Digital Sociotechnical Systems of Mutual Aid: How Communities Connected, Adapted, and Innovated During the COVID-19 Pandemic in New York City

CITIZEN SCIENCE:
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CAROLYNNE HULTQUIST
RAMZI M. TUBBEH

*Author affiliations can be found in the back matter of this article

ABSTRACT

New York City was one of the hardest-hit areas in the first wave of the COVID-19 pandemic. At the time, knowledge about SARS-CoV-2 and strategies to prevent and respond to outbreaks were incipient. Social distancing created additional challenges. As such, people turned to digital technologies to find creative ways, not only to keep in touch with their loved ones, but also to find help and to assist strangers in need. In this essay, we describe how individuals and organizations in New York City used digital technologies to monitor and share information on COVID-19, to provide support for vulnerable people, and to get medical devices to those in need. Using the concepts of citizen science, mutual aid, and digital sociotechnical systems, we make three arguments. First, digital sociotechnical systems have a unique capacity to enroll and connect people—including strangers—over long distances, therefore enabling participation in mutual aid initiatives despite strict social-distancing limitations. Second, pre-existing mutual aid initiatives supported by digital sociotechnical systems demonstrated high adaptability and were quickly repurposed for COVID-19 mutual aid. Lastly, mutual aid initiatives, confronted with certain limitations of digital sociotechnical systems, engendered innovations and calls for transformations toward more inclusive systems. Time will tell whether these emerging transformations outlast the disaster itself and enhance long-term community resilience.

CORRESPONDING AUTHOR:

Carolynne Hultquist

Center for International Earth Science Information Network (CIESIN), Columbia Climate School, Columbia University, New York, 10025, USA

c.hultquist@columbia.edu

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INTRODUCTION

Disasters often spark prosocial behavior among members of affected communities (Stallings and Quarantelli 1985; Rodríguez, Trainor, and Quarantelli 2006; Kitazawa 2010; Koch 2014; Zaki 2020; den Broeder et al. 2021; Uekusa, Matthewman, and Lorenz 2022). A new shared identity among a community of survivors, a heightened sense of empathy, and a growing belief that one can make a difference in other people's lives are at the root of disaster-related solidarity; the result is often a greater readiness to help others in need during crises (Zaki, 2020). Solidarity in action is often referred to as mutual aid, following Pëtr Kropotkin's thesis that mutual aid among members of social species is a fundamental component of evolutionary processes and species survival amid environmental hardship (Kropotkin 1902; Koch 2014).

Mutual aid is vital for addressing disasters because established organizations tasked with conducting disaster-related societal functions are often overwhelmed. Emergent organizations staffed by volunteers often fulfill those functions (Quarantelli and Dynes 1977; Stallings and Quarantelli 1985). In other cases, existing organizations switch their efforts to disaster response (Quarantelli and Dynes 1977).

Mutual aid initiatives increasingly rely on digital technologies to develop their purpose and to connect with the crowd. The 2010 Haiti earthquake marks a significant moment at which humanitarian volunteers effectively utilized digital technologies for crowdsourcing during a crisis. (Liu 2014; Meier 2015; Kankanamge et al. 2019). Many cases since then have demonstrated that "citizens as sensors" (Goodchild 2007, p. 211) or "human sensors" (Liu 2014, p. 407) can collectively produce timely and comprehensive information that improves situational awareness (Liu 2014; Meier 2015). Crisis informatics studies demonstrate that volunteers use digital technology for geolocation and mapping during crises to provide information, mobile communication, and volunteer services for humanitarian response (Kankanamge et al. 2019). Digital technologies are adapted by groups as needed (Liu 2014), and Web 2.0 enables agile multidirectional peer-to-peer communication (Kankanamge et al. 2019).

