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Digital inequalities in time of pandemic: COVID-19 exposure risk profiles and new forms of vulnerability

Laura Robinson, Jeremy Schulz, Aneka Khilnani, Hiroshi Ono, Shelia R. Cotten, Noah McClain, Lloyd Levine, Wenhong Chen, Gejun Huang, Antonio A. Casilli, Paola Tubaro, Matías Dodel, Anabel Quan-Haase, Maria Laura Ruiu, Massimo Ragnedda, Deb Aikat, Natalia Tolentino

Abstract

In this article, we argue that new kinds of risk are emerging with the COVID-19 virus, and that these risks are unequally distributed. As we expose to view, digital inequalities and social inequalities are rendering certain subgroups significantly more vulnerable to exposure to COVID-19. Vulnerable populations bearing disproportionate risks include the social isolated, older adults, penal system subjects, digitally disadvantaged students, gig workers, and last-mile workers. Therefore, we map out the intersection between COVID-19 risk factors and digital inequalities on each of these populations in order to examine how the digitally resourced have additional tools to mitigate some of the risks associated with the pandemic. We shed light on how the ongoing pandemic is deepening key axes of social differentiation, which were previously occluded from view. These newly manifested forms of social differentiation can be conceived along several related dimensions. At their most general and abstract, these risks have to do with the capacity individuals have to control the risk of pathogen exposure. In order to fully manage exposure risk, individuals must control their physical environment to the greatest extent possible in order to prevent contact with potentially compromised physical spaces. In addition, they must control their social interactional environment to the greatest extent possible in order to minimize their contacts with potentially infected individuals. All else equal, those individuals who exercise more control over their exposure risk — on the basis of their control over their physical and social interactional environments — stand a better chance of staying healthy than those individuals who cannot manage exposure risk. Individuals therefore vary in terms of what we call their COVID-19 exposure risk profile (CERPs). CERPs hinge on preexisting forms of social differentiation such as socioeconomic status, as individuals with more economic resources at their disposal can better insulate themselves from exposure risk. Alongside socioeconomic status, one of the key forms of social differentiation connected with CERPs is digital (dis)advantage. Ceteris paribus, individuals who can more effectively digitize key parts of their lives enjoy better CERPs than individuals who cannot digitize these life realms. Therefore we believe that digital inequalities are directly and increasingly related

to both life-or-death exposure to COVID-19, as well as excess deaths attributable to the larger conditions generated by the pandemic.

Overview of COVID-19 exposure risk profiles (CERPs)

In this article, we reveal novel and significant connections between exposure to COVID-19 and digital inequalities [1]. We pay particular attention to the following vulnerable populations: the socially isolated, older adults, penal system subjects, digitally disadvantaged students, gig workers, and last-mile workers. We lay out the accelerating impact of digital inequalities on each of these populations in terms of what we call *COVID-19 exposure risk profiles (CERPs)*. All else equal, individuals who can more effectively digitize key parts of their lives enjoy better CERPs than individuals who cannot digitize these life realms.

As we reveal, digital inequalities and social inequalities are rendering certain subgroups significantly more vulnerable to exposure to COVID-19. Globally, it is already clear that low-socioeconomic status (SES) populations are becoming infected and dying at much higher rates than their privileged counterparts. Due to longstanding social inequalities, their risks are higher, and their communities are suffering disproportionate losses in terms of infection, death, and economic devastation due to the pandemic. Low-SES groups are also much more likely to labor in high-contact, public-facing jobs such as supermarkets; provide essential transportation services; and do essential work in congregate workplaces such as food-processing facilities.

In addition to these social inequalities, in this paper we explore how digital inequalities may render certain groups significantly more vulnerable to exposure to COVID-19. Specifically, the digitally disadvantaged are deprived of opportunities to minimize risk of exposure to COVID-19. They are less likely to have the economic means to use digital services in the domain of consumption and are more likely to engage in face-to-face interaction to meet the needs of their families and communities. As we show, these digital inequalities contribute to shaping the *COVID-19 exposure risk profiles (CERPs)* for each group in our study.

Digital inequalities merit scrutiny as direct and indirect determinants of COVID-19 exposure risk, as well as excess deaths attributable to the larger conditions generated by the pandemic. Therefore, digital inequalities contribute to shaping the risk profiles for each group in our study, risks potentially related to infection from COVID-19. By illuminating these connections, we examine digital inequalities in the first global pandemic in the digital era and argue that CERPs are the newest frontier in digital and risk studies with interest for many disciplines.

Digital inequalities meets COVID-19: Taxonomies of vulnerability

The COVID-19 pandemic is radically altering the “landscape of risk” (Zinn and MacDonald, 2018) for individuals around the world. However, it has not done so in equal measure. There is systematic variation in infection exposure risks (Lioy and Weisel, 2014) due to individuals’ social locations, occupations, and consumption practices, all domains with implications for digital inequalities. Thus, in this article, we argue that the risks of exposure to COVID-19 also reflect individuals’ access and usage of digital resources for purposes such as work, consumption, and social communication.

Indeed, the importance of digital inequalities as key axes of social differentiation is more visible than ever, due to the COVID-19 crisis.

In the new landscape of risk brought about by the COVID-19 pandemic, individuals are constantly put at risk and called to make consequential decisions about managing risk within the existing parameters of their everyday lives (Beck, 1992; Giddens, 1990). Like other forms of risk management, those with resources generally have more autonomy in managing risk. In the case of COVID-19, exposure risk management must be carried out at home, work, school, and public places. Those individuals in a position to avoid contact with potentially contagious people and contaminated physical environments are better able to minimize exposure risk to themselves and others within their immediate social circles.

More specifically, individuals who have more autonomy over their homes, work and workplaces, modes of consumption, and modes of social communication can be characterized as having better COVID-19 *exposure risk profiles (CERPs)* than those who have less control over their everyday life realms. CERPs vary according to work engagements, home environments, manner and frequency of consumption, and modes of social interaction — all of which may vary across the life course and socioeconomic status. For this reason, those with more resources at their disposal can better insulate themselves from exposure risk than their counterparts with fewer such resources.

