observations of the citizens' and City's reactions to the crisis indicate that the 311 service request data is able to provide a lot of information about citizen responses and the corresponding performance of the municipality during the emergency. Journalist Dan Krauth expresses the effect of the COVID-19 pandemic on the 311 system as "…nothing shows that more than information from the city's 311 system" and mentions citizens are expecting to see an increase in the number of complaints in the following weeks [22], indicating that citizens are monitoring the 311 complaints to assess the risk in the city. Accessible, reliable, and up-to-date information could help citizens to better prepare for and respond to the rest of the emergency period. In this regard, 311 data could help both citizens and officials understand the current risks and how to continue avoiding widespread panic when it is time to reopen all city functions [13].

4. Analysis of 311 service requests during the COVID-19 Pandemic

As the discussion above makes clear, 311 systems adopt advanced information management practices to build successful relationships between government agencies and the broader public in emergency and non-emergency situations [4]. Prior research studies have analytically explored the value of municipal 311 requests as a data source for leveraging the operational performance and resiliency of non-emergency call systems during emergencies [1,3,8].

This rest of this study provides a descriptive analysis of the 311 non-emergency calls made in New York City, to illustrate and validate the comments made above. The intent is to provide a preliminary assessment of how the City was distinctively affected by the COVID-19 pandemic in terms of numbers of calls and changes in how the 311 system was used in order to handle the pandemic related complaints of the residents. The results indicate that 311 data can provide a broad array of different types of information for assessing the progress of a public emergency over time.

4.1. Analysis of standard 311 complaint types

In the first part of our 311 call analysis, we compared, for each complaint type, the difference in call volumes before and after all non-essential businesses were closed in New York City on March 20th. In order to reduce bias due to seasonal behaviors (calls about heating issues, for example), we compared 2020 call volumes against 2019 call volumes and analyzed the difference between the two in order to assess the change from "normal" call behavior. Table 2 subsequently provides the 20 complaint types with the largest net change in call volume (either positive or negative) from the period before to the period after non-essential

Table 2. Average change in number of daily service requests from 2019 to 2020

Category	Average change in number of daily requests		Net Change
	pre 3/20	post 3/20	
Non-Emergency Police Matter	1.31	683.3	681.98***
Noise - Residential	82.13	432.77	350.64***
Noise - Street/Sidewalk	39.15	316.44	277.29***
Illegal Fireworks	0.24	190.11	189.87**
Consumer Complaint	50.14	139.58	89.44***
COVID-19 Non-essential Construction	0	37.58	37.58***
Noise - Vehicle	19.64	48.06	28.42*
NonCompliance with Phased Reopening	0	24.09	24.09***
Traffic Signal Condition	-20.96	-46.31	-25.34**
Lost Property	28.08	-7.78	-35.85***
For Hire Vehicle Complaint	4.28	-34.8	-39.07***
Broken Parking Meter	15.09	-26.87	-41.95***
General Construction/Plumbing	-18.66	-78.59	-59.93***
Noise - Commercial	-9.33	-74.15	-64.83***
Derelict Vehicles	-4.01	-70.58	-66.57***
Abandoned Vehicle	115.33	34.1	-81.22***
Missed Collection (All Materials)	11.45	-84.61	-96.06***
Street Condition	-37.59	-193.92	-156.33***
Blocked Driveway	-16.06	-207.37	-191.3***
Illegal Parking	87.88	-218.97	-306.84***

(*** p-value < .001, ** p-value < .01, * p-value < .05)

businesses were closed, starting from January 1st and ending on June 27th, 2020. For each complaint type, we first calculated the average change in daily call volumes from 2019 to 2020, over the 79[1] days before and 99 days after the closure date. The results are given in the "pre 3/20" and "post 3/20" columns, respectively. We then used a t-test to assess the significance of the net change (at p=0.05) between these two time frames. The final dataset includes a total of 514,649 and 626,980 unique service requests for the years of 2019 and 2020, respectively.

The analysis of the differenced data shows that the change in the average number of calls per day was positive in nature for eight of the complaint types, with more complaints being received than in the previous year. At the same time, however, the corresponding change was negative for the other 12 complaint types, reflecting a significant decrease in the number of complaints received after the COVID-19 crisis began. A positive change in call volume generally indicates that there is an increase in illegal or irresponsible behavior, associated with that category of complaint, that is directly related to the crisis in some way. In contrast, a negative change in call volume typically means either that there is a decrease in behavior that would normally lead to a complaint, or that the seriousness of the

behavior is not considered significant enough to warrant a complaint at the current time because of the crisis. With this in mind, the following discussion provides more detail about the changes in each of the relevant complaint types.

