

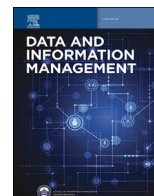


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Socially vulnerable populations adoption of technology to address lifestyle changes amid COVID-19 in the US



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ABSTRACT

The COVID-19 global pandemic has changed every facet of our lives overnight and has resulted in many challenges and opportunities. Utilizing the Lens of Vulnerability we investigate how disparities in technology adoption affect activities of daily living. In this paper, we analyze the existing literature and case studies regarding how the lifestyles of socially vulnerable populations have changed during the pandemic in terms of technology adoption. Socially vulnerable populations, such as racial and ethnic minorities, people with disabilities, older adults, children, and the socially isolated, are specifically addressed because they are groups of people who have been significantly and disproportionately affected by the pandemic. This paper emphasizes that despite seeing changes in and research on technology adoption across healthcare, employment, and education, the impact of COVID-19 in government and social services and activities of daily living is underdeveloped. The study concludes by offering practical and academic recommendations and future research directions. Lessons learned from the current pandemic and an understanding of the differential technology adoption for activities of daily living amid a disaster will help emergency managers, academics, and government officials prepare for and respond to future crises.

1. Introduction

The COVID-19 pandemic has not only changed how people work and learn but also how they go about their daily activities (Haleem et al., 2020). In the United States (US), COVID-19 resulted in the establishment of a variety of preventive measures, where lockdowns, social distancing, and a move to virtual schooling and work were prevalent. These preventive measures resulted in a multitude of lifestyle changes, whereupon non-essential workers were forced to stay at home, education and non-essential work were conducted virtually, in-person social gatherings or events were reduced, travel was greatly restricted, a greater dependency on online shopping was seen, and means of entertainment and

fitness were almost completely home-based (Statista, 2019). At the forefront of COVID-19 and these lifestyle changes was the increased dependency on technology. Despite the country's easements on social distancing practices, there continues to be a surge in the use of digital technologies to adjust to the new normal brought on by the pandemic (De' et al., 2020). As work and home dynamics shift due to the newfound use cases for technology, there is a need to address the lifestyle changes especially where inequities are concerned to better respond and recover from the pandemic and future crises.

Researchers have proposed a general research agenda on Technological Innovations in Response to COVID-19.¹ This study builds on that work and narrowly focuses on the adoption of technology by socially

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¹ Bennett, D., Knight, T., Dubois, E., Khurana, P., Wild, D., Laforce, S., Yuan, X.-J. (2020). NSF CONVERGE Working Group, COVID-19 Global Research Registry for Public Health and Social Sciences Technological Innovations in Response to COVID-19. This COVID-19 Working Group effort was supported by the National Science Foundation-funded Social Science Extreme Events Research (SSEER) Network and the CONVERGE facility at the Natural Hazards Center at the University of Colorado Boulder (NSF Award #1841338).

vulnerable populations for lifestyle changes brought on by COVID-19. During disasters, marginalized populations often face greater difficulties in preparing for, responding to, and recovering from a crisis (Dubois & Yuan, 2021; Fothergill & Peek, 2004; Mechanic & Tanner, 2007). This inequity has been studied in the context of natural hazards, human-induced disasters, and infectious diseases (Ardalan et al., 2019; Blaikie, 1994; Lotfata & Ambinakudige, 2019; Meltzer et al., 2020; Wisner et al., 2003). Social vulnerability is used broadly to classify "the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impacts of a natural hazard," where natural hazards include pest infestations, infectious disease outbreaks, and drought among weather-related hazards (Wisner et al., 2003, p. 11). Socially vulnerable populations can be found in all regions and countries around the world, yet the populations included can differ based on the socioeconomic construction of a society. Social vulnerability is not necessarily a permanent position or determined solely by one's membership in one of the socially vulnerable groups (Fordham et al., 2013; Wisner et al., 2003). These populations include children, older adults, marginalized racial and ethnic minorities, people with disabilities, low-income communities and households, gendered minorities, among others (Fordham et al., 2013). During COVID-19, researchers have examined the vulnerability of these groups in terms of exposure to the virus, susceptibility due to preventive behaviors, mental health concerns, adaptations to changes to employment, education, and healthcare regarding challenges in adoption, use, and reliance on technology.

COVID-19 has brought a host of lifestyle changes, including changes to medical access, education, employment, emergency response, government services, and daily activities. Lifestyles are rooted in societal ecology, where social vulnerability or inequities in-home, access to resources, means of transportation, clothes, speech, eating and drinking preferences, and leisure pastimes that result in individuality can lead to societal divisions (Featherstone, 1987), especially amid a disaster. In this, lifestyles are shaped by culture, religion, economic and social state, community norms, personal beliefs, childhood experiences, education, and demographics. Despite the widespread changes to lifestyles, research has placed a greater emphasis on healthcare (i.e., mental and physical health) (Balanzá-Martínez et al., 2020; Bennett Gayle et al., 2021; Venkatesh & Edirappuli, 2020), education (Dubois et al., 2021), employment (Bennett Gayle et al., 2021), and emergency response (Dubois & Yuan, 2021), especially outside of the United States, leaving the impact on government and social services and activities of daily living under-investigated. During the pandemic, the way people sought government and social services (i.e. disability benefits, court appearances) and activities of daily living (i.e. grocery shopping, social gatherings, physical fitness, marriages) faced drastic changes that required the adoption of technology. Yet, prior to and during disasters, social vulnerability increases risk and prior inequities alter one's ability to go about their work, education, or daily activities.

