Examining User Access Options for eGovernment Services During a Crisis from a Digital Inequality Perspective

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Abstract

City governments incorporate ICTs into government services to improve citizen participation and access to those services. Too much dependence on technology, however, can lead to concerns about creating a digital divide between different groups of citizens. The potential for digital inequality is a critical issue that can be exacerbated by insufficient attention being paid to vulnerabilities across communities. Given that socio-economically vulnerable populations are the ones who need government services the most, especially during disaster events, it is critical to investigate the extent to which digital inequality is an issue for technology-based government services. With this in mind, this paper analyzes the use of different technology-enabled access options for a representative eGovernment service system, the New York City 311 service system, in the early stages of the COVID-19 pandemic. Two sets of socio-economically distinct locations in New York City are compared, using average income as a proxy for vulnerability, to draw conclusions about potential inequalities in such a system during a crisis.

Keywords: 311, Disaster, Digital Inequality, Social Vulnerability, Non-Emergency.

1. Introduction

City governments are responsible for providing necessary everyday municipal services to citizens. Besides the responsibility for continuity of the functioning of regular city operations, such services also offer critical support for citizens with respect to their emergency and non-emergency needs during times of crisis (Pamukcu et al., 2021; Zobel et al., 2018).

311 service systems, which are focused on managing everyday (non-emergency) service requests, were initially established to reduce the burden on 911 emergency systems. Although such 311 systems initially focused on receiving and processing phone calls, over time they have transitioned from single-channel systems to multi-channel systems by incorporating additional access modes, such as online access and access via smartphone apps. Today, 311 systems are considered to act as a multimedia hub, a municipal data source, and a community engagement tool (Samuel, 2019).

Incorporating new information and communication technologies (ICTs) into government service systems is a significant part of improving citizen interaction with governments, and it helps to create more sustainable, engaged, and connected communities. It is important, however, to recognize that embracing technology-based approaches also brings with it the potential for *digital inequality* to arise, due to the different levels of technology access available to a population. This can specifically be a concern within more socio-economically underprivileged communities, in which individuals may have fewer resources available for internet or smartphone-based technologies and where ICT-based government services may thus amplify already existing disadvantages (Hsieh et al., 2008, 2011; Nam & Sayogo, 2011). In particular, given that those communities are also the most vulnerable to disaster events, there is a danger that such digital inequality will also reduce their access to the full breadth of critical services during a disaster (Zahran et al., 2011). For this reason, actively engaging communities and seeking to ensure different means of accessing government services during disasters is extremely important.

With this in mind, this paper seeks to begin characterizing the extent to which different groups of citizens make use of digital technologies in their interactions with 311 systems during crisis events, in order to better assess the relative importance and availability of such technologies across these different groups. To explore this in some detail, the following discussion focuses on the situation in New York City (NYC) during the initial stages of the COVID-19 pandemic. It uses descriptive analysis, based on secondary data, to consider two different sets of locations within the city: one that is socio-economically

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privileged and one that is socio-economically underprivileged. These two areas are compared with respect to their use of the 311 system and its different technology-enabled modes of access, both before and during the pandemic. To the best of our knowledge, this is the first study looking at the changes in how alternative technology-enabled access options are used in a public service system during a crisis, as compared to their use during non-crisis situations. This study is also the first that brings the digital inequality discussion into the public service system operations management literature, in a crisis context.

2. Background

Several local government service systems are available worldwide to support community needs. In addition to available emergency hotlines such as 911 in the United States or 112 in European countries, additional systems are also designated for various non-emergency community needs. Some examples are 116117 as a general medical helpline used in European countries for non-urgent medical assistance[1], 114 14 for non-emergency police matters in Sweden[2], and 101 for non-emergency and general inquiries for police service in Northern Ireland[3]. The United States and Canada established several unique and easy-to-remember three-digit call numbers for such community services, such as 211 for community information and referral, 311 for non-emergency services, 411 for general information, 511 for transportation, and 911 for emergency services. Each of these systems implements various ICTs to facilitate convenient access and to provide enhanced communication and collaboration between government agencies and citizens in support of maintaining the public's well-being (O'Brien, 2016).