Citizen science projects built upon digital technologies have great potential for enhancing public participation in disaster-response efforts, for challenging preconceived notions of expertise, and thus, for detecting a greater range of social or environmental impacts (McCormick 2012). Citizen science can challenge environmental monitoring standards through participatory approaches and create knowledge of local environments (Ottinger 2010). Development of digital technology has facilitated disaster convergence, in which crisis networks engage in disaster response (Auf der Heide 2003; Soden and Palen 2018). On the other hand, Soden and Palen raise concerns that some disaster-response projects that claim democratization of knowledge production on the basis of volunteer involvement require critical consideration of "what counts as expertise, how problems are framed, and whose voice is heard" (2018, p. 16). Still, projects with a high level of participation, such as in "extreme" citizen science, challenge "elitist aspects of scientific practice" and engender collaborative environments with deeper and more inclusive community involvement in scientific knowledge production (Haklay 2013, p. 13).

A thorough understanding of the role of digital technologies in channeling mutual aid during disasters is best served by a conceptualization of technologies as embedded in a network of tangible supporting infrastructures and intangible social institutions (Hughes 1987; Moss 2016). These sociotechnical systems (Fox 1995; Edwards 2003) are so intricately networked that it is difficult to determine their boundaries (Larkin 2013). The internet is a prime example. Networks of routers, modems, cables, satellites, computers, servers, and the electrical grid enable remote communication according to intangible conditions, like communication protocols, software, and funding systems like home or office Wi-Fi plans. Importantly, the internet is made functional only through use. Data production and exchange among users has driven the expansion of the internet from its initial function as a single organization's communications infrastructure in the 1980s to an acephalous globally networked infrastructure essential for modern life (Edwards, 2003). Finally, technologies are not "empty vessel[s]" at the disposal of their users; rather, society and technology are mutually constituted (Sandvik et al. 2014, p. 225). As such, the acephalous and distributed nature of internet communications has an imprint on social relations.

COVID-19 poses an exceptional opportunity for studying the role of digital sociotechnical systems in mutual aid responses to epidemics. Unlike other disasters, respiratory illness epidemics like COVID-19 require social distancing to prevent virus spread. Hence, digital forms of social interaction are even more important for channeling and facilitating response efforts (Chagas et al. 2020; Drew et al. 2020; Birkin, Vasileiou, and Stagg 2021). Furthermore, the COVID-19 pandemic may be triggering—or at least accelerating—important transformations in the institutions that govern our digital technologies. One of the most salient is a trend toward recognizing internet access as an essential public good to be supported through public funds, primarily because those without access have faced substantial challenges attending K–12 school (Anaya Figueroa et al. 2021; Fredman 2021) and receiving healthcare and health-related information (Watts 2020). Scholars warn, however, that ensuring internet access would not address much more complex sources of social inequality (Zheng and Walsham 2021).

Despite an abundance of research on mutual aid (Alakeson and Brett 2020; Chagas et al. 2020; Springer 2020; Zaki 2020; Li et al. 2021) and use of digital technologies during the COVID-19 pandemic (Drew et al. 2020; Watts 2020; Anaya Figueroa et al. 2021; Birkin, Vasileiou and Stagg 2021; Fredman 2021; Zheng and Walsham 2021), the complex interactions between digital sociotechnical systems and respiratory epidemics remain understudied (but see den Broeder et al. 2021). Hence, in this article we ask two research questions: (1) What roles have digital sociotechnical systems played in mutual aid responses to the COVID-19 pandemic? and (2) how is the COVID-19 pandemic changing our digital sociotechnical systems? We address these questions through a study of mutual aid initiatives in response to the first wave of the COVID-19 pandemic in New York City (NYC).

METHODS

We compiled and conducted a qualitative analysis of mutual aid initiatives in response to the COVID-19 pandemic in NYC. Criteria for including mutual aid initiatives were functional, spatial, temporal, and organizational. Mutual aid initiative functions include (1) providing goods (e.g., food, clothing, or medical supplies) or services (e.g., transportation or shelter) for people in need or (2) collecting data and producing information in order to support situational awareness. Initiatives were included only if they were active in NYC during the acute phase of the pandemic, characterized by high COVID-19 spread, a great number of deaths attributed to COVID-19, inexistent vaccines, limited testing capabilities, and social distancing. The first COVID-19 case in NYC was reported in the first week of March 2020. The 7-day average number of new daily reported cases rose quickly and peaked in mid-April at more than 5,300 cases; then it declined below 500 cases in early June. The first deaths were reported in mid-March and peaked at more than 800 daily deaths in mid-April, declining to below 20 daily deaths in early July (New York Times 2022). Vaccines were unavailable at the time, testing capabilities were limited, and physical social interactions were restricted. While COVID-19 spread was higher during the recent 2022 Omicron variant surge, daily deaths in the spring of 2020 were much higher than in later waves (New York Times 2022). As such, our analysis is based on mutual aid initiatives that were active in NYC during the first wave of the pandemic, precisely between March and June 2020.