During the pandemic, technologies have been used in various ways, including to assist individuals in work, education, and daily living, streamline government and organizational services, and provide life-saving measures to healthcare facilities and emergency response (Dubois et al., 2021). Nearly every aspect of life has moved online, with a majority of society relying on technology for employment, access to healthcare, education, access to government and social services, and other basic functions. The technologies adopted to respond to these changes include communication devices, video conference systems, personal health trackers, telehealth services, specialized equipment to aid in a particular job or a task, or technologies to assist in daily living activities. In particular, this study looks at the use of online government portals to access social services, video conferencing systems used for virtual visits, happy hours, weddings, exercise classes, online grocery shopping (i.e., via platforms like Amazon and Walmart), and streaming services and virtual entertainment offerings.

Research suggests that socially vulnerable populations may face greater barriers to technology adoption, prior to and during COVID-19

(Dubois et al., 2021). While many studies have examined the impact of new reliance on technology during the pandemic in various sectors, studies that explore the barriers to technology adoption for access to government services and activities of daily living, especially for socially vulnerable populations are lacking. Thus, a better understanding of the adoption of technologies in daily activities like access to social services, grocery shopping, physical fitness, and social gatherings would help researchers and practitioners determine and create effective policies and interventions for life amid COVID-19, and to prepare for future crises. Therefore, we probe this topic during this critical time for which people seek direction and answers on living life in the era of the COVID-19.

Given the expansive lifestyle changes brought on by COVID-19, the societal technological inequalities sub-populations face, and the need to find equitable responses, we sought to explore how COVID-19 has impacted Americans' lifestyles and behaviors, emphasizing socially vulnerable populations, including racial and ethnic minorities, gendered minorities, older adults, children, and people with disabilities. We aim to investigate technology adoption to account for shifts in government services and activities of daily living, including but not limited to access to disability services, marriages, shopping, meal preparation, physical fitness, social gatherings, entertainment. We specifically ask:

1. How has technology adoption amid COVID-19 affected socially vulnerable populations' lifestyles?

This study contributes to (1) research on lessons learned during the pandemic, (2) understanding secondary social disparities exacerbated during the pandemic, (3) research on socially vulnerable populations during disasters, and (4) practical solutions to the technology divide causing inequitable response amid the pandemic.

2. Working group

This paper began as a response to a call for proposals for the COVID-19 Global Research Registry for Public Health and Social Sciences Technological Innovations in Response to COVID-19 Working Groups issued by the CONVERGE Social Science Extreme Events Research Network through the University of Colorado's Natural Hazards Center (NHC CONVERGE). The working group team represented an interdisciplinary group of scholars, researching disaster, emergency management, socially vulnerable populations, communication, information science, and data science thereby representing multiple fields of study. The group developed a research agenda to examine both the innovative uses of existing technologies and the emergence of novel technologies developed in response to the pandemic. The research agenda explored use cases over multiple sectors, including Emergency Response, Government Services, Healthcare, Employment, Education, and Lifestyle. The team's collective research questions were identified by considering the potential effects of technology on the domains of influence and vice versa. The six-page research agenda was submitted to NHC Converge and later posted online as a public document. The under-researched areas discussed in the research agenda are critical to a successful response to and recovery from the pandemic.

As part of this research, the group met regularly via Zoom in Spring 2020 to identify topics of interest and key issues that unfolded during the pandemic. Through a series of meetings and knowledge exchanges, we arrived at the question of how to understand the technology adoption (or lack of) of socially vulnerable populations amid the pandemic. This paper is a compilation of the efforts of the research agenda and the authors' interests. The paper asserts that researchers and practitioners must recognize their responsibility to plan for and understand technology, especially in how it can and cannot be used among individuals, groups, and communities during a crisis. To answer this question, the researchers surveyed the literature to identify research regarding socially vulnerable populations' adoption of technology and pertinent case studies during COVID-19. Due to the nature of this study and the relatively little

research on this topic, the search and case studies were pulled from both academic and grey literature.

3. A review of human behavior and vulnerability in disasters

Socially vulnerable populations have the increased potential to be at risk before, during, and after disasters (Donner & Rodríguez, 2008; Peek, 2013; Wisner et al., 2003). A host of factors affect marginalized populations from adapting to or properly responding to a disaster, thereby increasing their vulnerability. International and national agencies such as UNICEF and the CDC recognize and emphasize the importance of being aware of historically marginalized communities, including racial and ethnic minorities, women, older adults, people with disabilities, individuals experiencing homelessness, and incarcerated individuals. Among these vulnerable populations, there are disparities in health, education, technology, and employment. Vulnerable populations are often also from low-income households, emphasizing the effects of a crisis. Historically socially vulnerable populations are faced with a multitude of divides – from digital to racial increasing their susceptibility to a disaster (Patel et al., 2020). Amidst COVID-19, said communities are not only more susceptible to COVID-19 because of systemic inequalities but face differential treatment because of where they live, their socioeconomic state (Dubois et al., 2021), or institutional barriers (Fordham et al., 2013). Although studies have looked at socially vulnerable populations during COVID-19, much of the research investigates the medical burdens that lead to disproportionate infection and death rates and mental health struggles (Bann et al., 2020; Gray et al., 2020; Sneed et al., 2020) and technology adoption for health, education, employment, and livelihoods (Bennett Gayle et al., 2021; Dubois et al., 2021). Thus, the investigation of the adoption of technology for government services and activities of daily living is limited.