The original 311 non-emergency service request system was established in Baltimore, Maryland in 1997 as a unique hotline for such local services (Schwester et al., 2009). Since then, many metropolitan areas have also built independent non-emergency service systems. 311 systems typically revolve around call centers that facilitate the collection of service and information requests from citizens and organizations and then direct those requests to the responsible local agencies. Such services are part of the e-government efforts of local municipalities to provide effective and transparent service delivery and to facilitate necessary data collection and information exchange in response to citizens' expectations (Larsen & Milakovich, 2005; Pamukcu & Zobel, 2021). 311 systems generally provide multiple modes of electronic access to government services and maintain detailed databases of individual service request results, with many cities offering free access to the actual service data.

The relevant details about each individual 311 service inquiry are usually stored in a standardized and structured way. Although there are slight differences in the functioning and structure of the independent 311 systems in different municipalities, each system generally uses a predetermined set of request types to categorize each inquiry. Additionally, each individual record includes the exact time, date, and location of the associated service request, along with the responsible agency. As a whole, 311 service data provides a rich record of historical and timely information about citizen concerns and problematic issues across the local area.

New York City provides an example of one of the most comprehensive 311 non-emergency call systems in the U.S., linking New Yorkers to various municipal services. The New York City 311 (NYC311) call system has been using e-government applications to reach out effectively to its citizens since 2003 (Idicheria et al., 2012). Currently, citizens can connect to the NYC311 system via multiple modes of access, such as through the website or via text messages, phone calls, skype calls, social media, or a dedicated smartphone app. Multiple language options are available for both online and phone call services to encourage all citizens to participate and stay in contact with the municipality (Pamukcu & Zobel, 2021). Additionally, the system offers Video Relay Service (VRS), and Text Telephone options for deaf, hard of hearing, or speech-impaired citizens.

One motivation for systems like NYC311 to provide a range of different access options is to help address issues associated with the so-called digital divide. The digital divide is a complex and multidimensional concept used to describe "the gap, separation, distinction, disparity or gulf between haves and have-nots in terms of various resources and competencies related to ICTs" (Nam & Sayogo, 2011). The availability of digital technologies is a significant part of the digital divide, which also includes aspects of motivation, physical access, and necessary skills. The digital divide between those with high or low access to technological means has been a major challenge of e-government, and it is particularly affected by socio-demographic attributes such as age, income, and education level, and by the use of internet functions for other tasks (Nam & Sayogo, 2011; van Deursen & van Dijk, 2013; Young, 2015). This challenge is echoed in the theory of Diffusion of Innovation, which argues that socio-demographic attributes affect innovation diffusion in situations where e-government services are

[1]https://ec.europa.eu/commission/presscorner/detail/en/IP_09_1842

[2] https://polisen.se/en/contacting-the-police/

[3] https://www.psni.police.uk/contact-information/

considered new practices and innovations for technology users (Nam & Sayogo, 2011).

The body of literature that focuses on digital inequality, in particular, discusses the digital divide in the context of different segments of populations that have diverse digital opportunities. This literature includes contrasting perspectives about the long-term outcomes of the digital divide (van Deursen et al., 2017), and some prior studies have been inconclusive concerning inequality issues associated with access to, and service from, 311 systems (Minkoff, 2016).

One stream of literature does argue that the availability of multi-channel options in 311 services reduces the participation gap across communities with different income levels (Young, 2021). In support of this perspective, Clark et al. (2013) point out that the use of smartphone-based 311 applications for submitting requests actually occurs at a higher rate in lower-income areas than in higher-income ones in the City of Boston. Likewise, the results of a city-administered survey by Clark and Brudney (2018) indicate that enabling smartphone-based access modes in San Francisco's 311 system increased coproduction rates among minority groups. There is thus evidence that digital innovations may mitigate socioeconomic disparities in the use of e-government services. At the same time, however, a greater percentage of the population has access to a telephone rather than the Internet or a computer (Young, 2015). This implies that access to government services may be more easily available through telephone-based means than through internet-based means for many citizens.