Figure 1 illustrates the net change in 2020 for complaint types that received, on average, significantly more requests after March 20th than before. As discussed above, for example, *Consumer Complaints* began to increase around the time that a state of emergency was declared on March 7th, when some businesses began to be accused of price-gouging. These types of complaints started to gradually decrease after about April 10th and stabilized at only a slightly elevated level by the beginning of May.

Figure 1 also indicates that the number of *Noise - Street/Sidewalk* complaints began to show increased variability after all non-essential businesses were closed on March 20th. It then increased dramatically after the Phase 1 reopening on June 8th and peaked with the Phase 2 reopening on June 22nd, reflecting the reaction of residents to the loosening of restrictions. The *Noise-Residential* complaint type showed similar behavior, as did the *Noise - Vehicle* complaint type, although to a lesser extent. As an additional signal of the relaxing of constraints, complaints about *Illegal Fireworks* began to

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[1] Due to the leap year of February 29th in 2020, the time period is one day less (78 days) in 2019.
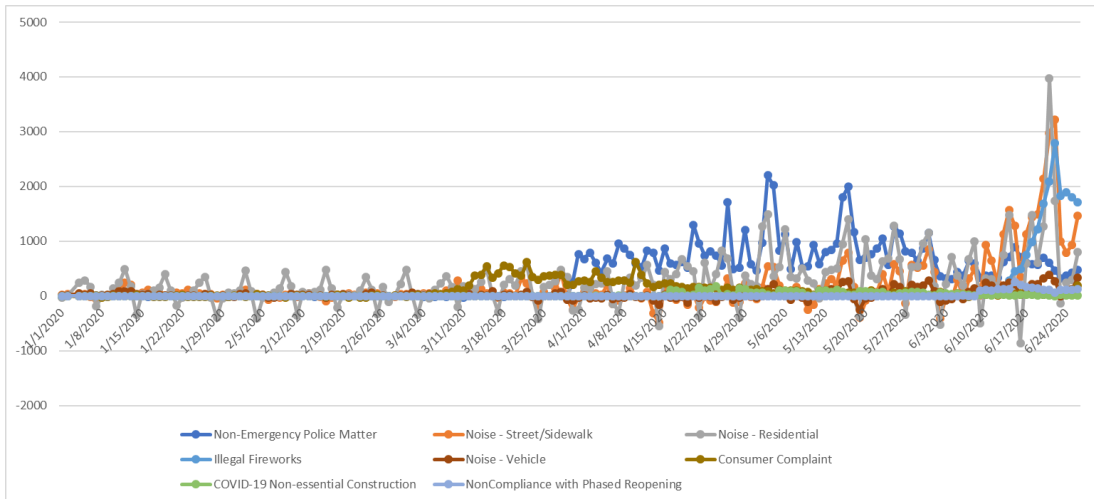
Figure 1. NYC 311 calls – net change in 2020 – increased requests after 20 March

increase consistently and dramatically after June 8th until they peaked on June 22nd.

In conjunction with a ban on non-essential and non-emergency construction that was instituted on March 31st, the City also added a new *COVID-19 Non-essential Construction* complaint type to the 311 system in late March. The number of associated complaints that were received grew relatively quickly for the first two weeks and then peaked after about a week before slowly decreasing over time. Interestingly, even though this provides an indicator of the population's vigilance to violations of the rules, most of the complaints were ultimately determined to be unfounded [26]. Furthermore, the City also instituted a new