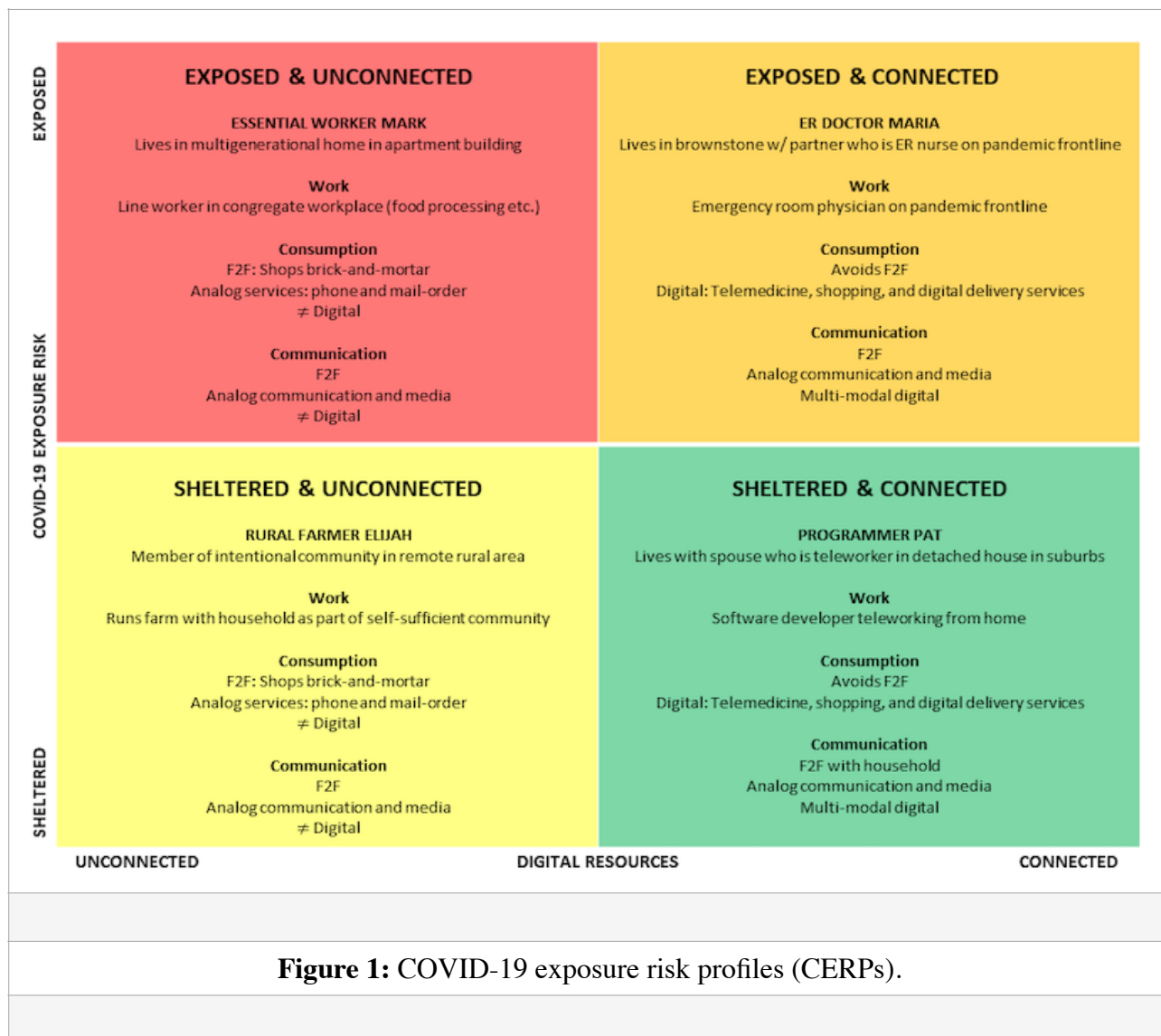
The COVID-19 pandemic is truly the first large-scale global pandemic which is taking place during the Internet age. During this global health crisis, individuals have for the first time the capacity to minimize their exposure risk by engaging in digitized interaction with others and avoiding shared physical “contact zones” (Askins and Pain, 2011). Thus, in order to understand individuals’ exposure to infection risk, digital resources have to be taken into account alongside the non-digital elements of individuals’ exposure risk profiles such as their living arrangements, their manner and type of work, and their consumption practices. People employed in different kinds of jobs and who engage in different kinds of consumption practices vary in their risk of exposure, in part because channels for work, consumption, and social communication may be more or less digitized.

COVID-19 exposure risk profiles and new forms of vulnerability

Within this context, this study fills an important gap in our understanding of risk management as related to digital inequalities. We break new ground by making explicit linkages between the role of digital resources and risk management regarding contracting the COVID-19 virus. We argue that it is critical to understand engagement with digital resources as a shield against potential exposure. Digital resources allow individuals to shelter in place to avoid potentially risky physical environments and obviate face-to-face interaction thanks to digital communication media, digitally enabled delivery services, and telework.

As may be seen below in [Figure 1](#), *ceteris paribus*, individuals who can more effectively digitize work, consumption, and social communication have additional tools to minimize their exposure risk. These digital tools allow individuals to mitigate their exposure risk profiles, as compared with those individuals who are constrained to analog modes of work, consumption, and social communication. For this reason, in order to fully grasp the sources of individuals’ CERPs, we need to scrutinize digital inequalities, which can impact many consequential life realms (Robinson, *et al.*, 2020a, 2020b, 2020c). We do so here in terms of a taxonomy of heterogeneous groups including the socially isolated, older adults, the incarcerated, students, teleworkers, gig workers, and last-mile workers. With the aid of stylized individuals, we typologize individual members of these groups, depending on their non-digital exposure risk profiles as well as their modes of engagement with work, consumption, and social communication. While some of the individuals tend towards less

digitized (more “analog”) modes of engagement with these realms, others tend towards more digitized modes of engagement.



Each of the ideal types in [Figure 1](#) represents individuals who share a similar exposure risk profile. Figure 1 synthesizes the four CERPs across work, familial situation, consumption, and communications *vis-à-vis* digital inequalities and SES. For example, *Programmer Pat* exemplifies the *sheltered and connected* CERP. This profile is the CERP with the lowest exposure risk thanks to teleworking at home with a spouse, living in a detached home in the suburbs, and using digital resources to meet all consumption and interactional needs. At the onset of the stay-at-home orders, Pat and her family were able to shelter in place and have many work and consumption needs met via digital sources. Even as lockdowns lift, they have high relative autonomy over their exposure risk thanks to digital and socio-economic resources that allow for digital delivery services to bring groceries and necessities to their home.

By contrast, in [Figure 1](#), *Mark* represents the *exposed and unconnected* CERP. As an essential worker in a congregate workplace, Mark is emblematic of those who risk exposure on all fronts.

Mark has the highest risk exposure profile as he has no autonomy over his living and work environments. Further, Mark lacks digital resources for either consumption or interaction. Both Mark's job as an essential worker in a meat processing facility and his home in a multi-generational apartment building literally put him into the "red" or "hot" "contact zone" in terms of potential exposure to COVID-19. His risk exposure is further magnified by his lack of digital resources that necessitates contact in public spaces as he does all of his shopping in brick-and-mortar supermarkets and stores. During and after lockdowns, Mark's exposure risk for himself and his family members is magnified on all life fronts. Those who are *exposed and unconnected* are most likely to come from low-socioeconomic status groups already at higher risk.

Less exposed to risk in [Figure 1](#) are those belonging to the *sheltered and unconnected* CERP represented by *Elijah*, a rural farmer. Elijah's family farm is part of an intentional community (such as the Amish or Mennonites). Elijah's risk exposure profile is lower mainly due to the collective capacity of his intentional community to self-isolate. While not all intentional communities live in rural areas, Elijah's farm is in a remote rural locale with limited contact with the outside world. Within the community, Elijah and his family are at higher risk of exposure as they rely on face-to-face interaction in their workplaces and to meet their consumption and interactional needs as they do not use any digital resources. Therefore, their collective exposure risk is entirely dependent on their particular community's ability to collectively isolate from the wider world, something not possible for all intentional communities.

Nonetheless, digital resources alone are insufficient to lower individuals' exposure risk profiles as we see in [Figure 1](#) with *Dr. Maria* who represents the *exposed and connected* CERP. Despite being connected, she has a high exposure risk due to her work as an emergency room physician daily treating patients in the New York metropolitan area. Maria lives with her partner, an ER nurse, in a brownstone and uses digital resources for all consumption and interactional needs outside of the workplace. Therefore, Maria's exposure profile is higher due to her work on the frontline of the COVID-19 pandemic despite high socio-economic status and ample access to digital resources. As we will see, Maria's situation is an important one in that digital resources mitigate the risk from exposure from consumption and social interaction. Nonetheless, even high SES and digital resources are insufficient to protect those working on the frontlines of the pandemic whose work puts them at high risk of exposure to COVID-19.

To flesh out these connections, we examine CERPs among key vulnerable populations: the socially isolated, older adults, the incarcerated, digitally disadvantaged students, and last-mile workers. We conclude the article with considerations of the short-term and long-term consequences of digital inequalities and CERPs for each class of individuals. We conclude the article with an analysis of the costs paid by each group to manage risk for themselves, as well as the costs paid to mitigate risk for others. This is particularly important for those making the greatest sacrifices in the COVID-19 pandemic: frontline workers including those in essential services.

Here we make an important point about unequal risks and costs extorted by the COVID-19 with potentially lethal consequences for those serving in public-facing jobs. In addition to the medical personnel, transportation, and utilities workers who continue to serve to protect others, we believe that recognition is due to the last-mile and location-based gig workers in public-facing jobs who ensure the food chain and delivery of vital goods upon which so much digital consumption relies. Therefore, while recognizing the risk mitigation offered by digital resources for some, we also argue that some of these benefits are only possible due to the costs paid by others. The digital delivery chain is only possible thanks to last-mile workers and location-based gig workers who put themselves at risk so that others may shelter in place. Significantly, location-based gig and last-mile workers come disproportionately from low SES backgrounds — the very populations that are already suffering in greater numbers from the ravages of the pandemic — and yet their service

simultaneously augments their risk while allowing for the reduction of risk to others. It is, therefore, vital to make a thorough account of costs, who is paying them, and who is benefitting from them to fully understand the implications of CERPs.