We focus on how mutual aid initiatives assist existing organizations when these are overwhelmed by the extenuating circumstances created by the disaster. Therefore, we excluded organizations that existed prior to the disaster and performed regular disaster-related tasks. For example, COVID-19 healthcare provided by professional medical staff as part of their regular hospital jobs is not included in our analysis. In terms of Quarantelli and Dynes' (1977) typology of disaster-response organizations, we include mutual aid by emergent groups that perform regular tasks (e.g., volunteers running a shelter after a hurricane), established groups that perform non-regular tasks (e.g., a construction company digging out debris and rescuing survivors after an explosion), and emergent groups that perform non-regular tasks (e.g., programmers creating an app that tracks disease spread through self-reported symptoms). Finally, since our focus is on the role of digital sociotechnical systems, our analysis is restricted to groups that made substantial use of said systems in disaster-related efforts. The types of mutual aid initiatives included in the study are indicated in Figure 1.

We compiled information on mutual aid initiatives from news articles, peer-reviewed journal articles, and mutual aid initiatives' digital activity repositories (e.g., GitHub, Google docs, Slack, and Discord servers), websites, blogs, and technical reports. Using these sources, we conducted a qualitative content analysis with structural interpretation (Mayring 2014) of each initiative's mission or function during the acute phase of the pandemic, the technology they used, and their organizational structure. Following this analysis, we synthesized patterns across groups of similar initiatives. This cross-initiative synthesis informed our findings about the roles of digital sociotechnical systems in channeling mutual aid initiatives during the pandemic, as well as the pandemic's effects on digital sociotechnical systems.

SOCIOTECHNICAL SYSTEMS OF MUTUAL AID IN NYC DURING COVID-19

In this section, we describe a series of mutual aid initiatives in NYC. These descriptions are organized around our three main arguments: (1) that digital sociotechnical systems helped connect people for mutual aid; (2) that mutual aid initiatives demonstrated high adaptability; and (3) that the pandemic engendered innovation and calls for transformations in digital sociotechnical systems.