Noncompliance with Phased Reopening complaint type that began to capture business reopening-associated complaints after about June 6th. It resulted in a fairly high level of calls right from the beginning and remained relatively steady afterwards.   Another preexisting complaint type, *Non-Emergency Police Matter*, also saw a surge in calls after March 30th, with subsequent spikes in call volume a few days after the announcement of a peak number in the daily COVID-19 positive cases in New York State[2] on April 24th, May 1st, and May 14th.   This increase in complaints was primarily due to the City augmenting the category with new options in order to support enforcing non-
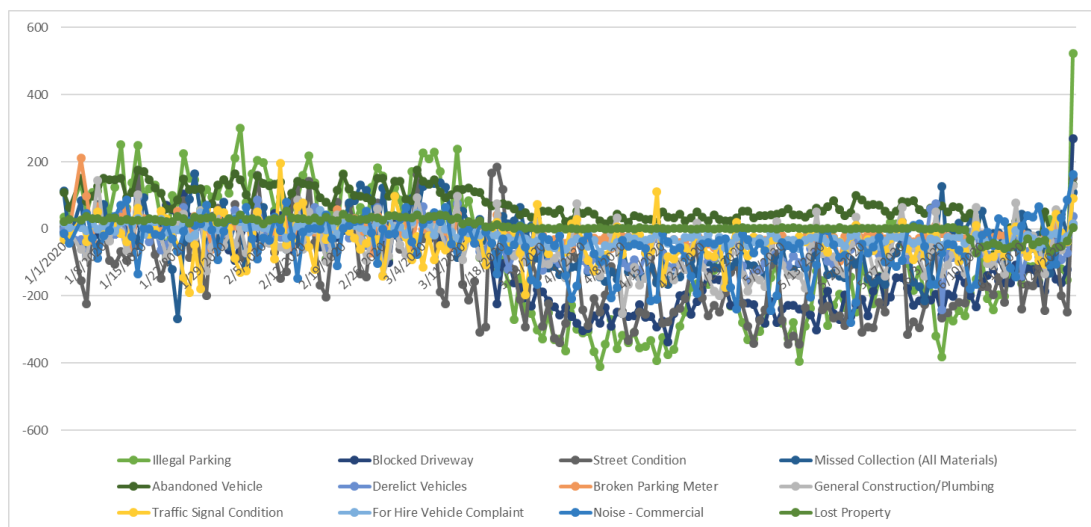
Figure 2. NYC 311 calls – net change in 2020 – decreased requests after 20 March

emergency COVID-19 restrictions. This change is discussed in more detail in Section 5.2.

The fluctuations in these complaint types reveal citizens' sensitivity to the health emergency and their reactions to related violations. When the perceived health threat increased, citizens tended to complain more about the violations of social distancing restrictions and phased reopening rules. Additionally, this behavior indicates that citizens are less tolerant of noise and gatherings during such a time of crisis, which could be associated with their overall level of stress.

As an extension of Figure 1, Figure 2 provides the net daily change in number of calls for those complaint types, which actually had a *decrease* in requests from before March 20th to after March 20th. It is interesting to note, first of all, that one of the complaint types presented in Figure 2 is *Noise – Commercial*. In contrast to the other noise-related complaint types discussed above, the number of complaints associated with commercial noise began to drop slightly after March 20th and it stayed lower until after Phase 1 reopening began in June. This provides a good example of the multi-dimensional nature of the data at hand. By virtue of the different types of signals about noise, we can specifically identify the impact not only of closing businesses but also of subsequently increasing the number of people at home and on the streets during the daytime.

The *Lost Property* complaint type is interesting in that it is slightly elevated in 2020 before March 20th, but then it drops close to zero afterwards, presumably because people are no longer visiting businesses outside of their homes. Even after reopening begins in June, however, the call volumes in 2020 only increase slightly and do not return to their 2019 values. Complaints about *Abandoned Vehicles* and *Derelict Vehicles* follow the same basic pattern, as do the complaints for *Broken Parking Meter*, *Traffic Signal Condition*, *Street Condition*, and *For Hire Vehicle*, although these last four seem to recover a bit more quickly after Phase 1 reopening began. Each of these complaint types can be tied to the reduced mobility of the people requesting services during the time period in question.

The remaining complaint types that experienced significant changes were *Illegal Parking* and *Blocked Driveway*, which are both generally associated with the mobility of others and its impact on the caller, and *Missed Collection (All Materials)*, and *General Construction/Plumbing*, which can be associated with outside service provision. In the case of each of the above, there was a decrease in call volumes after March 20th, but the number of calls clearly started increasing again as reopening began, indicating that businesses were opening up and stay-at-home restrictions were being lifted so that more normal daily activities could once again take place.

Overall, the preceding observations about the different complaint types show a strong relationship between the call volumes and the current level of the emergency. This specific set of data indicates that citizens make inferences and adjust their 311 system use behavior (whether implicitly or purposefully) based on pandemic-related announcements by the authorities and publicly available information such as the number of new COVID-19 cases each day.

4.2. Analysis of specific complaint attributes related to COVID-19

In addition to the Complaint Type attribute, each recorded 311 request in NYC includes a Descriptor attribute that is associated with the Complaint Type and can be used to specify more detailed information about a given complaint. This Descriptor variable is categorical in nature, and only a single value is assigned to any given request. Its purpose is to provide further information about its associated complaint type, and it is not a required value [24].