COVID-19: Social isolation

We begin our examination of digital inequalities and exposure risk profiles with social isolation. In response to the first wave of the COVID-19 pandemic, countries around the world reacted by imposing strict measures of social distancing, effectively putting more than half of the world population into a prolonged period of social isolation. At the time of writing in June 2020, the world continues to await a vaccine and effective treatment. As infection and death rates continue to climb in some regions and countries, they are plateauing and stabilizing in others. As some areas are reopening, the world is collectively holding its breath to see if a second wave will appear and wreak additional devastation. Globally, we are all asking: What are the social and public health consequences of this large-scale social distancing? Does differential access to digital technologies affect the outcomes?

Insights into some of these questions may be found in [Figure 2](#) below (CERP: The socially isolated and older adults). Those without digital resources will not reap communication and interactional benefits made possible by ICTs (information and communication technologies) and thereby may suffer from diminished well-being. When evaluating risk, individuals without digital resources may be forced to make difficult choices between self-isolating and risking exposure to the virus to seek social interaction with others. For example, *Helmut* belongs to the *sheltered and unconnected* CERP. Living alone and lacking digital resources, Helmut faces difficult tradeoffs between social interaction and risk mitigation. By contrast, individuals from the *sheltered and connected* CERP, like *Carlos*, are better able to meet social, communication, and consumption needs thanks to digital media. These idealized types offer insight into the plight of the socially isolated who are confronted by these choices (often in much more subtle ways) to manage their risk exposure to COVID-19.

Particularly for the socially isolated, COVID-19 threatens the very social cohesion and social integration that offer protection and bind society together (Durkheim, 1951). COVID-19 risk management engages much larger questions *vis-à-vis* social isolation. The forces at play have long been of interest to social scientists who note how social disintegration can have the opposite effect, raising the likelihood of loneliness and the risk of social isolation. For example, using religious involvement as a form of social integration, Idler and Kasl (1992) document how religious group membership can have protective and life-preserving effects for health and well-being, especially among the elderly population. Klinenberg's (2002) work on the 1995 Chicago heatwave documents how the lack of social capital in some neighborhoods contributed to one of the worst urban catastrophes in U.S. history which claimed more than seven hundred lives, offering important insight to the dynamics of risk exposure that may be similar to the suffering generated by COVID-19.

Offering direct evidence to the harmful effects of social disintegration and isolation, Klinenberg (2002) explains that hundreds of elderly residents died alone in their homes because they had no support networks or social contacts, and thus no one was checking in on their wellbeing. The heatwave study highlights how natural disasters can have differential impacts on particular demographic groups due in part to social isolation and lack of social support. The adverse effects of social isolation have been documented in the psychology literature as well. For example, Holt-Lunstad, *et al.* (2015) find a strong relationship between social isolation and the risk of early mortality. Their study distinguishes objective isolation (*e.g.*, living alone) and subjective isolation

(e.g. feelings of isolation and loneliness), and establishes that both types are associated with a higher risk of mortality.

To the extent that digital connections can enhance social connections, access to and use of digital technologies may provide some social support when people are forced into social distancing during the pandemic. Let us define digital connections as having adequate access to digital technologies and being connected through the Internet and social media platforms and social connections as being connected through in-person, face-to-face interactions. To the extent that people are forced to be socially (or physically) isolated, everyone will suffer socially when social distancing is imposed. But the effect will be manifested differently across social and demographic groups when we consider the role of digital technology in social interactions.

The [table](#) below maps digital versus social connections. When social distancing is imposed, people in Groups A and B (with strong digital connections) can choose to switch from being socially connected to digitally connected, while people in Groups C and D do not, thereby exposing the latter group to greater risk of social isolation. People that are both digitally and socially disconnected (Group D) may thus be most vulnerable under conditions of forced social distancing. In the realm of digital inequalities, previous studies have identified particular demographic and socio-economics groups that are less digitally connected along such lines as gender, race, age, education, and income (for recent review, see Robinson, *et al.*, 2020b). The literature on social isolation has also identified characteristics of people who are at higher risk of social isolation (*e.g.*, McPherson, *et al.*, 2006; Miyawaki, 2015). The intersection of these two streams of literature points definitively to the elderly population, and especially older immigrants.

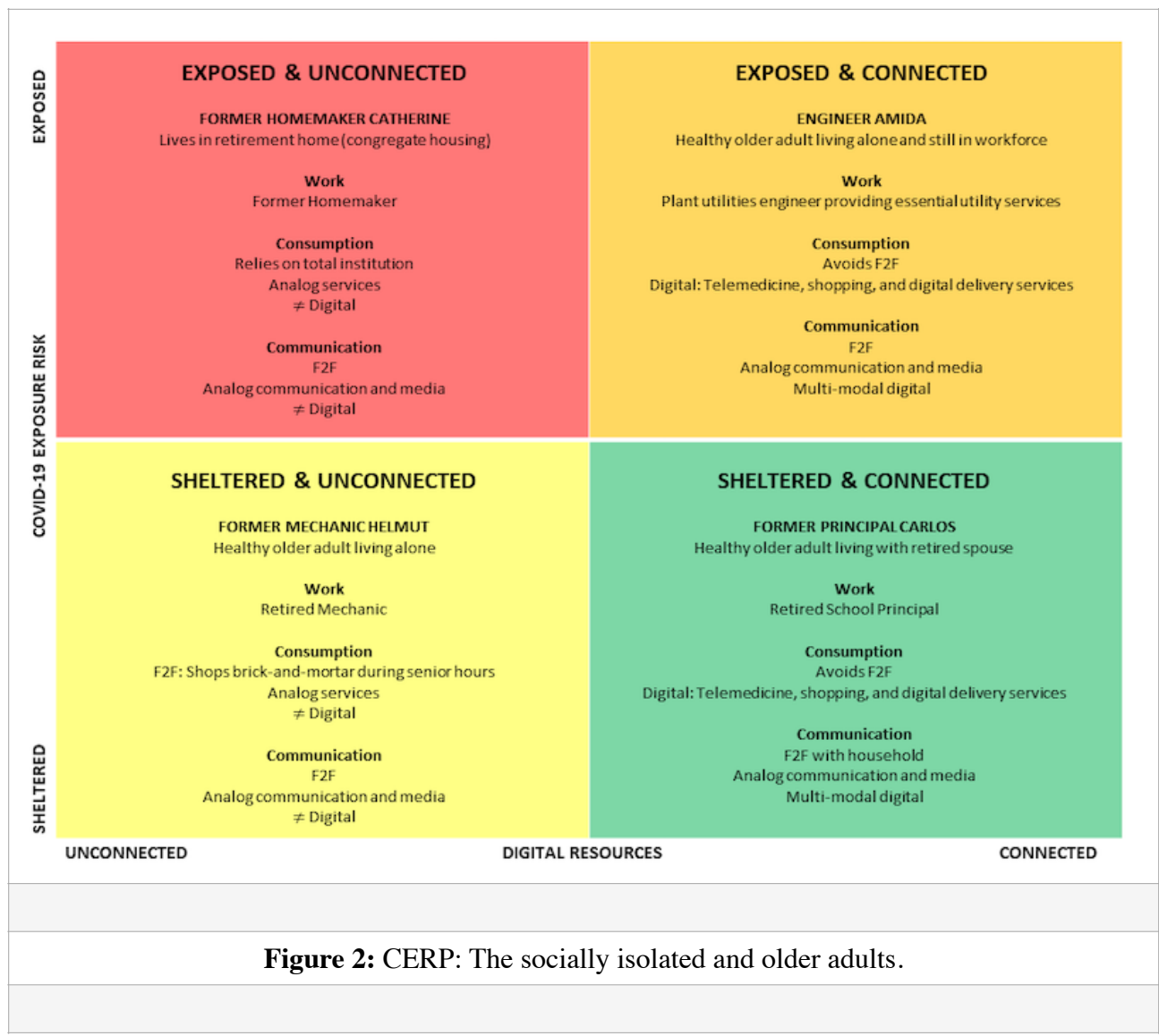
Table 1: Digital connections and social connections

Digital connections	Strong	B	A
	Weak	D	C
		Weak	Strong
		Social connections	

In the U.S. and Latin America, information and communication technology (ICT) ownership and use have been confirmed to be significantly lower among immigrants and populations who live in non-English speaking households (Galperin, 2017; Ono and Zavodny, 2008). The lack of access and use of ICTs among the elderly population is a consistent finding in the digital inequalities literature, although studies have also established that there is great disparity in access and use even within the elderly (Hargittai, *et al.*, 2019). In their study of social isolation in the U.S., McPherson, *et al.* (2006) show that older adults are more likely to have smaller social networks. Social isolation is significantly associated with negative health outcomes among the elderly, and especially among the minority and immigrant populations (Miyawaki, 2015). It should be emphasized that social isolation is not only limited to the elderly population. For example, *hikikomori* are young adults and teens who withdraw from society to seek social isolation. What distinguishes *hikikomori* from the elderly population is that many *hikikomori* are actually digitally connected (through video games, social media, etc.) and are positioned in Group B, while the elderly are not. The elderly population is already categorized in the high-risk mortality group of COVID-19 by virtue of their weakened immune system and pre-existing conditions. The combination of social and digital isolation may

further increase the mortality risk of the elderly population, as well as other negative outcomes such as anxiety and depression.