Socially vulnerable populations face evident digital divides, where access to and ability to use technology may be limited (Scheerder et al., 2017; H.; Yoon et al., 2020). For older adults, the reliance on technology and quick decisions that need to be made amid a disaster may be affected by digital illiteracy or common cognitive or physical barriers that come with age (Gibson et al., 2013; McSweeney-Feld, 2017; J.-S.; Yoon et al., 2021). Likewise, people with disabilities, that face cognitive, physical, or psychological barriers may find that needed technology is inaccessible due to limited accommodations (Bennett, 2020). Additionally, older adults and individuals with disabilities are also likely to become marginalized in several ways, have multiple health conditions, become dependent on social services, or reside in low-income household incomes (Peek, 2013; Powell, 2009). Socioeconomic state is another dimension that affects vulnerability to disasters, where lower-income increases the effect on populations due to natural environment, household settings, limited personal resources, and infrastructure, like communications technology to respond to a disaster (McMahon, 2007). The digital divide is also prevalent among racial and ethnic minorities, where despite access (although inequitable) they are less likely to use technology outside of a disaster situation (Campos-Castillo, 2015), even less so for health-related purposes amid a disaster (Mitchell et al., 2019). In disaster contexts, the emphasis on technology use has left many children, especially racial and ethnic minorities and individuals with a disability far behind their peers due in part to limited access, literacy, or English language barriers (Gillen & Morris, 2019; Seiden, 2020). On their own, being part of a social vulnerability population increases vulnerability to COVID-19 but the intersectionality of these compounds one's social vulnerability (e.g., a Black 65+ year-old essential worker) (Winecoff et al., 2021). In this example, the intersection of age, race, and socioeconomic state may intensify vulnerability to the impact of disasters.

Although inconsistent across demographics and the urgent need to relay health and safety information promptly, technology is the main source of message distribution during disasters. The inequities marginalized populations face in accessing, properly understanding, and acting on crisis communications put them at greater risk of injury, loss of life or

property, or negative and post-disaster outcomes including physical and economic impacts. In the literature, there are critical knowledge gaps about the ways socially vulnerable populations adopt technology during disasters, especially in regards to the impact on accessing government social services and activities of daily life. This gap must be addressed to create better lifestyle accommodations and enhance the wellbeing of said populations during a crisis.

4. The lens of vulnerability

Throughout history, countless inequalities have existed in society, yet in times of crisis, they are said to intensify. Donner and Rodríguez (2008) pointed out that disasters exacerbate pre-existing inequalities within the impacted society. These inequalities are often among historically marginalized populations.

The *social vulnerability perspective* asserts that marginalized populations often lack access to vital economic and social resources, possess limited autonomy and power, and have low social capital levels (Morrow, 1999). Therefore, these populations are socially vulnerable to disasters, where there is difficulty in accessing resources (Wisner et al., 2003). The lens of vulnerability (Peacock et al., 2014) depicts how socially vulnerable populations have less access to resources before the disaster (y-axis); see Fig. 1. During the disaster, these populations often suffer more disproportionately, and while their situations improve during recovery, they often find themselves worse off following a disaster than they were prior. Originally designed to discuss inequalities in housing, the lens of vulnerability anticipates how often marginalized populations may have difficulty securing resources during the protracted response and recovery efforts during COVID-19. The multiple waves of COVID-19 have prolonged the time between 'impact' and full recovery as depicted in the lens of vulnerability. This prolonged time extends the potential damage during and exacerbated inequalities after we recover from COVID-19. The inequalities may be measured based on a variety of resources needed during a disaster. In this paper, the use of technology is the inequality measured. As employers, education systems, government services, and day-to-day lives moved to extensive reliance on technology amid COVID-19, individuals and households lacking access to fixed or mobile broadband, technological devices, and technology knowledge are further marginalized during the response to this pandemic, especially as many free and discounted broadband wireless access points may have been closed (i.e. restaurants, community centers, schools) and schools, workplaces, and daily activities have gone online. In this, individuals or households facing difficulties in technology use or knowledge acquisition are marginalized during the response efforts, as they have been required to utilize technology for work or support students in distance learning. The lens of vulnerability highlights how the least vulnerable and most vulnerable populations during the pandemic are not only able adapt to lifestyle changes but adopt technology accordingly.

5. Technological impact on lifestyles amid the pandemic

Technology was adopted at a fast pace amid COVID-19 given pre-existing reliance on technology coupled with stay-at-home orders and social distancing mandates. Changes brought on by the increased reliance on technology were evident across every aspect of life from schooling to grocery shopping. Yet, currently, the academic research on the technological impact of the pandemic is heavily catered to healthcare, education, and employment. These concepts although affected do not account for the barriers and successes of technology adoption for carrying out daily activities. These subsequent under-researched lifestyles areas include government and social services and activities of daily living.

5.1. Government and social services

Various facets of government changed overnight, with mandates affecting the way government operates and social services run. At the