Prior research identified *income* as one of the most significant indicators of one's socioeconomic status (Hsieh et al., 2011) and a powerful predictor of ICT use or non-use (van Deursen & van Dijk, 2013), which therefore affects the access and use of e-government services (Lu & Johnson, 2016). It is the higher income groups that are more likely to use smartphones for information seeking, for example, and their frequent use of such technologies for information exchange also reflects their relative economic status (Tsetsi & Rains, 2017). Lack of wealth is regarded as one of the primary indicators of social vulnerability, which results in individuals being less resilient to crises due to limited access to critical resources for responding to and recovering from their adverse impacts (Cutter et al., 2003). Income, as an important indicator of personal wealth, is thus identified as one of the significant contributors to social vulnerability in a number of well-accepted social vulnerability indexes that have been applied to hazard events (e.g., SoVI (Cutter et al., 2003), and SVI (CDC, 2016)).

Potential restrictions on the availability of certain ICTs during crisis times can further exacerbate the digital inequality between communities with different income levels. The availability of Internet access at home, and the skills needed to use different technologies, can also affect the digital divide among groups. Recent studies note that during the COVID-19 shutdown, socio-economically disadvantaged people in many different countries faced significant barriers to having adequate access to technology and the internet (Kim & Padilla, 2020; Rahiem, 2020). Although public libraries and internet cafes typically provide options for technology access outside the home, pandemic-related lockdowns made it much more difficult for individuals to make use of these public areas. One of the objectives in this paper is to explore whether such limitations on the availability of digital options during the crisis also affected the ability of disadvantaged groups to request help from government services.

3. Data

Because of its highly structured nature, the 311 data for different municipalities is generally available for public download in the form of comma-separated values (CSV) files, which facilitates the process of importing it into a spreadsheet or a relational database for analysis. For example, the NYC Open Data initiative enables free public access to all current and historical NYC311 data in this format. As with other such data sets, each record in the NYC311 data set represents a unique service request. The data collected about each request consists of fundamental attributes such as the exact time and date of the complaint, the corresponding agency, the complaint type, the incident address, the borough, and the date and time that the issue was resolved, as well as the specific mode (PHONE, MOBILE, ONLINE, UNKNOWN, and OTHER) used to access the system.

In order to explore the extent to which potential digital inequality was an issue during the first months of the COVID-19 pandemic, the complete set of NYC 311 service request data was downloaded for the period between January 1st and May 12th, 2020, which covers an equal number of days before and after a pandemic-initiated State of Emergency was declared in NYC on March 7th. The complete downloaded data set includes 683,583 unique service requests placed during this time.

New York City is one of the most diverse cities in the United States, with the highest population density in terms of social and economic characteristics (Zobel et al., 2018). The City consists of five distinct boroughs (the Bronx, Brooklyn, Manhattan, Queens, and Staten Island). NYC Department of City Planning creates 59 community districts within the city boundaries with a population range between 50,000 to over 200,000 (Citizens' Committee for Children of New York, 2019).

Since the populations of some community districts are too small to meet the population threshold of 100,000 residents, the Census Bureau paired some

districts together to create 55 total statistical geographic areas, called Public Use Microdata Areas (PUMAs). In this study, the PUMAs are used as the geographic unit of interest. The NYC PUMAs and their populations are illustrated on a heat map in Figure 1.

The average salary in each PUMA was chosen as a proxy measure for identifying lower salary areas that may be more likely to suffer from issues of digital inequality, as well as to identify more socio-economically advantaged high salary areas that would be less likely to do so. In order to incorporate some of the diversity inherent in different parts of the city, the five PUMAs with the lowest average salaries (01-02 Bronx, 03-06 Bronx, 04 Bronx, 05 Bronx, 16 Brooklyn) and the five PUMAs with the highest average salaries (01-02 Manhattan, 06 Manhattan, 07 Manhattan, 08 Manhattan, 06 Brooklyn) were identified as the two sets of population areas to be compared. The corresponding subsets of requests were then extracted from the downloaded 311 data set, resulting in a reduced data set of 166,917 total records. The two defined population areas have approximately similar population sizes. Therefore, the numbers of service requests per group are comparable.