Diffusion of ICTs in our lives has raised concerns that technological advances may undermine existing social relationships. However, under the unprecedented circumstances of the COVID-19 pandemic and its prolonged period of forced social distancing, digital connections may provide some social support and lower the risk of social isolation for those populations that can afford them. Indeed, use of ICTs has been shown to be effective in promoting social connectedness especially among older adults and for students (Robinson, 2018). With the prospect of social distancing continuing at least until 2022 (Kissler, *et al.*, 2020), expanding the use of ICTs may be one way to overcome social isolation and loneliness among the high-risk populations who are digitally advantaged. However, at the same time, those without digital resources will not reap these benefits, may suffer from diminished well-being, and be forced to make difficult choices between self-isolating and risking exposure to the virus to seek social interaction with others.



COVID-19: Older adults

As we see in [Figure 2](#), in our taxonomy of older adults, we contrast individuals such as *Carlos* (*sheltered and connected*) and *Helmut* (*sheltered and unconnected*). Both are healthy older adults who have retired from their former jobs as a high school principal and mechanic. Like other older adults, *Carlos* and *Helmut* are more susceptible to infection simply on account of age. However, both have a relatively favorable exposure risk profile compared to *Catherine* (*exposed and unconnected*) or *Amida* (*exposed and connected*). Neither *Carlos* nor *Helmut* spends time in a shared office or workplace or lives with a spouse or family members who are likely to be transmission vectors themselves. However, only *Carlos* uses digital media to meet a variety of consumption and communication needs including zoom sessions with grandchildren, ordering groceries online, and receiving contactless deliveries.

Also in [Figure 2](#), by contrast, *Helmut* lives alone and does not use digital technologies to communicate with members of his social circles. Equally important, *Helmut's* lack of digital resources means that he is forced to eschew Internet purchasing and e-commerce activities in order to procure consumer goods. Where social interaction is concerned, *Helmut* relies on the telephone rather than digital communication. As the months continue, *Helmut* increasingly feels isolated and alone as a member of the *sheltered and unconnected* CERP. *Helmut* no longer is able to attend religious services, the local library, or other community institutions that gave him much-needed social interaction pre-pandemic. Therefore, to satiate his hunger for food and longing for contact with the world, *Helmut* ventures out to his local grocery store with a mask and gloves during “senior hours.” Despite these difficulties, *Helmut* is thankful he does not face the far greater risks confronting *Catherine* (*exposed and unconnected* CERP) who lives in a retirement home, relies on this total institution for all consumption, and whose communication is limited to analog services. *Catherine's* plight represents one of the many tragedies of the pandemic; like others in retirement homes, *Catherine's* CERP is high and relatively devoid of autonomy.

As these CERPs indicate, while all individuals may experience social isolation due to COVID-19 lockdowns, older adults are particularly susceptible because those aged 65 and older are more likely to suffer negative physical health consequences from COVID-19 (Centers for Disease Control and Prevention, 2020). As such, it is critical that they shelter in place and maintain physical distance from others during this pandemic. However, these behavioral changes, mandated to maintain physical health, are likely to impact older adults' connections to social ties and quality of life, in part due to their use or non-use of ICTs.

A significant segment of older adults already experience chronic loneliness; over 40 million older adults in the U.S. experience chronic loneliness; across Europe, the elderly suffer more social isolation than any other adults (U.S. Department of Health and Human Services. Administration for Community Living, 2018). Loneliness and social isolation are both associated with depression and mortality (Cacioppo, *et al.*, 2002; Cacioppo, *et al.*, 2010; Steptoe, *et al.*, 2013). A pandemic, such as COVID-19, and the ensuing social distancing mandates are exacerbating rates of loneliness and isolation, as well as resulting impacts on health and quality of life among older adults.

With the social distancing mandates in place in many areas of the world, this necessitates that contact among social ties be minimized. One way that many digitally resourced individuals overcome social distancing mandates is through the use of ICTs for maintaining contact with social ties (such as *Amida* and *Carlos* in [Figure 2](#)). Though older adults are increasingly crossing the digital divide, a significant portion of older adults do not use ICTs (such as *Helmut* and *Catherine* in [Figure 2](#)). And, as age increases, use rates decline; for example, 82 percent of 65–69 year old individuals in the U.S. report using the Internet compared to only 44 percent of those aged 80 and older (Anderson and Perrin, 2017); similar patterns appear across Latin America (Galperin, 2017).

Extensive variation exists in how older adults use ICTs, with much of this variation resulting from the timing of technological developments, differences in ICT exposure and use across the life course, and whether older adults have support networks that can provide assistance with maintaining use over time (Cotten, 2020). For example, even if they use ICTs, older adults may not garner their full benefit. Older adults may use ICTs in more basic ways, such as to talk to others via phone or to use the calendar and clock functions, than younger age groups who tend to use a variety of applications, including social media. Many older adults prefer and are more amenable to having in-person (face-to-face) interaction and landline phone communication (though mobile phone communication is increasing) (Chan, 2015; Ling, 2008; Yuan, *et al.*, 2016).

The COVID-19 pandemic highlights the importance of multi-modal communications for older adults both for consumption and to maintain contact with social ties. While analog technologies including landline phones can be important, tablet computers may be one of the easiest ICT options for older adults who are digital novices (Tsai, *et al.*, 2017). Simple operating manuals, such as those developed by Oasis Institute (www.oasisnet.org), can be helpful. However, social ties via phone and in person (when social distancing mandates are lifted) even more invaluable to enable older adults to develop digital literacies and skills with which to seek healthcare information and maintain contact with others (Cotten, 2020). Making technologies less expensive, easier to learn how to use, and easier to maintain use over time will enable older adults to cross the digital divide so that they can go online initially and are able to maintain use over time (Cotten, *et al.*, 2016).

However, enhancing use of ICTs among older adults and enhancing their social contact and communication will require training and continued support. While it may be easy to give a device to an older adult, helping them learn how to effectively use it and how to troubleshoot problems as they arise will be key to helping them to connect online during the COVID-19 pandemic, be in touch with friends and family, and to remain online in the future. Training programs that are tailored to types of devices, user experience level, and cognitive ability may also be needed for some older adults to enable them to cross the digital divide and reap social connection and communication benefits of using ICTs (Berkowsky, *et al.*, 2013; Cotten, *et al.*, 2016; Winstead, *et al.*, 2013).