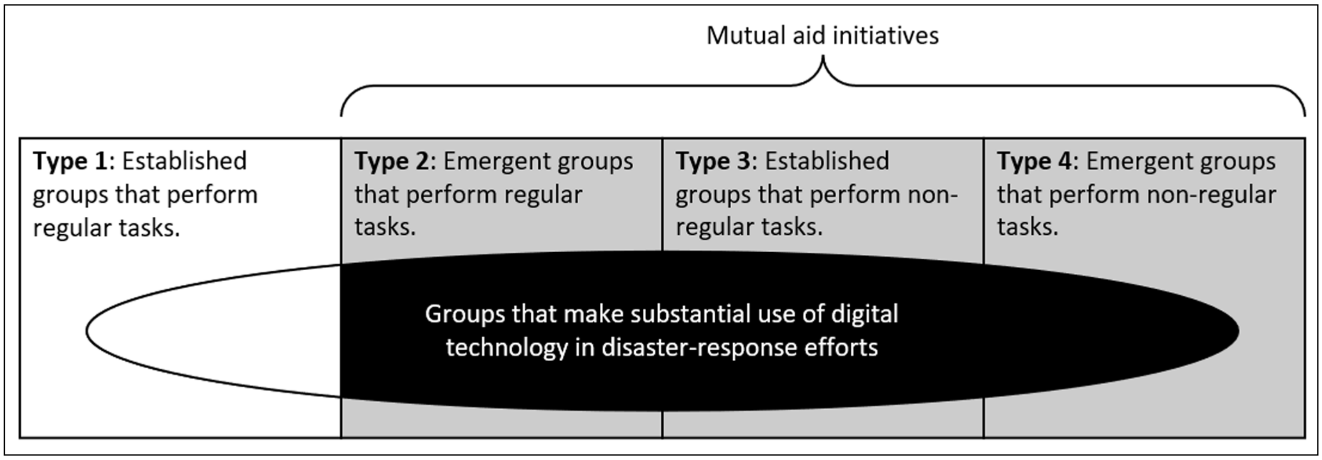

Figure 1 Typology of groups involved in disaster response, based on Quarantelli and Dynes (1977). The study discussed in this paper focuses on the black intersection.

CONNECTING PEOPLE FOR MUTUAL AID

Mutual aid initiatives spawned without intervention from external groups and expanded through digital sociotechnical systems. Given public awareness of needs—particularly during the early stages of the pandemic—communities of mutual aid developed among strangers.

Helpful Engineering was launched in mid-March 2020 during the outbreak of COVID-19 as a community for development of open-source innovation and technology (Helpful Engineering, no date). In less than two weeks, 3,400 volunteers joined for information sharing and contributed to tasks (Helpful Engineering 2020c); to date, there are approximately 20,000 members. Many participants contributed while working from home without set schedules, and others, when suddenly out of work (Helpful Engineering 2020b). Participants of all trades—engineers, developers, writers, social media specialists, high school students, and healthcare specialists—coordinated remotely and asynchronously through Slack, and used their skills to help solve pandemic-related problems amid social-distancing restrictions. A GitHub community page was set up to monitor projects, and Google products were used to vote and to prioritize actions. Helpful Engineering developed a project-review process involving a small group of known specialists and community voting to select quality, low-cost, and quick projects (Helpful Engineering 2020a). The group performed various tasks, including production and delivery of medical supplies like ventilator parts, masks, and temperature sensors. In addition, the Helpful Engineering Slack group formed local channels such as the New York City immediate needs group, which was very active early in the pandemic. People made direct requests for help, sometimes on behalf of organizations, and these were often met immediately through direct communication without formal organization. Helpful Engineers exemplifies how social distancing restrictions and digital sociotechnical systems mediate modes of communication and collaboration for mutual aid.

Reach4Help is a tech nonprofit organization supported as a project by Helpful Engineering that used an app to connect volunteers with people who needed help, such as quarantined and high-risk people (Reach4Help 2021). The organizers used Slack and Twilio to communicate and GitHub to map the locations of people in need and connect them with others who could provide help. In addition, the COVID Mutual Aid Map was set up as an associated participatory mapping tool to locate organizations, mutual aid groups, medical centers, and companies that offered community help. The web map allowed people to add sites and to find local centers to get or offer help. This initiative filled information deficits to facilitate assistance for those in need under social-distancing restrictions.

Some mutual aid initiatives combined digital and non-digital technologies, thereby making communication accessible to vulnerable people who might lack access to digital technology or might not be tech-savvy. One such network is Mutual Aid NYC. The organizers set up the network in direct response to COVID-19 and state that their actions respond to the failure of government and social service institutions. The group coordinated and supported mutual aid efforts in NYC and connected neighborhoods for technology and language services. It provided a telephone hotline, in addition to online forms for people to request help (Mutual Aid NYC 2021). This initiative served to improve the accessibility of communication services for the community.

The digital environment enabled connectivity among strangers in NYC to support local mutual aid efforts. Each of these sociotechnical systems facilitated different levels and types of connection: matching work for tasks, filling information deficits to meet needs, and providing accessible communication. Helpful Engineering was highly networked through many-to-many community communication systems featuring top-down, bottom-up, and peer-to-peer requests for help on tasks. Reach4Help organized the connection of those requesting and offering to help. COVID Mutual Aid Map transferred knowledge from community mapping contributions, and Mutual Aid NYC did the same by improving accessibility to a knowledge network on where to find aid. A range of synchronous and asynchronous digital communication systems proved essential to providing mutual aid.