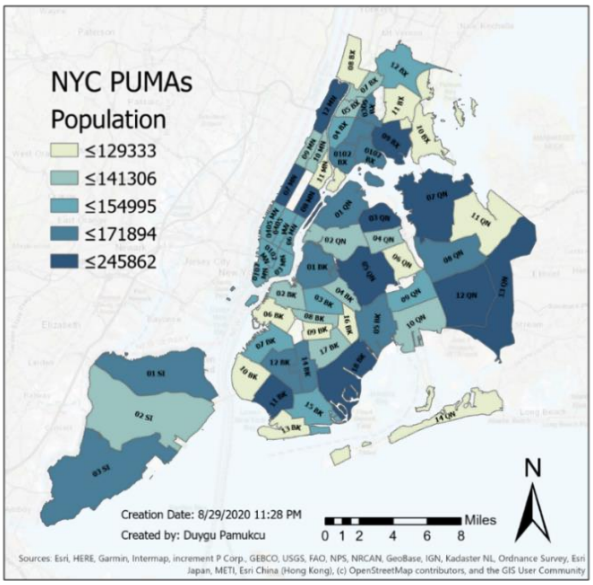

Figure 1. NYC PUMAs and population levels based on American Community Survey (ACS) 5-year estimates (2018).

4. Analysis

The following analysis looks at two different aspects of the 311 service request data. First of all, it considers the overall number of daily service requests for each of the two populations of interest. It then examines the data in a bit more detail by focusing on the number of service requests received through several different access modes, in order to look more closely at potential digital inequalities.

4.1. Daily service requests

To begin the analysis, the total number of service requests made per day was calculated across all categories, both for the low salary PUMAs and for the high salary PUMAs, during the time period of interest. Figure 2 shows the resulting time series behavior. It is clear that the announcement of the State of Emergency had an impact on the number of requests made, but it is also a bit surprising that the two populations reacted in opposite ways. Before the announcement, the two groups had similar behaviors in terms of the numbers of requests made each day, but after the announcement, the behaviors changed somewhat dramatically, with the lower salary locations increasing the number of daily requests and the higher salary locations decreasing the number of such requests by an even greater amount.

To analyze this overall behavior more directly, a series of two-tailed paired t-tests were run to statistically compare the distributions of requests before and after the start of COVID restrictions. Table 1 provides the average number of daily requests for each time interval, along with the results of the t-tests on the daily values.

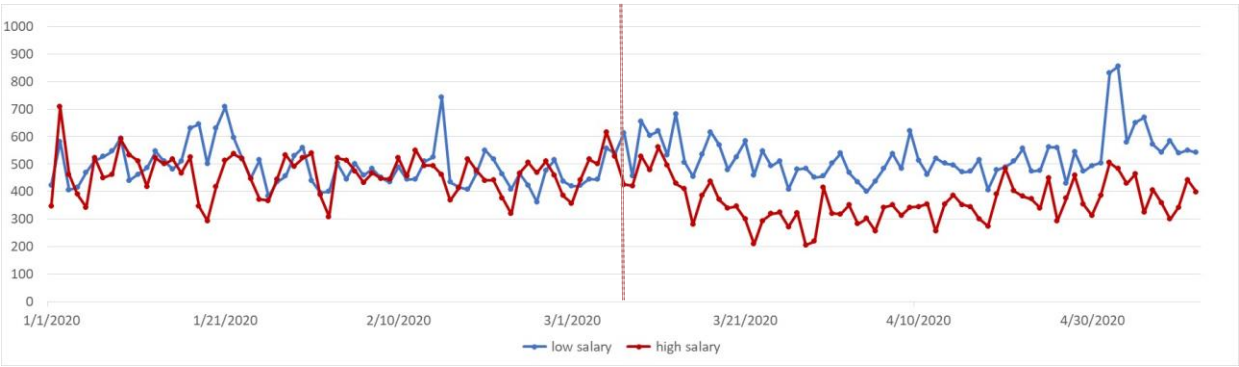

Figure 2. Daily number of service requests

Figure 3. Daily number of service requests by access mode (low and high salary)