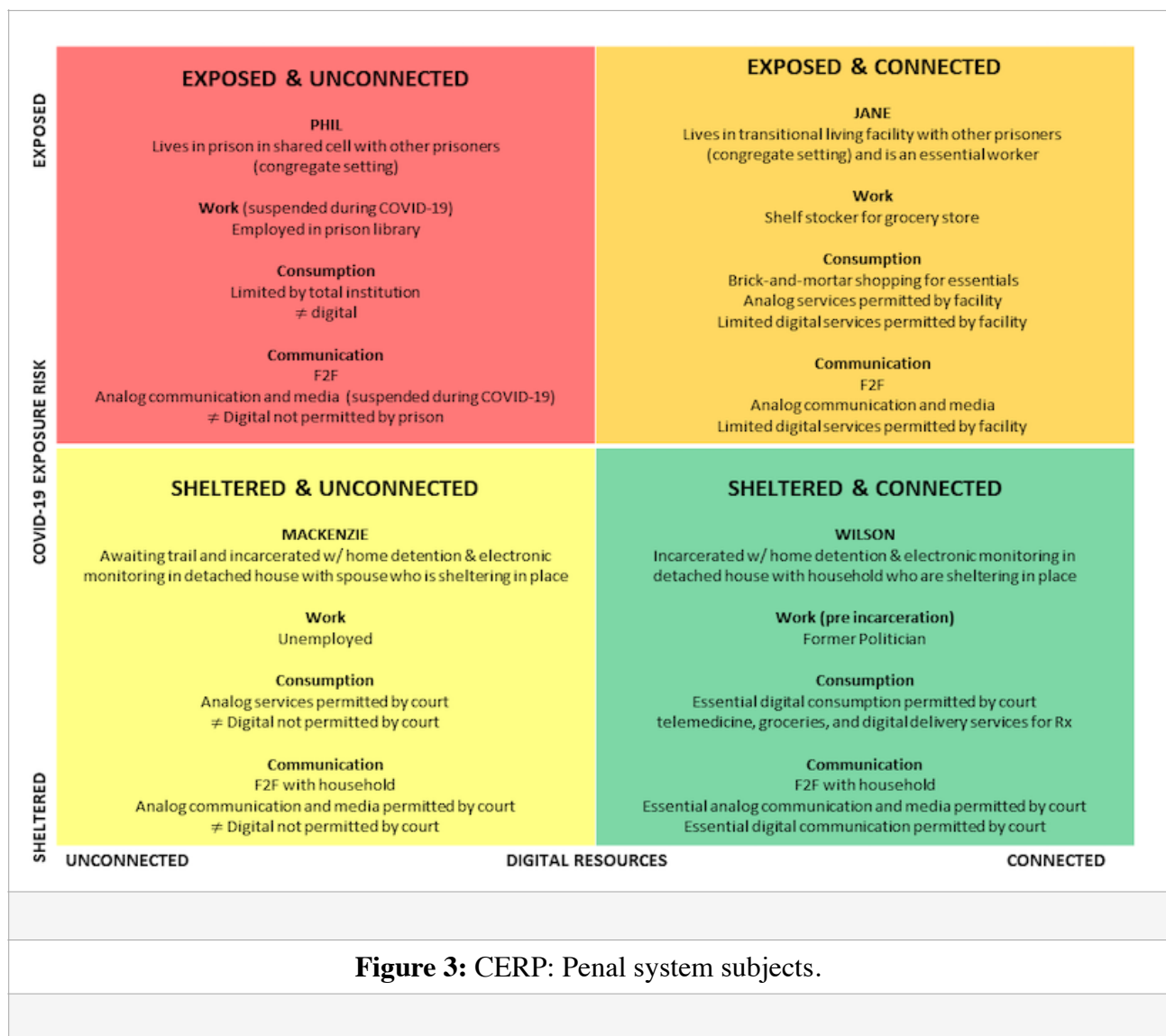
Finally, we note that many of the solutions here that rely on digital technologies do not prevent risk for older adults living with extended family members or in congregate housing. Related to this, for older adults in care communities, such as nursing homes, who may not have cognitive or physical capabilities to use technologies for social connection, having staff in these communities who can help older adults to communicate with social ties through video or audio applications is critical. This necessitates that communities such as nursing homes, assisted living facilities, and memory care units have (1) technologies, such as tablet computers, that are available to be used with residents across the communities; (2) Wi-Fi for connecting the devices to the Internet; and, (3) staff who are skilled in using these technologies and willing to use them to facilitate contact for residents even during times of social distancing (always carefully and routinely sterilizing any shared devices or surfaces that increase risk of exposure to COVID-19).

COVID-19: Incarceration

The pandemic is a particularly acute emergency for prisoners around the globe. Prisons are overcrowded settings often already lacking in basic health services or robust governance. Worldwide, they are often riven with neglect — and in some cases abuse — of human rights (Darke and Kamran, 2016; Salla, *et al.*, 2009). Internationally, multi-morbidity is significantly more common among prisoners than the broader population, which increases the potential severity of any new health challenge (Kinner, *et al.*, 2020; Morelle, *et al.*, 2020). These conditions lethally combine in institutions. Pre-COVID-19, infectious disease was already a major cause of death in many

prisons (for example, 17.5 percent in Chinese prisons as of 2018; see Yang and Thompson, 2020). Punitive considerations have long eclipsed the values of humanitarianism and rehabilitation, such as we have recently seen in El Salvador, where, even as COVID-19 spread, hundreds of prisoners putatively belonging to gangs were made to huddle chest-to-back on the ground as a form of punishment (*Economist*, 2020). The challenges of facing the pandemic in prisons are staggering, but we focus here on basic issues of human connection in U.S. penal institutions, where restrictions imposed in the name of security already sharply curtail communication beyond prison walls, yet where fresh provision for digital communication might deliver outsized benefits.

Many of the exposure risks in congregate settings like nursing homes are also present in penal systems around the globe as we see in [Figure 3](#). Individuals like *Phil* with *exposed and unconnected* CERPs are at greatest risk, followed by *Jane* whose *exposed and connected* CERP makes her vulnerable. Only *Mackenzie* (*sheltered and unconnected*) and *Wilson* (*sheltered and connected*), who are not representative of the majority of penal system subjects, are able to shelter in place in their homes.



Even prior to the current crisis, precarious connections between prisoners and their families were made all the more tenuous by deep restrictions on prisoners' access to means of communication. Nearly globally, prisoners are denied substantive Internet access (Bagaric, *et al.*, 2018; Reisdorf and Jewkes, 2016; Tynan, 2016). In the U.S., a smartphone within prison walls is treated as a major breach of security, and, in some jurisdictions, a social media post attributed to a prisoner can be cause for severest discipline (Shapiro, 2016). Some approximation of e-mail is possible through supervised terminals in some jurisdictions, though each message is tolled for length, with a base price usually greater than the hourly prison wage (Kruzman, 2018). Still, those messages are often much more affordable than the predatory cost of prison phone calls, generally borne by inmates' families (Wagner and Jones, 2019) already coping with the loss of an incarcerated family member's income and other forms of support (deVuono-powell, *et al.*, 2015).

This global pandemic brings a crisis of mutual isolation between prisoners and their families. In the U.S., jail and prison administrators have overwhelmingly responded to COVID-19 with "lockdown" measures in which prisoners are confined to their cells more or less full-time in efforts to slow contagion in overcrowded facilities (Williams, *et al.*, 2020). The measures make in-person visits impossible, and may limit if not halt access to phone calls and risk leaving prisoners and loved ones to face the pandemic crisis in reciprocal isolation from a parent, child, sibling or romantic partner, bringing long-term consequences for their ties.

While the digitally enfranchised in the free world migrate their interactions to online platforms during the pandemic, the incarcerated have been migrated away from what little video-interaction opportunities they may have had. Closed-circuit video-based family visits, medical consultations and even official hearings were introduced more than two decades ago in "supermax" prisons as an efficient, punitive alternative to in-person contact (Haney, 2003). In more recent years, however, "video visitation" has been widely introduced by prison phone companies like Securus at shocking price points. Reportedly, the interfaces routinely freeze, disconnect, or fail entirely (Kozłowska, 2015). In a small number of examples, free video-visit programs have been introduced to enhance contact between incarcerated people and their families, especially when travel and personal schedules make in-person visitation difficult. A New York City program has, for several years, linked kiosks in local public libraries to terminals in city jails (City of New York, 2020). But the joint closure of the libraries and lockdown of the jails during the COVID-19 pandemic has suspended the program and most others like it, as well.

This deprivation can have significant effects. The ties prisoners struggle to maintain during the COVID-19 lockdown are also those which have been found as key to "successful" post-incarceration reentry — that is, to securing stable work and housing and avoiding re-incarceration (Cobbina, *et al.*, 2012; Riggs, in press). Prison visits have been found to support the emotional health of prisoners and may decrease chances of recidivism (Cochran, *et al.*, 2020). When someone is sentenced to prison, their close ties are sentenced also to the deprivation from their loved one and to years of navigating complex rules of contact, part of the "collateral consequences" of incarceration (Hagan and Dinovitzer, 1999; Comfort, 2002). Extending to prisoners and their families the same electronic tools — however flawed — of prosocial connection and intimacy now essential in the free world can ease some emotional burdens, and even may offer an evidence-based strategy to reduce recidivism and ease penal overcrowding in advance of the next crisis.