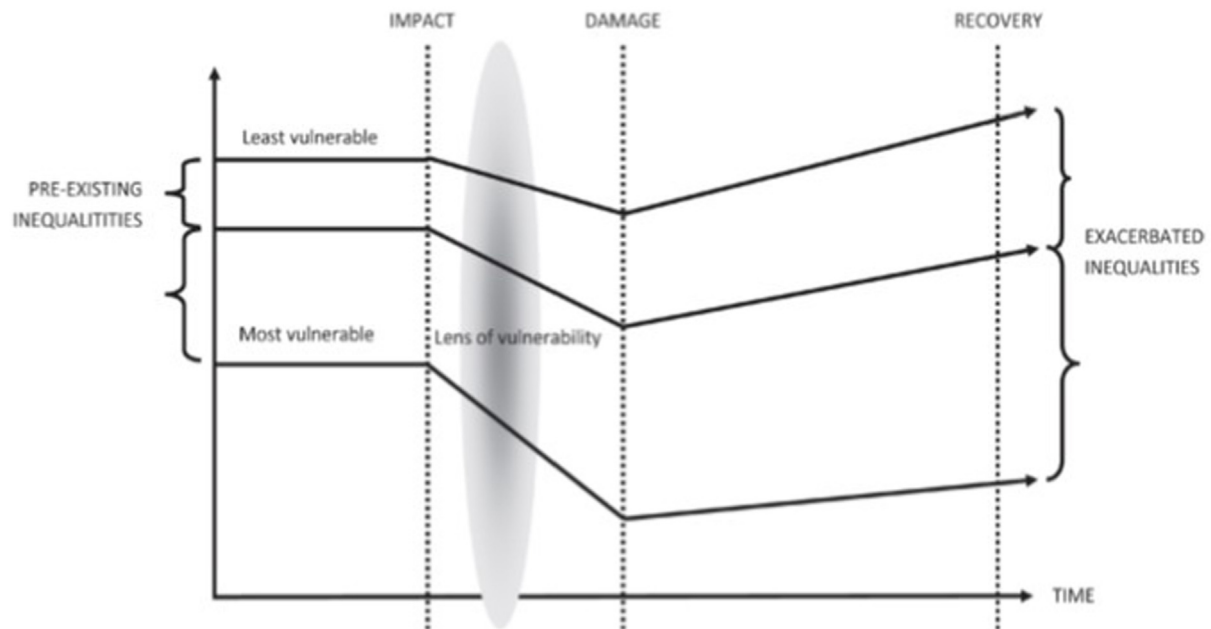


Fig. 1. Depiction of the lens of vulnerability (Peacock et al., 2014).

forefront of government, is access to broadband and physical devices. The government is charged with ensuring broadband access to citizens all while moving towards equitable services, which have been further exaggerated during COVID-19. As such, the government has partnered with several telecommunication organizations via the Keep Americans Connected Initiative to not terminate services to those unable to pay bills, offer discounted or free services to those unable to afford the services, and open WIFI hotspots to anyone who needs them (Federal Communications Commission, 2020).

The pandemic changed the way government social services were managed and utilized. To respond to the non-essential work from home mandates and government layoffs many of the social service departments like the Departments of Public Health, Education, and Human Services had to move many of their services online. As the unemployment rates climbed the need for social services and government support increased as did work from home policies, leading to many of the in-person services moving online or being paused altogether. For example, with offices for the Social Security Administration closed, many of the appointments were moved online, replacement cards had to be requested through their online portal, and denied benefits could only be appealed via a phone or video appointment (Konish, 2021). Similarly, service disruptions affected home health and disability services which also moved virtually, or aid was stalled altogether (The U.S. Federal Emergency Management Agency, 2020). With the rise in COVID-19 in early 2020, in-person courtroom hearings were quickly shifted to virtual hearings, where trials at all levels of government were conducted via video conferencing software (United States Courts, 2020).

5.1.1. Marriages

Similarly, marriages took on a new form. During the pandemic, due to non-essential offices being closed, couples applied for marriage licenses online and met with a county representative via Zoom as opposed to in-person. Besides receiving an online marriage license, ceremonies have shifted as well. As more and more wedding plans were canceled due to COVID-19 restrictions, many couples turned to video conference platforms like Zoom for their weddings (Dickinson, 2020). Although the legality of virtual weddings varies by state and county, couples choosing this route opt-out of a traditional in-person ceremony or have chosen a later date for the reception, having the officiant and family and friends join their virtual ceremony. In New York State, former Governor Andrew

Cuomo signed a bill allowing couples to apply for marriage licenses and get married virtually during the height of the pandemic (Meisenzahl, 2020).

5.2. Activities of daily living

5.2.1. Grocery shopping and food delivery

Amid COVID-19, online purchase and home delivery of groceries surged. An early 2020 consumer poll found that 52% had chosen to shop online more, compared to significantly lower percentages in pre-COVID polls (Statista, 2020). Likewise, since March 2020, 68% of households bought groceries online, compared to 13% of households one year prior, representing a five-fold increase (Stuckey, 2020). The opportunity and convenience of online grocery shopping have encouraged 81% of consumers to state they will continue ordering groceries online following the pandemic. Similarly, downloads of apps for food delivery services like DoorDash, UberEats, and GrubHub have more than doubled (Sumagaysay, 2020).

5.2.2. Physical fitness

Due to business closures, including gyms, many individuals that wanted to stay fit turned to at-home workout equipment or virtual exercise routines or classes. Although lack of motivation and mental health challenges arose from breaks in exercise routines many turned to alternatives including online group exercises or yoga routines (Kaur et al., 2020). Social media was also found to be a beneficial platform for virtual fitness techniques and opened opportunities for online exercise training, some of which were live and enabled an individual to workout with others (Kaur et al., 2020). Live streaming workout classes gained popularity as they allow people to interact with trainers, create private group workout sessions, and interact and support family and friends (Sassos, 2020). Likewise, the ability to use fitness trackers or mobile devices to maintain a workout schedule and track exercise was commonplace.

5.2.3. Social interactions

At the forefront of daily living for many was in-person social interactions, whether at work, school, in the community, or within their household, all of which were drastically affected during COVID-19. Yet, technology provided people the opportunity to remain connected. Zoom happy hours, virtual visits with loved ones, video conferenced holiday

celebrations, and Facebook Live watch parties became the norm as people moved their lives online.

5.2.4. Entertainment

Going to the movies, to see a Broadway Musical, or to a sporting game became stalled pastimes as the pandemic closed the doors of countless entertainment facilities across the nation. Although streaming services like Netflix and Amazon Prime were prevalent prior to COVID-19, their convenience and availability during the pandemic filled the gap left by prior leisure entertainment activities (Spangler, 2020). Besides this, people sought ways to curb boredom and foster engagement amid stay-at-home orders and social distancing requirements. Some of the ways people adopted technology during COVID-19 to stay entertained include virtual tours (i.e. the White House, the Statue of Liberty, the Vatican), watch parties via streaming services like Amazon Prime Video, Netflix, and Disney+, online concerts (i.e. One World Together at Home), online learning (i.e. online language or skill classes), reading online via the Kindle or local online library system, online clubs (i.e. book club, cooking class), and gaming (16 Minutes, 2020). In this, Verizon Communications Inc. said that while video usage on its internet network was up 40%, there was a 200% increase in gaming (Lachapelle, 2020).

While the technological impact of the pandemic on lifestyles is widespread, the lens of vulnerability highlights that the impact will be accentuated for the most vulnerable population during the response and recovery.