Table 1. Average daily number of service requests

	Low salary	High salary	Difference (low vs high)
pre-07 Mar (n=66)	489.68	465.47	-24.21* (p=0.029)
post-07 Mar (n=66)	529.27	363.88	-165.39*** (p=6.8E-10)
Difference (pre vs post)	39.59* (p=0.015)	-101.59*** (p=6.8E-10)	

From Table 1 it can be seen that before the State of Emergency was declared the number of requests per day was slightly more for the low salary regions than for the high salary regions, and that this difference is significant at the $p<0.05$ level. The results also show that after the announcement the difference between the two groups is subsequently much larger (and at an even higher level of significance ($p<0.001$)), as was suggested in Figure 2. Table 1 also shows that the difference in request behavior between the two groups is the result of the low salary regions' requests going up slightly ($p<0.05$) at the same time that the requests from the higher salary regions actually went down by more than 20% ($p<0.001$).

Together these results indicate not only that the population's behavior changed as a result of the COVID crisis, but also that individuals with fewer resources may require more assistance during a disaster. This makes it critical to ensure that they are able to request that assistance and that the city is able to provide it in a timely manner.

4.2. Daily service requests by access mode

There are five distinct access modes recorded in the 311 data set: *phone*, *mobile*, *online*, *unknown*, and *other*. The current analysis focuses on the first three types because of their more specific nature. Figure 3 thus shows the daily service requests for each of the two populations, grouped together depending on whether requests were made by phone call, by using the mobile app, or via the online website.

As with Figure 2, one can see that there are changes in the service request behaviors for the different access modes after the State of Emergency was declared. For the low salary areas, the number of requests made by phone did not change very much, but the number of requests made using the mobile or online access options actually seems to increase. In contrast, the data for the higher salary regions suggests that phone usage actually decreases, while online usage appears to become much higher, and mobile usage stays relatively the same.

These initial observations are more or less validated by looking at the statistics presented in Table 2. The number of requests made by phone within the lower salary areas does decrease significantly overall (-40.43 requests per day ($p<0.001$) – about a 14% change) from before the emergency announcement to after that announcement. At the same time, the corresponding number of requests increases for the mobile option (+23.9 requests per day ($p<0.001$) – around a 31% change) and even more for the online option (+74.04 requests per day ($p<0.001$) – about an 87% change).

In the high salary locations, the results are slightly different than the graph seemed to indicate. The number

Table 2. Average daily number of service requests by access mode

	Low salary			High salary		
	phone	**mobile**	**online**	**phone**	**mobile**	**online**
pre-07 Mar (n=66)	284.08	76.74	84.94	178.59	59.03	171.77
post-07 Mar (n=66)	243.65	100.64	158.98	108.12	47.64	162.83
Difference (pre vs post)	-40.43*** (p=3.8E-04)	23.90*** (p=1.1E-05)	74.04*** (p=5.5E-14)	-70.47*** (p=2.6E-16)	-11.39*** (p=1.9E-05)	-8.94 (p=0.19)
% change (pre vs post)	-14.2%	31.1%	87.2%	-39.5%	-19.3%	-5.2%
% of requests (pre-07 Mar)	58.0%	15.7%	17.3%	38.4%	12.7%	36.9%
% of requests (post-07 Mar)	46.0%	19.0%	30.0%	29.7%	13.1%	44.7%

of phone calls made decreases significantly (-70.47 requests per day ($p<0.001$) – around a 40% change), but the number of mobile requests also goes down slightly over the given time period (-11.39 requests per day ($p<0.001$) – a drop of about 11%). Despite the relative increase in online requests in late April and early May, however, there is no significant difference between the distribution of online requests before and after the emergency is announced ($p>0.1$). A closer look at the data indicates that the apparent increase in online requests towards the end of April may be being canceled out by a corresponding decrease in such requests in late March. Additional analysis that looked more specifically at other instigating events and at differences between different categories of service requests (which is beyond the scope of this paper) would be able to clarify this behavior further.