To its credit, at least one U.S. state prison system has been occasioned by the COVID-19 crisis to enhance digital connectivity between prisoners and their support networks by instituting free — albeit rationed to once-weekly — video visitation opportunities via Zoom (Commonwealth of Pennsylvania, 2020). Expanding inmate online communication elsewhere will require complex solutions that balance the need for social distancing and yet maintain prisoners' rights to communications, which have been curtailed in the name of security in response to COVID-19. As

the pandemic continues, the intervention of engineers and technologists is vitally important to facilitating mediated communication in ways that ensure prisoners' rights, meet the concerns of penal authorities, and lower risk of exposure to the virus.

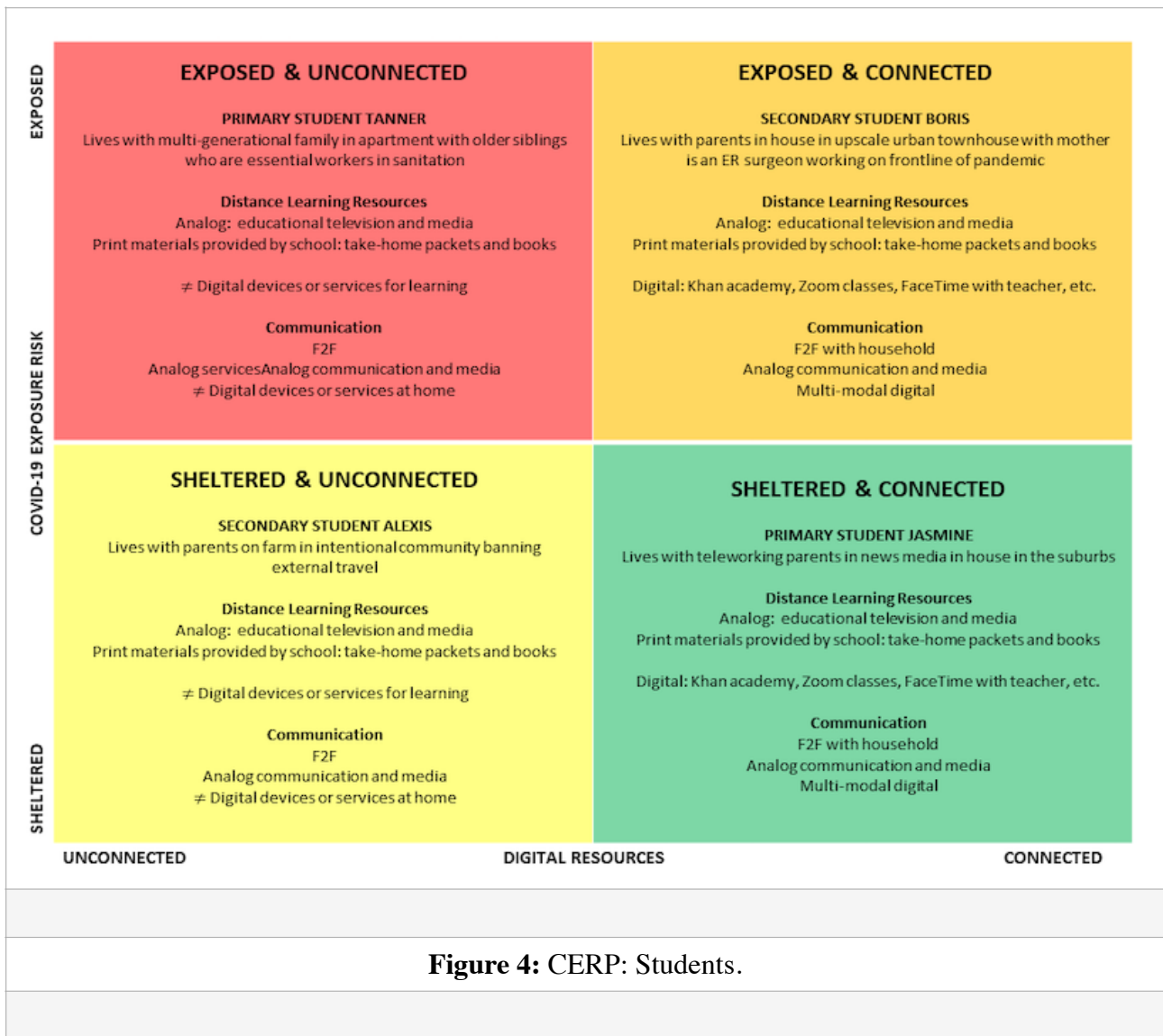
COVID-19: Education

In many developed economies, computers and Internet access are increasingly implicated in academic achievement (Robinson, *et al.*, 2018; Gulek and Demirtas, 2005; Jackson, *et al.*, 2006) under the traditional, pre-pandemic schooling model. However, as lockdowns were put into place in the first half of 2020, many schools closed and attempted to continue education for students via distance learning. Under lockdowns, distance learning has varied widely even in economically developed countries like the U.S. For example, the California Department of Education's state-wide plan for distance learning defines distance learning broadly:

For the purpose of this guidance, “distance learning” means instruction in which the student and instructor are in different locations. This may include interacting through the use of computer and communications technology, as well as delivering instruction and check-in time with their teacher. Distance learning may include video or audio instruction in which the primary mode of communication between the student and instructor is on-line interaction, instructional television, video, telecourses, or other instruction that relies on computer or communications technology. It may also include the use of print materials incorporating assignments that are the subject of written or oral feedback (California Department of Education, 2020).

As this indicates, distance learning may vary in terms of quality, use of different instructional modes, and employ both analog and digital media via different delivery platforms.

One possible result of this variation is that distance learning (albeit necessary to mitigate risk of exposure to COVID-19) could intersect with digital inequalities and thereby exacerbate existing disparities in a stratified fashion. If this occurs, differentiation will likely correlate with traditional markers of disparity (Kim and Quinn, 2013) and educational stratification related to household media, digital media, and knowledgeable people as resources for academic achievement. With school and libraries closed to slow the pandemic, given this heterogeneity in learning opportunities, the shift to remote education in response to COVID-19 has the potential to exacerbate learning gaps. As we see in [Figure 4](#) below, during lockdowns students like *Jasmine* with a *sheltered and connected* CERP may benefit from the richest mix of analog and digital resources at home. By contrast, students with an *exposed and unconnected* CERP like *Tanner* are at greatest risk of being compromised academically due to inadequate distance learning and falling behind students like *Jasmine*.



Even pre-pandemic, students whose households provide plentiful multimedia materials and people as educational resources (Robinson and Schulz, 2013) are more likely to have positive outcomes academically. Therefore, we may posit that students with insufficient resources for distance learning are more likely to suffer learning gaps — particularly if remote instruction is unequal to that of their better-resourced peers. Where remote instruction necessitated by COVID-19 is concerned, students with greater and more varied resources are likely to have multiple advantages over those whose resources are limited. Those households with meaningful Internet access (Levine, 2018) are likely to be best able to minimize exposure to COVID-19 by moving students to fully remote instruction. By contrast, under fully remote instruction, disadvantaged students may not enjoy instructional support, lessons and assignments, and educational materials comparable to that of their more advantaged peers (Kuhfeld and Tarasawa, 2020).

Even with their best efforts to learn, students with insufficient access to effective remote instruction channels may be at risk of comparative disadvantage and associated learning gaps both short- and long-term. In the U.S., some students experience a “summer slide” necessitating review (Thum and Hauser, 2015). If this holds true for the lockdowns, inadequate remote instruction in response to COVID-19 school closures could generate similar or even greater “slides” if left unaddressed. Should this occur, remote learning disparities stemming from COVID-19 may impact long-term

educational outcomes (Siraj-Blatchford, 2004). In this way, existing digital disparities and COVID-19 lockdowns may have potentially deleterious effects for low-SES students in terms of educational trajectories and life opportunities if not effectively remediated.