6. Lifestyle changes of socially vulnerable populations during the pandemic

COVID-19 has resulted in disproportionate lifestyle changes across healthcare, education, employment, access to government services, and activities of daily life for socially vulnerable populations. Within these socially vulnerable populations, individuals experiencing homelessness cannot shelter in place, those without access to safe running water are unable to adhere to proper hygiene protocols, detainees (immigrants in detention centers and prisoners) lack physical space to social distance, those relying on public transportation cannot avoid large crowds, and people with limited digital infrastructure are unable to participate in online education, work, or shopping, which have become the norm during COVID-19 (Bavel et al., 2020). Children, older adults, racial and ethnic minorities, people with disabilities, lower-income, and other socially vulnerable populations have faced barriers in adopting technology to respond to lifestyle changes. Yet, for this paper, given the prior research on technology adoption in healthcare, education, and employment we are particularly interested in the lifestyle changes affecting government services and activities of daily living, in particular socially vulnerable populations.

6.1. Government and social services

Lifestyle changes of socially vulnerable populations during disasters can be seen in government and social services. Departments of Public Health, Education, and Human Services have an array of programs covering childcare and nutrition, public hospitals and health care, social safety net assistance, and supportive services for the disabled and other socially vulnerable groups (The U.S. Federal Emergency Management Agency/FEMA, 2020). The US's child welfare system was drastically impacted by COVID-19 as children were cut off from social interactions, confined at home, and households faced a rise in socioeconomic strains, resulting in increased cases of abuse and neglect (Welch & Haskins, 2020). The country's child welfare system is heavily reliant on in-person interactions where reports are often led by teachers, doctors, and friends, but during COVID-19 home investigations, child-parent visits, court appearances, and other programs have been nonexistent or reliant on technology. This can also be seen in cases of domestic and emotional abuse, which due to the pandemic increased and were harder to pinpoint given

the stay-at-home orders. Older adults and lower socioeconomic state individuals that are dependent on government subsidies or home-delivered necessities (i.e. food, water, medicine) have had to adapt to the changes to receiving said services during COVID-19 (The U.S. Federal Emergency Management Agency/FEMA, 2020). Likewise, people with disabilities that relied on in-home support faced limited to any physical support, as services were stalled or faced drastic home aide workforce cuts. During COVID-19, many insurance providers stopped mailing medications, which for older adults or people with disabilities that are not mobile leaves them without life-sustaining medications.

6.2. Activities of daily living

6.2.1. Grocery shopping and food delivery

Amid COVID-19, the US was in a state of stay-at-home orders and social distancing requirements, limiting one's ability to and interest in in-store grocery shopping and food delivery. For those with lower income, the challenges of meeting their bare necessities during the pandemic increased as grocery shopping or food delivery became a challenge. In the US, there has been a dramatic increase in food insecurity, as seen amid various other disasters, where socially vulnerable populations face income loss or monetary challenges that inhibit their ability to get groceries. At the same time, in light of shopping frenzies (i.e. toilet paper) and low supply, those with mobility impairments (i.e. older adults, people with disabilities, or those relying on public transit) may be unable to purchase necessities. Similarly, millions of people may have trouble finding ways to purchase groceries or alternatives (i.e. food pantries) due to cognitive, cultural, or language barriers (The Petrie-Flom Center Staff, 2020).

Food security became a major concern during the pandemic, as food security often lies with middle to high incomes who have not been forced into poverty during the pandemic. Currently, 54 million Americans, including one in four children, do not know where their next meal is coming from (Fields, 2020). Over 20% of people in Nevada face food insecurities in the face of COVID-19 (Fields, 2020). Similarly, food insecurity exacerbates the inequities among vulnerable populations, leaving minoritized populations who faced disproportionate threats during the pandemic at a disadvantage. Despite this, for students school lunch programs, which are funded by the government, were required to continue providing breakfast and lunch at free or reduced rates to those that qualify during the pandemic, but issues arose in the distribution of those meals given the rise in students qualifying (Goldschmidt, 2020).

6.2.2. Physical fitness

While stay-at-home orders limit the spread of the coronavirus, it reduces people's physical activity and changes their exercise patterns. COVID-19 resulted in the closure of gyms, stadiums, pools, dance and fitness studios, physical therapy centers, parks, and playgrounds. Thus, individuals were not able to actively participate in their regular individual or group sporting or physical activities. Although some turned to virtual fitness classes when gyms and fitness centers closed during the pandemic, there is little evidence that socially vulnerable populations did so. Instead, it has been cited that many socially vulnerable populations reduced their physical activity (Hoffman et al., 2021; The United Nations, 2020). According to Hoffman et al., due to social isolation, physical activity, especially among people with disabilities and older adults, worsened which led to worsened mobility and increased fall risks (2021). Likewise, for children and athletes, social distancing meant an end to sports, from marathons to football tournaments (The United Nations, 2020). For children, sports and physical activity are a way to enhance community and provide social support which for many works as an outlet for stressors. According to The United Nations, low-income families are especially vulnerable to changes in physical activity due to the increased potential to have sub-standard accommodations and more confined spaces, making it difficult to engage in physical exercise (2020). This new reality pushed many to be less physically active, spend more time using

technology, have worse diets, and have a loss of physical fitness, which was emphasized for socially vulnerable populations.

6.2.3. Social interactions

While social distancing was recommended and mandated across the country, many populations were at increased risk due to the limitations of such practices. Many socially vulnerable populations work in essential services which were required to work and interact with people throughout the pandemic. Also, many, especially racial and ethnic minorities and lower-income households are unable to practice social distancing as they live in multi-generational homes or live-in multi-unit complexes that require the use of shared spaces (i.e. laundry rooms). Likewise, during disasters, people with disabilities, older adults, and children may not properly understand or be able to follow safe social distancing requirements (The Petrie-Flom Center Staff, 2020). Although these challenges can be due to physical or cognitive impairments, they could also be because of general misunderstanding or knowledge on what 'physical distancing' actually entails.