ADAPTIVE MUTUAL AID INITIATIVES

Many mutual aid initiatives developed from pre-existing communities, and activated quickly by pivoting their attention and resources to the most pressing pandemic-related needs. For example, Makesense, a global organization created in 2010 to facilitate collective mobilization of citizens, entrepreneurs, and organizations for inclusive and sustainable communities, pivoted to supporting those affected by COVID-19. Makesense grew from 50 volunteers in March (Columbia University 2020b) to 6,000 in May and 50,000 by December 2020 (Makesense 2020). Volunteers communicated with community organizers through WhatsApp and Facebook, and participated in daily virtual networking via Zoom. The core team placed volunteers and monitored groups through Zapier for task management, and used Typeform surveys to track impact. Their relief work, reoriented toward the pandemic, involved checking on the elderly, providing hygiene kits to the homeless, providing personal protective equipment (PPE) and food to healthcare workers, and meeting the basic needs of low-income families.

There was broad participation in contributing health data to support research. The CovidWatcher app was developed by Columbia University to collect data on COVID-19 exposure, symptoms, medical access, and impacts in NYC (Columbia University 2020a). Applications were developed to map the spread of COVID-19. COVIDcast—an open-source project of the Delphi Group at Carnegie Mellon University—used Facebook surveys to estimate the spread of COVID-19 (Carnegie Mellon University Delphi Group, no date). COVID Near You, now part of Outbreaks Near Me, was a collaboration of 30 volunteers from Apple, Amazon, and Alphabet with an epidemiologist. The team repurposed the technology from a prior flu application to track the spread of COVID-19 based on how people were feeling (Farr 2020). More than 6 million people contributed their age, sex, zip code, health status, and, later on, vaccination status. Another application was the COVID Symptom Study by medical professionals and scientists in collaboration with Zoe Global, a holistic health science company (Drew et al. 2020). It was deployed to understand the symptoms and spread of the virus, especially to high-risk populations and healthcare workers. Health studies benefited from initiatives that tracked the spread of COVID-19 through broad and fast information capture for self-reporting of symptoms (Birkin, Vasileiou, and Stagg 2021). These studies were enabled by the ubiquity of smartphones and other devices.

Several participatory mapping initiatives were set up to provide information about the location of risks and services. A primary source of information was the Johns Hopkins University GIS dashboard, which compiled COVID-19 cases from many sources (Dong, Du and Gardner, 2020). Particularly at the beginning of the pandemic, it was difficult for many people to get a COVID-19 test. Safecast, an organization sparked by the Fukushima nuclear accident in 2011, created a map on the relative difficulty of getting tested (Safecast, 2020). The webmap used Ushahidi's open-source platform with a repository on GitHub. Coders Against COVID (CAC) was started March 15th to help people find testing sites (Coders Against COVID, no date). They had launched a website by March 21st with 10 volunteers (Erickson 2020). Following reports about a data gap in the location of COVID-19 testing sites (Lanclos and Geraghty 2020), GISCorps—a program established in 2001 to provide volunteered Geographic Information Systems (GIS) services for humanitarian, environmental, and health causes—developed testing site maps by building off of Coders Against COVID (CAC) data and adding to it. Later, GISCorps developed vaccination site maps and maps for recording vaccination status and recovery stories (URISA's GISCorps 2020). Participatory mapping processes involved the online submission of site locations by the general public, followed by review by GISCorps volunteers (URISA's GISCorps, no date). GISCorps also repurposed a web map template previously used as a memorial to people lost to the opioid epidemic as a memorial space for victims of COVID-19. Mapping organizations, such as Esri, repurposed existing participatory mapping applications for COVID-19, and produced maps on the availability of health services and on the location and status of food pantries and shelters (ESRI, no date).

There are also virtual applications for distributed intelligence to solve problems related to COVID-19. These projects provide an online interface to perform a virtual task and generally do not require local knowledge. FoldIt is a computer game in which players design proteins that solve digital puzzles and could help advance research. A number of projects on FoldIt provided options for participants to help to design drugs against COVID-19 infections (Howard Hughes Medical Institution 2020).