On March 29th, 2020, NYC added a new *Social Distancing* option to the descriptor attribute that could explicitly capture complaints related to violations of the social distancing mandate put in place on March 20th [25]. A different descriptor value, *Face Covering Violation* was later added on April 27th, after an order was issued on April 17th that made wearing facemasks in public mandatory. Both of these descriptors are used in conjunction with the *Non-Emergency Police Matter*

Table 3. # of social distancing complaints

Location Type	Total # of complaints	Percent of complaints
Street/Sidewalk	11898	20.8%
Store/Commercial	18038	31.6%
Residential Building/House	12465	21.8%
Park/Playground	6097	10.7%
No location given	8672	15.1%

Table 4. # of face covering violation complaints

| Location Type	Total # of complaints	Percent of complaints
Street/Sidewalk	2068	21.9%
Store/Commercial	3683	38.9%
Residential Building/House	1469	15.5%
Park/Playground	892	9.4%
No location given	1356	14.3%

complaint type, and between January 1st and June 26th, 93.4% of the *Non-Emergency Police Matter* complaints were specifically associated with one of those options.

Because all requests within the 311 system contain a *Location Type* attribute, each record that is associated with either *Social Distancing* or a *Face Mask Violation* can also be assigned one of the following locations: Street / Sidewalk, Store / Commercial, Residential Building / House, or Park / Playground. As illustrated in Tables 3 and 4, the largest number of such complaints in each case were associated with the *Store/Commercial* Location Type, followed by the *Street/Sidewalk* and *Building/House* locations, and finally *Park/Playground*. The remainder of the *Social Distancing* and *Face Mask Violation* complaints had no specific location provided.

Overall, the *Face Covering Violation* has a higher percentage of complaints associated with Stores and Commercial locations than *Social Distancing* does, along with a correspondingly lower percentage of complaints associated with Residential locations. This matches what might be expected in each case since the lack of a face covering in a crowded store is an easy violation to recognize. In contrast, one might be less concerned about the lack of face masks at home because of being around more familiar people.

It is interesting to note that the four specific types of *Social Distancing* complaints are all highly correlated with each other ($r \geq 0.74$ in each case, after first-differences detrending of each time series), and that they all follow the same basic pattern over time, as illustrated in Figure 3. This is also true for the *Face Covering Violation* complaints associated with streets, residences, and parks, as shown in Figure 4 (all also with $r \geq 0.56$ after detrending). The exception to this is the *Face Covering Violation* complaints associated with Store/Commercial locations. This set of complaints is not highly correlated with any of the other *Face Covering Violation* complaints ($0.13 \leq r \leq 0.22$ after detrending), indicating that the number of complaints about others not wearing masks in stores is relatively independent of the responses in other situations.

Figure 4 shows that the *Face Covering Violation* call volumes, in the case of Store/Commercial locations, do not follow the same general pattern as those associated with the other three location types. As with the greater overall number of complaints of this type, this relatively independent behavior seems to reflect a wider recognition by the public of the overall greater significance of wearing face coverings in an indoor, public context.
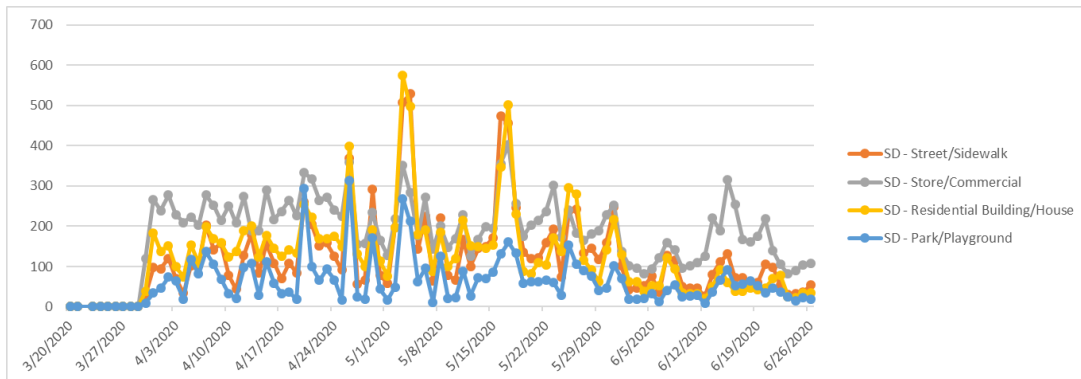
Figure 3. Location-specific *Social Distancing* complaints
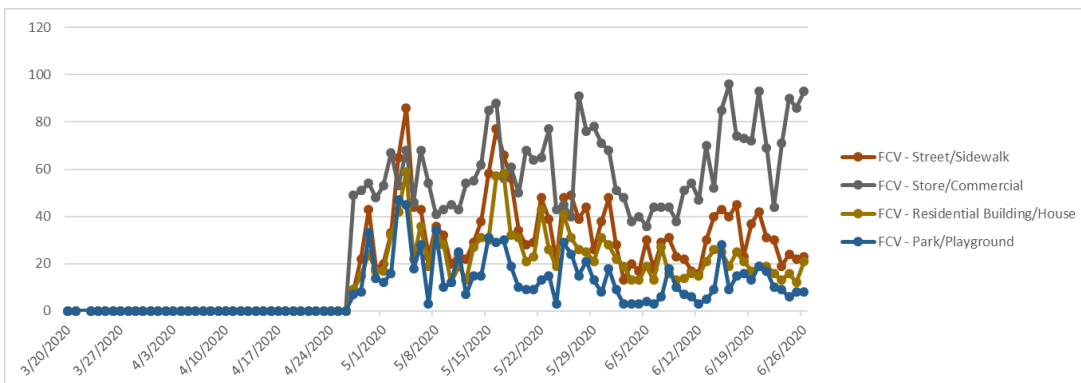
Figure 4. Location-specific *Face Covering Violation* complaints