Directly comparing the different access modes within the high salary locations shows that the number of requests made by phone and the number made online were not significantly different during the pre-COVID time period before March 7th ($p>0.1$). After March 7th, however, there was a significant shift in overall numbers from phone calls towards online requests (p=3.01E-09), even though, as discussed above, the actual number of online requests didn't change significantly. This suggests that the decrease in the number of phone calls was not primarily due to a shift from the phone option to the online option. Instead, the decrease simply appears to be more associated with fewer phone calls being made in the high salary areas after the crisis began.

A similar comparison for the low salary locations shows that before March 7th the number of online requests was slightly more than the number of mobile requests ($p<0.001$). After March 7th, however, there was a significant shift towards requests using online access ($p<0.001$), thus reflecting a greater increase in use of the online option among this population. Even with this increase, however, the numbers show that the number of requests made via phone calls is still much larger within the low salary group than is the number associated with either of the other options.

These behaviors are also reflected in the relative percentage of requests across all access mode types, including those classified as *unknown* and *other*, as shown at the bottom of Table 2. The mobile access option has the lowest percentage of the three on which the discussion is focusing, across both low salary and high salary locations and both before and after the State of Emergency was declared.

In the low salary case, the phone access option clearly has the highest usage percentage both before and after March 7th. Together, the phone, mobile, and online access options make up 91% of the total requests received before the crisis and as a group, they increase to 95% of the total afterwards. Echoing the earlier discussion, the overall percentage of phone calls from the low salary areas decreases from before to after while the percentage of online requests increases by a similar amount.

In the high salary case, the phone and online access options are very similar in their percentages before March 7th, and the three modes together make up about 88% of the total requests in both periods. The shift towards online access after the announcement date is reflected in a corresponding upward shift in the percentage of requests received via that access mode. In

the period after the crisis began, the relative percentage of online requests in the high salary areas ends up being similar to that of phone calls in the low salary areas, with both being the most popular option in their respective areas.

5. Discussion

Based on the results of the analysis in the preceding section, several general observations can be made about the observed behaviors. These observations apply specifically to the NYC311 system, but they can provide helpful guidance to other 311 systems as well.

Observation 1: It is important to give appropriate focus to more vulnerable people during a crisis

The increase that was observed in the total number of requests made in the lower salary locations, from before the declaration of a State of Emergency to after that declaration, reflects the expectation that more vulnerable people may have more need for support during a crisis. The corresponding decrease in requests in the higher salary areas also suggests that those who have more personal resources may actually need less assistance during a disaster. This can provide the opportunity for communities to shift resources during times of crisis in order to reallocate them to those with more need at that time.

As indicated above, the increase in requests by the lower salary populations was primarily due to increased use of the mobile and online access options, leading to the second observation:

Observation 2: It is important to provide an online option for submitting service requests during a crisis event.

In the case of the NYC311 system, the online access option was the one that was used most often by the high salary locations during the first few months of the COVID crisis. It was also used substantially more during the crisis by the lower salary locations than it was before the crisis was officially declared.

Before the crisis began, the use of the online option in the higher salary locations was very similar to that of the phone option and its relatively lower use in the lower salary locations was very similar to that of the mobile option. The implication is that online access may have more perceived value in better resourced areas but also that there is not necessarily a strong preference for it over other options during non-crisis situations, particularly in locations with less resource availability.

This leads to the third observation:

Observation 3: It is important to provide the option to submit service requests via phone calls, during both crisis and non-crisis situations.

Even though it was used somewhat less during the COVID crisis, the phone option was the one that was most heavily used in the low salary areas both before and after the State of Emergency was announced. This is particularly important to recognize because of the potential for socio-economically disadvantaged individuals to have less access, in general, to other types of communication technology.