6.2.4. Entertainment

During COVID-19, going to the movies, a concert, or a sporting event was non-existent. Yet, for many, the use of technology was a strong alternative. For socially vulnerable populations though, changes in entertainment were more expansive. Because of struggles with technology use and adoption and rising costs associated with streaming and other forms of entertainment, socially vulnerable populations had to opt for free options or revert to entertainment outside of technology (i.e. hikes, reading). The desire to save money has caused many to use free streaming-video services like PlutoTV and Tubi (Lachapelle, 2020).

Although socially vulnerable populations have faced significant changes to lifestyles, the adoption of technology to access government services and carry out daily activities is lacking.

7. Technology adoption among socially vulnerable populations to address changes in lifestyles during the pandemic

A host of disparities have been exacerbated during COVID-19, but the digital divide and inequalities in digital infrastructure and technology adoption have put some populations at a severe disadvantage, risking lives (Holpuch, 2020). The pandemic has made it so those not connected to the internet may face total isolation. With strict social and physical distancing measures in place, the new normal requires accessing the internet and using technology for most services and daily activities. Although socially vulnerable populations have adopted technology to respond to the lifestyle changes brought on by COVID-19, there was a significant digital divide disproportionately affecting them leading up to the pandemic, resulting in increased barriers compared to their peers in response and recovery.

7.1. Government and social services

At the forefront of the digital divide and technology adoption for socially vulnerable populations is access, which relies on broadband and physical devices. According to Holpuch (2020) in March, 62% of the US counties did not meet the government's minimum download speed for broadband Internet. Other varying accounts state that between 21 and 163 million people lack access to the Internet (Holpuch, 2020). These numbers are not proportionate: one in four households overall in Georgia do not have broadband access, but 28.8% of African American/Black, 38.9% of Hispanic/Latinx, and 37.4% of American Indians/Native American households lack access (Seiden, 2020). Besides this, gender disparities among women who are 25% more likely to live in poverty and are expected to conduct unpaid work further limit access and use of technology (United Nations, 2020). Similar inequalities are seen among people with disabilities, where 28%–55% of students with disabilities are not receiving the educational or social support they need (Kamenetz,

2020). Likewise, with over 1.2 billion children worldwide being affected by school closures, the socioeconomic gaps emphasized and expanded the inequities in online education, where almost all children from a higher socioeconomic background had a computer to work on, and almost 25% of children from lower socioeconomic states did not have the digital equipment needed to engage in virtual education (Li & Lalani, 2020). Although, 4 in 5 older adults find technology beneficial to staying connected with family during the pandemic, such acceptance and reliance is uneven, where 15% of older adults do not have Internet and 60% state high-speed internet costs are a challenge (Kakulla, 2021).

To address the gaps, students and employees alike are forced to search for broadband access and technologies like computers and tablets so they can keep up with schools and workplaces that have gone digital. Around the US, schools have gone so far as to set up WiFi hotspots in parking lots and distribute thousands of laptops to ensure that students from low-income households have the opportunity to participate in online education (Winberg, 2020; WJTV, 2020). Cases of students' and employees' struggles to interact and excel in a virtual environment are widespread. In one case, over \$130K was raised for a California family after their daughters were forced to use Taco Bell's WiFi for school work (Yancey-Bragg, 2020). The technological resources available and students' ability to succeed during the pandemic waivered due to the move to virtual learning. During the pandemic, we have seen people who had the means to leave the public school system send their children to private schools, or homeschool pods freeing their burden following school closures (Scaia, 2020). Yet, these opportunities were not equal, with socially vulnerable populations at a disadvantage, where public schools are becoming resegregated, and minority students are falling behind (Seiden, 2020). Likewise, for older adults, people with disabilities, and lower-income households, the lack of broadband or access to technology limit their ability to engage in critical social services, where disability benefits, Medicaid applications, or other social services were moved online. For people with disabilities, the delivery of specialized therapies in many cases was moved online, giving the potential to reach rural areas, yet the barriers that limit access to broadband and physical technologies remain present (Goldschmidt, 2020).

7.2. Activities of daily living

Age is also a strong determinant of the ability to use technology, where children and older adults often face increased challenges. For baby boomers who are more susceptible to the virus, they continue to have a greater reliance on grocery delivery, direct-to-consumer goods, and in-home entertainment (Glazer, 2020). Yet, this reliance directly depends on their environment, where individual status, economic state, and social network determine their ability to not only access but use technology. Similarly, to address social isolation during COVID-19, many have turned to virtual family dinners, Netflix parties, or virtual meetings. For grandparents that want to safely see their grandchildren or those in nursing homes to see their loved ones, technology served as the only option for well over a year. According to Todd and Atabakhsh (2020), video calling platforms can help support the development of a stronger sense of connection and maintain already existing relationships, yet challenges arise as technology devices and knowledge is lower among older adults where lack of broadband, mobile devices, or knowledge limits their adoption. In this, access to, and the ability to effectively use technology is much lower among older populations than in younger adults (Friemel, 2016; Paul & Stegbauer, 2005), where during COVID-19 older adults cited lack of access due to financial, knowledge, or age-related issues, lack of interest, and physical barriers including cognitive impairment (i.e. dementia or Alzheimer's) or stroke limit their use of technology (Haase et al., 2021). Due to these barriers, older adults face challenges in utilizing technology to complete day-to-day activities, where online shopping and getting groceries delivered entails their ability to use the Internet and to physically be able to move and put away the groceries. Younger people (those under 35) were more likely to

increase their online shopping than older people (those over 55), at 30 percent and 20 percent, respectively, while older adults make up half of the 20% that would never shop online (Ecola et al., 2020). Likewise, their ability to maintain entertainment through streaming or online concerts could have been hampered by the same barriers.