5. Conclusion

Governments are implementing CiRM systems to allow information exchange and encourage the participation of both citizens and public services providers. NYC has a well-established 311 Citizen Service Management System as a part of the city's CiRM strategy to improve accessibility, transparency and accountability of the City government. 311 service requests during the pandemic show that NYC is well-connected with its citizens. Those individuals are effectively using the 311 system to inform local authorities of their needs during the emergency, and it allows them to be indirectly involved in the government's decision-making process by providing timely reactions to announcements and policy changes. In addition, providing public access to the 311 data, as is done by NYC Open Data, allows citizens to track service requests around the city and can motivate them to continue reporting violations in the system. This information exchange provides a good feedback mechanism for the city management who can monitor citizen behavior and plan for the future steps of the emergency management process accordingly.

The discussion above was able to show that the data from NYC's existing 311 system can be used to characterize the different impacts of the COVID-19 pandemic on the community. It also showed that the city's adjustments to that system were subsequently able to provide valuable new information about the ongoing crisis. These adjustments clearly demonstrate the commitment of the city to utilizing the system to capture how New Yorkers are reacting to changes in the ongoing threat. In particular, their use of the new *Social Distancing* and *Face Mask Violation* options as complaint descriptors provides an excellent example of how even simple changes to existing systems can provide significant value in a crisis situation.

There are a number of avenues for future research that could extend this initial analysis of the reaction of NYC's 311 system to the COVID-19 crisis. For example, data mining techniques could be used to dig into the relationships between different complaint types, in order to better understand the implications of the changes in the population's behavior. This could allow the municipality to address the root causes of that population's response to the crisis more directly, and reduce the number of service requests while better serving the community's needs.

A related extension of the current research effort could involve looking at the impact of the pandemic on the city's ability to respond effectively to the varying types and numbers of service requests as the situation evolves. In particular, the results discussed above could be used to support the process of re-allocating resources to address changes in demand due to the pandemic. Because each service request in the data set also has a corresponding response time, there is potential for both measuring and improving the city's overall ability to respond to its citizens' needs during the pandemic.

Another potential opportunity for future research, based on this work, would be a comparison of different 311 systems. A significant number of metropolitan areas in the United States, including San Diego, California and Houston, Texas, also have active 311 systems whose data is publicly available. Particularly because the service request types and the specific attributes that are collected in each case may be very different, it would be interesting to compare the relative ability of those systems to capture different aspects of the pandemic's impacts.

Finally, even though a 311 system such as that of New York City can be used effectively to characterize the interactions between a municipality and its citizens during a pandemic, it is also important to keep in mind that it is just one example of a CiRM system implementation. Other similar systems, such as the 911 system for emergency calls and the 211 system for community information and referral services, could also be considered in this context and they might provide additional information, or a different perspective, that could be useful for managing the city's pandemic response. 311 systems, however, have the distinct advantage that their detailed data is more often publicly available. This can facilitate more effective and efficient information exchange and thus provide additional value to both the municipality and its citizens in helping to offset some of the uncertainty inherent in such a crisis.

6. References

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