The subsequent shift towards using different access options during the crisis does imply that there is an opportunity to meet different people's needs through such alternatives. It also implies, however, that a balanced approach is necessary, with appropriate resources being put towards supporting the phone-based option. Such investments can benefit system users in high salary locations as well, since the phone option is also chosen for a significant portion of their service requests during both crisis and non-crisis times.

6. Conclusions

This paper discusses the need for, and use of, alternative technology-enabled modes of access in an eGovernment non-emergency service system, i.e., a system developed to manage non-emergency service requests that continues to manage such requests during times of crisis. User interaction with the system is compared during both crisis and non-crisis time periods in order to examine potential digital inequality issues due to differences in socio-economic vulnerability. This is accomplished by analyzing two sets of locations within New York City with the highest and lowest average income levels, and observing the shift in the use of different modes of system access in the early stages of the COVID-19 health crisis.

The relationship between the digital divide and the potential for social inequality has been a concern of researchers for the last few decades. Nevertheless, the discussion about how to mitigate rather than exacerbate the digital divide still needs further attention. The observations above point out the importance of giving proper focus to more vulnerable people during a crisis and enabling access options that can better serve people with diverse socio-economic backgrounds. Although digital inequality related to lack of access doesn't appear to be a significant issue within the NYC311 system, the availability of multiple access options does support bridging the digital divide across communities with different income levels. These multiple modes of access can be helpful for all system users, regardless of their current circumstances.

It is important to note that many, if not most, of the 311 requests received during a disaster are unrelated to the actual crisis. However, any subsequent increase in new requests because of disaster-related issues (a fallen tree blocking a road, delayed garbage retrieval, etc.) will still require more resources to be allocated. Because of these changing system needs, and the potentially increased urgency of the government's response, such a system may adapt its functions and capacities to better respond to citizens' requests (Pamukcu et al., 2021; Williams, 2011). This flexibility is important in the process of managing the everyday interactions with the system as well, in order to continue to meet citizens' evolving needs over time.

There are several important opportunities for future work that arise from this research effort. One obvious opportunity is to extend the analysis to other 311 systems in different cities, and to conduct a comparative analysis in order to better generalize the results. Another opportunity is to consider alternate approaches for measuring social inequality, and for connecting it to digital inequality, in order to go beyond just the economic aspects of the issue. One could also more explicitly characterize the specific advantages that digital technology options have over non-digital options such as the telephone, in terms of the value provided to the system users in a crisis situation. The results discussed above could then be extended to allow for measuring the actual cost of the digital divide.

Another future research direction might focus on a more extended period of COVID-19 in order to examine the recovery phase and enrich the conclusions by examining longer-term effects on system usage. A pandemic differs from many other crises in that the recovery phase overlaps significantly with the response phase. In other words, the system still continues to experience the effects of the event while in the process of recovery. The analysis of the recovery period may provide additional insights into varying preferences of access modes of people over time as the crisis evolves, and how the system might best be adapted to longer-term changing conditions.

The pandemic has exacerbated pre-existing inequalities, where historically underprivileged people experience an enormous increase in job losses (Cortes & Forsythe, 2022). A future study may explore if job loss rates explain the increased use of such a public system by low-income populations since they may seek more help and information during the crisis.

Future research could also look at the observed shifts between the use of different access modes with respect to the different types, or categories, of service requests. This would help to clarify why the overall shifts in behavior occur when they do, and in the way that they do. Furthermore, by revealing requests that require more (or less) attention during a crisis, service providers could more effectively mitigate any unintended service inequalities within particular communities.

Finally, there is also an opportunity to examine the relative amount of time it takes for the municipality to respond to service requests received via different access modes. A service provider's response is just as critical as the user's inputs and interactions for understanding and improving a service system's performance. Because of this, a better understanding of the relationship between access modes and actual response times could further help to reduce any potential service inequalities, particularly during crisis events.

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