Mutual aid initiatives for relief and health benefited from being adaptable and not being tied to a structure so they can use the technology that fits their needs. Projects relied on pre-existing digital technology to create catered platforms for data collection, information sharing, and plans for action. Present-day digital sociotechnical systems are highly developed to a point that those with enough interest can quickly repurpose digital infrastructure for their own purposes or find a knowledgeable partner to support them. Users without software development skills can start up and modify—often with an interface selection of templates—pre-formulated technical infrastructure for apps and website platforms, mapping layouts, data storage, and other services. Public groups turned to pre-existing or quickly deployable mobile and web-based platform sites, mapping technologies, and group-based communication channels. Many volunteers' familiarity with these platforms facilitated the process. However, participation was not determined by technological capacity; many roles did not require anything beyond everyday digital technology use.

INNOVATIONS AND EMERGING SHIFTS IN DIGITAL SOCIOTECHNICAL SYSTEMS

While many physical forms of connection were cut off during the COVID-19 pandemic, digital sociotechnical systems provided avenues for people to connect remotely. However, actual network connectivity depends on the accessibility and affordability of digital infrastructure. Many New Yorkers relied on the internet from public spaces, and did not pay monthly internet service providers (ISPs). For many, COVID-19 brought additional costs, as they had to purchase home internet for work or school at a time of economic hardship. There was unforeseen demand for high speed, video-capable internet in residential areas, and commercial internet providers struggled with network outages and scrambled to increase their coverage (Zimmer 2021). In response, discounts were offered by service providers, and a government-benefit program called SafeLink Wireless was made available for cell phone service. A community project called NYC Mesh (NYC Mesh 2020) was built to meet the need for internet access by encouraging the development of a public internet network for the city set up at strategic points.

Community-support groups on social media channels like Facebook served local needs. Many communities helped by distributing food to hospital staff and vulnerable populations. The Death Panel podcast developed a Discord server, which gained popularity by sharing healthcare information and as an affirming space for community care, mutual aid, and correction of misinformation (McNamara 2021). Tech for America was developed to support small businesses with website needs during COVID-19 (Coding Dojo, no date). They helped to develop company websites to handle an online-only workflow that was necessary for contactless services. There was an outpouring of virtual fundraising through digital platforms like GoFundMe to cover home rents, unmet business expenses (including salary and health insurance for employees of closed businesses), and medical bills.

As reliable and open epidemiological data became essential during the pandemic, major efforts were made to produce, regulate, and disseminate COVID-19 information. Medical professionals contributed by summarizing and sharing information on the spread, symptoms, and treatments of COVID-19. News outlets, such as the *New York Times*, and scientific journals dropped barriers for COVID-19 content to spread reliable information. Online groups provided free and open information with alerts for misinformation. These initiatives helped health officials, researchers, politicians, organizations, and the general public to access up-to-date scientific information.

DISCUSSION

Using the concepts of citizen science, mutual aid, and digital sociotechnical systems, we make three arguments. First, digital sociotechnical systems have a unique capacity to enroll and connect people—including strangers—over long distances, therefore enabling participation in mutual aid initiatives amid social-distancing restrictions. Second, pre-existing mutual aid initiatives supported by digital sociotechnical systems demonstrated high adaptability and were quickly repurposed for COVID-19 mutual aid. Lastly, mutual aid initiatives, confronted with certain limitations of digital sociotechnical systems, engendered innovations and calls for transformations toward more inclusive systems.

Digital sociotechnical systems connected strangers both synchronously and asynchronously despite social-distancing limitations. This resulted in massive enrollment of participants in various networks of solidarity, which ultimately led to a quick response to needs and good spatial coverage of aid. Volunteers turned to citizen networks to provide aid through various tasks. Many of these networks relied on participants' local knowledge of needs, the definition and prioritization of tasks through online voting, and volunteers quickly signing up to complete tasks. What made this work is that digital infrastructure was already accessible for interaction through virtual networking, mapping, fundraising, and resource sharing. Barriers to dissemination of scientific knowledge and to production of medical equipment were reduced significantly through the expansion of community-driven scientific and medical Free and Open Source Hardware (FOSH) (Chagas et al. 2020).