COVID-19: Work and telework

Since its advent in the 1970s, telework and remote work arrangements have become increasingly feasible thanks to advances in ICTs. By some measures, as of 2018 almost a quarter of American workers worked remotely on any given workday (Frazis, 2020). However, pre-pandemic, full-time telework was rare (Galperin, 2017). However, even after the proliferation of these technologies, relatively few American workers could be characterized as full-time remote workers. Prior to the COVID-19 crisis, only two to three percent of the American workforce actually worked full-time from a remote location. By some estimates, only about one-third of existing jobs in developed economies are “conducive” to telework (Dingel and Neiman, 2020). Other studies report that this percentage drops to less than 25 percent of jobs in Latin America and between 25 percent and 30 percent globally in countries including Argentina and France (Albrieu, 2020; Global Workplace Analytics, 2020; Odoxa, 2020).

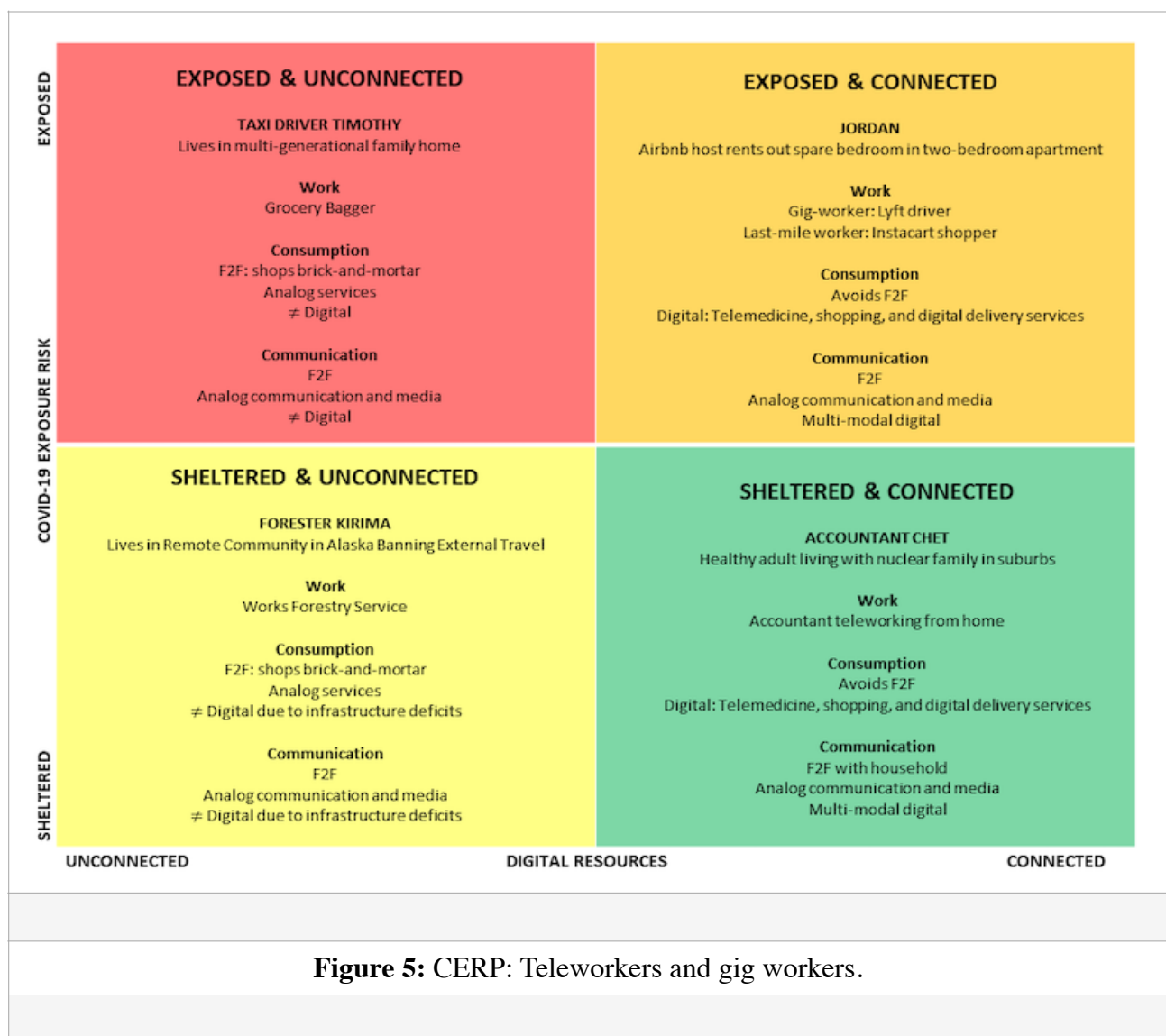
However, few would argue that, as of the onset of the global COVID-19 crisis, the landscape of remote work has changed radically and abruptly. In the first few months of the pandemic, as many as half of workers in the U.S. were expected to shift at least some of their duties to telework at home (Guyot and Sawhill, 2020). On the employee side, recent surveys suggest that the majority of American workers currently working remotely under lockdowns would prefer to continue working from home “as much as possible” in the future (Harter, 2020). Silicon Valley is riding this wave. Several months into the pandemic, organizations across the economy have expanded their remote work options in numerous ways for many different classes of employees. At the extreme, many firms are reconsidering the merits of full-time remote work. In a mid-May survey of San Francisco Bay area businesses, for example, some 18 percent of the surveyed businesses predicted that they would likely transition to “full remote work” after the pandemic subsided (Bay Area Council, 2020). Leading the way towards home-based, long-term, full-time remote work are tech firms such as Twitter, which announced that it would become an all-remote workplace in the post-pandemic period even after all of the restrictions have been lifted.

This being said, the share of jobs in any location that can be performed at home varies dramatically by city, region, to country. For example in the U.S., from 28 percent to 51 percent of jobs may be done in different metropolitan regions (Dingel and Neiman, 2020). Even in San Jose, the epicenter of Silicon Valley, only just over half of jobs are telework-friendly. There is a clear correlation between telework and occupational status and income levels both in the U.S. and globally:

... a clear positive relationship between income levels and the shares of jobs that can be done from home. While fewer than 25 percent of jobs in Mexico and Turkey could be performed at home, this share exceeds 40 percent in Sweden and the United Kingdom ... the nature of an occupation likely varies across economies with different income levels ... developing economies and emerging markets may face an even greater challenge in continuing to work during periods of stringent social distancing. (Dingel and Neiman, 2020)

These relationships confirm connections between telework, socio-economic disadvantage, and potential risk exposure to COVID-19 for those in the labor force overall (Reeves and Rothwell, 2020).

In addition to tracking with larger disadvantage and inequalities in terms of race and class, teleworking is intimately related to digital inequalities in that many workers are providing their own digital tools to work at home. Often, telework depends on the ability to afford multiple high-quality digital devices and access to broadband Internet, both of which are stratified by SES status economic class even in developed economies (Global Workplace Analytics, 2020). These connections between digital inequalities and telework are clear in [Figure 5](#) below. *Timothy* exemplifies the *exposed and unconnected* CERP. His service as an essential worker in a grocery store puts him in a public-facing job with higher risk. His own consumption and communication needs rely on in-person interactions and analog technologies, the former of which increases his risk of exposure. In direct contrast, *Chet* represents the *sheltered and connected* CERP that is faring best in response to COVID-19. He and his nuclear family work and study from their home in the suburbs; it was relatively seamless to transfer his work as an accountant from his workplace office to his home office. Like other *sheltered and connected* CERPs, his entire family employs digital technologies for consumption and communication, thus avoiding potential risk of exposure through face-to-face interaction.



COVID-19: Gig, platform-, micro-, and last-mile workers

Although the COVID-19 pandemic has been regarded as the triumph of platform-assisted “smart work,” as we see in [Figure 5](#), this does not illustrate how some gig and last-mile workers are subject to much higher levels of risk exposure to COVID-19. In Figure 5, *Jordan* is the ideal type representing platform, gig, and last-mile workers. *Jordan’s* work as a Lyft driver, as well as his work as an Instacart shopper, exemplify the public-facing essential work being performed by gig and last-mile workers. In addition, pre-pandemic *Jordan* was a host for Airbnb. Although *Jordan’s* work is heavily dependent on excellent digital skills and high-quality resources, as a worker these only allow him to serve to mitigate others’ risk. While he also uses digital resources to meet his own consumption and communication needs, on all other fronts his risk to exposure is extraordinarily high. *Jordan* does his best to provide his own PPE (personal protective equipment) but like many others has run into shortages and is using stopgap measures including re-using his mask.