For children, those from lower socioeconomic households appeared to not only have lower levels of engagement in virtual learning but lack the resources, like computers or the Internet to actively engage in virtual lessons (Chen et al., 2021). Likewise, children who were forced to stay at home for a portion of COVID-19 missed out on social interactions which were critical for their development. Therefore, those that were able turned to technology to ensure interaction through video conferencing, texting applications (i.e. Snapchat, WhatsApp), and video games (Goldschmidt, 2020). According to Goldschmidt, to further aid children, calls and video chats were suggested in place of playdates, co-engagement with media to promote learning, telementoring for COVID-19 emergency response and readiness programs, and telehealth appointments while others call for a reduction in television and social media use (2020).

Populations are not immune to social isolation and loneliness, which has become the norm during the pandemic and heightened by inequalities in technology infrastructure that detrimentally affects their lifestyles, mental, and physical health (Tarantola, 2020). The current technology infrastructure often limits the ability of racial and ethnic minorities who are also from low socioeconomic households to find health information, including symptoms, testing locations, and mental health services. The COVID-19 pandemic is likely to exacerbate behavioral health vulnerabilities, including fear of the virus, collective grief, financial hardships, evaluated stress levels, and prolonged isolation, especially given the unequal access to and ability to use technology (Bradford et al., 2020). The use of technology for telemedicine has also been at the forefront of pandemic response, yet for socially vulnerable populations not only is telemedicine calls harder, but oftentimes such visits may not get to the route of the vulnerability (Pappan et al., 2021). Although the information on COVID-19 testing sites and vaccines is shared online, such messages do not account for the challenges some face due to the inability to access or understand the information. Within this, Pappan, Austin, Venkat, and & Thakkar (2021) suggest that there is a need to provide information using various communication styles to account for access barriers that exist because of race, language, or disability. Along those same lines, given hospital policies many individuals who were hospitalized with COVID-19 and ultimately died often had to do so alone, with many families relying on technology to say their final goodbyes (Selman et al., 2021). Given the disproportionate death rates, with older adults and ethnic minorities at the greatest risk and facing technology barriers, such farewells for such subpopulations were limited.

Moreover, individuals with disabilities face increased vulnerabilities during emergencies. This diverse demographic represents those with cognitive, physical, and perceptual disabilities. Additionally, many older adults experience these kinds of disabilities as they age and must also be considered regarding emergency services (Dyer et al., 2008). Unfortunately, many traditional emergency notification services may be unavailable to the population of people with disabilities. For example, auditory sirens conveying severe weather information are likely to be undetected by those with hearing difficulties (Wood & Weisman, 2003). A common misconception by first responders is that the general population can safely and effectively evacuate (and quarantine) independently, creating a dangerous situation for those who are unable to do so (a) without assistance or (b) without inclusive emergency communications and response systems in place (Fox et al., 2016). In fact, people with disabilities experience a higher chance of mortality during emergencies due to this demographic being overlooked in response efforts (Van Wiligen et al., 2002). The technology shortcomings, including the unevenly tailored emergency messages and the ability for people with disabilities to effectively access and use technology, presents challenges amid a

public health crisis, exacerbated by ongoing daily life stressors of being a member of a minoritized population. Moreover, the ability to maintain lifestyles during COVID-19 particularly relied on access to and use of technology. Yet, barriers in technology access and use for people with disabilities, many of which were on the technology development side failed to account for an array of physical or cognitive challenges when developing food delivery services, COVID-19 testing sites, social support, and educational or workplace needs (Shakespeare et al., 2021). For example, online shopping can be a challenge for someone suffering from a cognitive disability as they are unable to properly process what they need. Such activities of daily living can also be a challenge for those with physical disabilities as one is unable to retrieve packages or put groceries away. Likewise, these challenges can manifest into physical exercise or rehabilitation efforts as well as entertainment in the virtual sphere.

Lower socioeconomic states are associated with multiple dimensions of health and accentuated by overlapping social vulnerability (i.e. race/ethnicity, age). Whether shopping, staying fit, socializing, or staying entertained, lower socioeconomic states brought increased barriers prior to COVID-19, which were further exacerbated during the pandemic. For non-essential hourly wage workers, they lost their source of income during the protracted stay-at-home orders, making those individuals unable to pay for rent, utilities, food, and other necessities for themselves and their households (Rollston & Galea, 2020). People in higher-income households were more likely to increase their online shopping: More than one-third of households with incomes over \$125,000 increased their online shopping, while only 20% of households with incomes under \$40,000 began shopping more online (Ecola et al., 2020). For those that are unable to afford to buy online groceries, many rely on food pantries and food drives to help them support themselves and their families. Yet, finding where these food pantry's and drives are and what hours they are opened rely not only on the ability to search via the internet, but also the ability to read, make sense of, and physically go to these sites which may be hampered by physical or cognitive impairments, cultural taboos, or language barriers (The Petrie-Flom Center Staff, 2020). For lower-income households, going to fitness classes may have been an unwarranted expense leading up to the pandemic, but many fitness studios offered reduced subscriptions or free online video class sessions, many of which did not require a lot of space or special equipment (The United Nations, 2020). Yet, the digital divide and limited broadband strength limited many socially vulnerable populations in using such resources.

8. Recommendations

The lens of vulnerability takes into consideration the pre-existing inequalities of socially vulnerable populations and their use of technology across various environments. In disasters, it is no surprise that inequalities exist, especially regarding resources available and used. With stay-at-home orders and business closures in the early days of the pandemic, many relied on technology to go about their daily lives – engaging in virtual school or work, getting food or groceries delivered to their doorstep, seeking medical advice through telemedicine appointments, and interacting with friends and family. Yet, these lifestyle changes relied on one's ability to access and use technology, where many socially vulnerable populations faced barriers or did not have said luxuries.