A mature, flexible, and adaptive digital sociotechnical system existed prior to the pandemic. Both digital infrastructures and the pre-existing mutual aid projects were highly responsive to new needs. The sociotechnical system includes not only effective hardware and software, but also users with organizational capabilities. These adaptive characteristics were common across various types of mutual aid groups, ranging from democratic, self-organizing systems (e.g., Helpful Engineering) to more structured systems with a clear leadership (e.g., Makesense). In the former case, for instance, complete strangers coordinated through Slack to design, produce, and deliver medical supplies with or without formal leadership. In Makesense, a core group of full-time leaders recruited volunteers for multiple COVID-19 response projects using online tools. This insight also shows that digital sociotechnical systems are highly adaptive, such that significant positive outcomes can be achieved with relatively minor changes (cf. Furlong 2011).

Third, sociotechnical innovations during the COVID-19 pandemic highlighted the ethical dimensions of infrastructure and the need for more inclusive digital services. Some companies and policymakers quickly realized the need to put aside profits and prioritize the common good. Media companies made pandemic-related content free, while the internet was subsidized by governments, and local organizations provided free access. Thus, communication and dissemination of information through digital technologies was more effective, contributing further to expanding mutual aid initiatives. For all its merits, a drawback of digital sociotechnical systems is that the poor or elderly—precisely those in greatest need of help—might be unable to navigate or access digital technologies to request help from volunteers or benefit from participatory maps related to the pandemic. A full transition toward more inclusive internet access and digital literacy is yet to be seen. In the meantime, alternatives to digital technologies remain important for prosocial disaster responses.

Perhaps one of the most interesting aspects of the NYC mutual aid response to the pandemic is its longevity. Disaster research shows that community engagement is strongest in the response and immediate aftermath of a crisis, but wanes significantly over time (Fullerton et al. 2010). Instead—perhaps due to the widespread nature of COVID-19—solidarity networks' responses were often sustained over more than a year. This suggests that opportunities exist for a reckoning with vulnerable people's needs and a significant shift from profit-driven, consumer-funded sociotechnical systems to more prosocial, collectively funded safety nets, which can be implemented not only to address pandemics, but also other ongoing crises (e.g., housing crises, food crises, climate change, and natural hazards). Needless to say, the trajectories of change are complex and undetermined; the existence of opportunities does not imply an actual shift toward more prosocial systems. While it is too early to demonstrate, there are early signs that important temporary services provided by mutual aid initiatives are being covered by new private or public service providers. It is yet to be determined whether and how permanent systems will adopt truly prosocial models.

Our findings suggest that digital sociotechnical systems mediate mutual aid for network connections, community support, and health information amid social distancing restrictions. These restrictions are likely common to other respiratory epidemics. Our research also reveals an emergent, yet potentially important influence of the COVID-19 pandemic on digital sociotechnical systems. These findings should be interpreted within the limitations of our exploratory study in a Global North megacity with a large digitally literate population. Further research is needed to understand the coproduction of digital sociotechnical systems and respiratory epidemics in different settings (e.g., rural, peri-urban, Global South). In addition, there is a need for deeper analysis of the development of organizations, volunteer participation, and technical applications used during the COVID-19 pandemic.

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

C.H devised the project. C.H. and R.T developed the conceptual ideas and designed the methods. C.H. carried out the data collection and analysis. C.H. and R.T. synthesized the findings and wrote the manuscript.

AUTHOR AFFILIATIONS

Carolynne Hultquist orcid.org/0000-0002-7770-946X
Center for International Earth Science Information Network (CIESIN), Columbia Climate School, Columbia University, New York, 10025, USA

Ramzi M. Tubbeh orcid.org/0000-0002-5304-8011
Department of Geography, The Pennsylvania State University, University Park, Pennsylvania, 16802, USA

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