This paper explored how COVID-19 has impacted Americans' lifestyles and behaviors, emphasizing socially vulnerable populations, including racial and ethnic minorities, older adults, children, gendered minorities, and people with disabilities. During the pandemic technology accessibility was likely connected to citizens' ability to participate in work and education, access health services, and the ease at which they were able to go about their daily activities. Although many recommendations can be derived from this study to increase technology adoption and improve equitable response to socially vulnerable populations, we suggest three that speak to both academic and practical implications.

8.1 Enable Full Engagement in the Virtual Environment via Broadband Expansion and Partnerships

As it stands, COVID-19 accentuated the digital divide whereupon minority students, those in rural areas, those with disabilities, or those below a certain financial state have less access and knowledge on how to use technology, which in many cases has been required for people to work or do schooling from home (Holpuch, 2020). Besides this, as many relied on delivery of groceries others (especially older adults) were only able to communicate with their loved ones virtually to limit any potential exposure. It is here where lack of access or inability to use the technologies present challenges to people, putting those unable to order online at greater risk of exposure due to having to shop in-store and further isolating those without the means to communicate virtually with their loved ones.

The first step in addressing these challenges and improving digital equity is ensuring that everyone, regardless of socioeconomic state, location, or abilities has access to technology and broadband. Expansion of broadband can be achieved through working with telecommunication companies to expand their offerings, services, and pricing scales to ensure that those that are most vulnerable can not only afford but have service. For example, the Emergency Broadband Benefit by the FCC sought to discount internet services to support households struggling to afford Internet during COVID-19. Besides this, it is essential to engage businesses and schools to not only offer technology devices to their students and staff but training to curve the challenges. Although some schools sought to provide access to devices to students, with an emphasis on the socially vulnerable, there is a need to go beyond mere access to enable students and families to support one another with virtual work, school, and day-to-day activities.

8.2 Support Lifestyle Changes by Providing Training to Improve Ability to Conduct Daily Activities Virtually

The critical feature here is that access alone will not solve the problem but coupled with usability training, such measures can not only improve equality but the wellbeing of individuals and communities amid a disaster. By addressing digital inequities, the government, communities, and individuals will be better equipped to respond to a disaster and be able to maintain their lifestyles while remaining safe. According to Eshet (2004) digital literacy “involves more than the mere ability to use software or operate a digital device” relying on a variety of “complex cognitive, motor, sociological, and emotional skills, which users need in order to function effectively in digital environments” (p.1). As technology innovations expand and a greater emphasis is placed on the digital environment, more research and policies need to speak to improving not only digital literacy but the cognitive, motor, sociological, and emotional inequities that may put populations at a disadvantage. Digital literacy is the basis of citizenship to not only be efficient but effective, especially as many activities were moved online during the pandemic.

Improving digital literacy first relies on ensuring digital equity, where people not only have broadband access but reliable technologies to engage in the online environment. Following this, workplaces, schools, community centers, and other public-facing entities should offer training, on both technical and interpersonal skills needed to engage in the virtual environment as well as provide equity training. In improving the skills to effectively use technologies, the interpersonal skills to improve outcomes, and improving literacy on the inequities and challenges caused by technology, such disparities will become common knowledge and people will be better equipped to address them. This can be carried out by taking a holistic approach to school or work, limiting the siloed lifestyles and merging household activities, whereupon a student and their household are taught to properly use technology to the fullest extent. Likewise, by taking away some of the individual struggles brought on by COVID-19, one can emphasize the value of teamwork and achieve more in a community manner.

8.3 Greater Investment in Academic and Practical Research on the Adoption of Technology to Access Government Services and for Activities of Daily Living

Given the identified gaps in the study, there is a need for both academic and practical research on the adoption of technology outside of the mainstream channels like healthcare, education, and employment. In this, research is critical on how changes to government services and daily living during COVID-19 emphasized the need for technology and the subsequent barriers of adoption among socially vulnerable populations. Access to government services and activities of daily living are often critical to fulfilling basic needs, where child protection and grocery shopping are essential to individuals well being. To fully respond to the pandemic, there is a need to highlight how technology has been used and what challenges and opportunities exist to aid practitioners in the design, distribution, and training using technology.

9. Conclusion and future research

Literature reveals that socially vulnerable populations are disproportionately affected by COVID-19, much like in previous disasters. These populations, including minorities, women, older adults, children, and people with disabilities, have been forced to make lifestyle changes and alter their behaviors to survive the pandemic physically and mentally. The ways in which Americans behave and adapt their lifestyles during the pandemic may define the country for the next century. Therefore, investigating how people behave and live amidst COVID-19 given the reliance on technology will help build an understanding of how to adapt to and recover from the current pandemic and future crises. Because COVID-19 has affected lifestyles and behaviors, we can use lessons learned from the current pandemic to predict behavioral changes and inform more inclusive and equitable preparedness and response to future crises, especially in regards to bridging the digital divide.

Our research looks at the social implications and behavioral changes of socially vulnerable populations' use of technology in the United States amid COVID-19. There are areas for future research that highlight further contributions that can be made. One area could be to look at the social determinants of health for varying populations and the impact on health outcomes. Another area could investigate the impact of COVID-19 and social determinants on how vulnerable populations change their behaviors and adapt to varying practices. Through this, it would be of interest to examine the socially vulnerable populations separately to determine the major differences between these often marginalized groups to better create policies and aid in technology adoption. A further area of interest would be to examine the social determinates that influence the extent and speed of behavioral change regarding social norms, culture and polarization, and politics to help policymakers identify risk factors and prepare for and intervene accordingly. A major aspect of societal behavioral changes during crises relates to political polarization, scientific communication, and misinformation which needs to be further investigated. It would be integral to analyze leadership in times of crisis and how COVID-19 has presented an opportunity for leaders across the world to assist marginalized populations. Stemming from this research there is a call for research on the social constructs that affect peoples' lives, especially regarding underserved and marginalized populations.

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