Digital labor platforms such as Uber, Deliveroo, Upwork, and Amazon Mechanical Turk provide earning opportunities by outsourcing on-demand gigs and tasks. There is consensus that they reinforce existing inequalities and generate new vulnerabilities by generalizing low-paid and contingent work (Robinson, *et al.*, 2020c). As “gigs” are mainly location-based and “tasks” can be performed online, we could expect that the global COVID-19 crisis would disrupt the former, while boosting the latter. But especially in countries where stay-at-home measures have been implemented, the differential impact of the global health crisis follows more complex dividing lines. As we saw in the previous section, overall, the uneven distribution of remote and proximity work opportunities and risks follows lines of social privilege: middle and upper-classes can mostly work safely at home, while working class and precarious “last-mile workers” are forced into out-of-home occupations, both essential and non-essential.

A class gradient seems to be at play, as platform-assisted telework is common among higher-income brackets (DeSilver, 2020; Reeves and Rothwell, 2020), while people on lower rungs of the income ladder are more likely to hold jobs that involve physical proximity, which are deemed essential and cannot be moved online or interrupted. These include contingent workers in delivery, logistics, and other jobs at the end of the supply chain — often with no safety net and/or sick leave in regions where they are classified as contract workers (currently being contested in California). With healthcare professionals and police, they are those who face the greatest health risks (Gamio, 2020). The first line of fracture between those who can and those who cannot work from home reveals another, even more troubling divide among the latter, distinguishing formally employed out-of-home laborers and platform-based last-mile workers.

The COVID-19 pandemic gives unprecedented visibility to last-mile workers but without increased social security. Especially delivery and urban transportation platforms are an important part of this digital economy, which has remained operational during lockdown and has even seen a rise in activity — with a worldwide surge in worker signups, and an increase in service demand (Ghosh, 2020). Platforms have even started offering “contactless delivery” services that require riders not to hand-deliver meals, thereby reducing infection risks for customers (Yu, 2020). However, the work of riders is not contactless, as they must still interact with restaurant staff, circulate in public spaces, and touch potentially contaminated surfaces. Sometimes after court decisions, on-demand platforms have recognized the health risks that workers are exposed to and thus started providing them with gel, masks, and gloves (Wikilabour.it, 2020). Out of 120 platforms in 23 countries, more than half have gone as far as offering bonuses and expanded sick pay to affected workers (Fairwork Project, 2020). However, according to unions, these measures are mere “PR spins,” because without systematic COVID-19 testing, it is virtually impossible to claim payments (Independent Workers Union of Great Britain, 2020).

Another group of essential, yet invisible workers, are those that ensure the “last-mile of automation” (Gray and Suri, 2017), *i.e.*, contingent platform workers who do human-in-the-loop tasks such as data preparation and algorithm verification for artificial intelligence (Tubaro, *et al.*, 2020). Because such activities can generally be performed from home, some platforms have taken the epidemic as an opportunity to expand their offer, notably in the preparation of data for health-related applications. Effects are mixed and vary across types of activity and over time. Oxford’s Online Labour Index data point out that work-from-home initially stagnated for many types of remote contractors (also including freelancers like designers) as companies with declining revenues downscaled online outsourcing (Stephany, *et al.*, 2020). However, several months into the pandemic, hiring has bounced back as lockdowns began to lift in Europe and North America and jumped to higher levels than ever before, driven by demand for IT freelancers. While at the time of writing, it is too early to see the long-run effects of this change, it suggests that companies may be switching to a platform model of organization that taskifies work and allocates it to underpaid workers all around the world.

Commercial content moderation is another type of last-mile digital labor consisting of tasks that are similar to those needed for automation (Roberts, 2019). Social media companies pay minimum-wage workers to perform human-judgment tasks that escape algorithmic assessment, filtering problematic contents ranging from terrorist propaganda to self-harm. Because of the sensitive nature of these tasks, moderators are not allowed to work from home. But they are essential, and Facebook has prioritized them for an early return to their offices, which exposes them to higher infection risk, while remote work continues for other employees (Biddle, 2020; Hatmaker, 2020).

Platform, gig, micro and more generally last-mile workers shoulder a disproportionate share of the risk. While their exposure to risk allows others to be safer, their contribution has been relatively little recognized. Future scenarios include use of industrial actions to increase recognition and improve working conditions of last-mile workers. COVID-19 has opened spaces of visibility by organizing workers at least in logistics. Across the U.S. and Europe, workers in Amazon fulfillment centers have launched walkouts over health risks and outbreaks in distribution facilities, with tech workers organizing “virtual walkouts” in solidarity. Since March 2020, delivery workers have staged street rallies and wildcat strikes to demand health measures or to protest remuneration cuts, potentially indicating new connections between digital inequalities, labor movements, and social protest.

Implications of unequal risks and costs of CERPs: Taxonomies of vulnerability

History has taught us that during pandemics individuals suffer varying degrees of exposure risk, depending on their economic resources, occupation, health status, and other attributes. These trends are already implicated in the mortality rates of COVID-19, disproportionately striking low-SES communities. The Black Death in the fourteenth century reduced the European population by a third and led to widespread change that fundamentally altered power relations across society (Herlihy, 1997). With the highest number of deaths observed among the economically disadvantaged, the devastation wrought by that bubonic plague pandemic was particularly extreme within the already vulnerable communities (Ahmed, *et al.*, 2020). In modern times, economic disadvantage also played an important role in the impact of the Spanish Flu (Mamelund, 2006).

While the COVID-19 pandemic is still in its early stages, the highly unequal rates of infection and death across different communities and countries show that the COVID-19 pandemic is likely to follow the same pattern. Globally, low-socioeconomic status populations, as well as disadvantaged ethnic and racial minorities, are becoming infected and dying at much higher rates than their more

privileged counterparts (Dyer, 2020). This disparity can be traced to many causes. Members of disadvantaged groups are forced to put themselves at higher risk of exposure through their work, their consumption practices, and sometimes their mode of social communication. Certain occupational groups, for example, run a high risk of exposure. High-contact jobs carry high levels of risk of exposure for supermarket and grocery store staff, transit workers, food processing personnel, and other essential workers whose job conditions make it impossible to maintain social distance from coworkers and/or the public (Laurencin and McClinton, 2020).

Unlike pre-digital disease outbreaks in the past, however, resourced individuals can avail themselves of digital tools to avoid exposure risk. But these digital risk mitigation tools are only available to varying degrees across groups, activities, and socio-economic circumstances. Thus, digital inequalities have come into play for the first time in shaping exposure risks during a pandemic. Because digital inequalities contribute to COVID-19 exposure risks, this article examines the interplay between digital inequalities and COVID-19 exposure risk profiles stemming from these non-digital characteristics of individuals. In order to conduct this investigation, we therefore have focused on ideal typical exemplars drawn from illustrative populations, namely the socially isolated, older adults, penal system subjects, students, gig workers, and last-mile workers.

We have shown that individuals who belong to particular populations can differ in terms of their COVID-19 exposure risk profiles in part because they bring different digital resources to bear in their engagements with life realms such as work, school, consumption, and social communication. Using our ideal typical exemplars as case studies, we argue that the ways digital and analog resources are employed into these various life realms influences overall risk of exposure to the potentially deadly COVID-19 virus. As our study underscores, the conjunction of digital inequalities and non-digital inequalities are rendering certain subgroups significantly more vulnerable to exposure to COVID-19 around the world (Robinson, *et al.*, 2020a). As the pandemic continues, digital inequalities will continue to contribute to shaping the risk profiles for each group and thereby indirectly contribute to infection and potentially death rates.

Drawing on our concept of COVID-19 exposure risk profiles, we compare individuals as four types: the *sheltered and unconnected*, the *sheltered and connected*, the *exposed and connected*, and the *exposed and unconnected*. Each type is located in one of the four quadrants of the fourfold analytical scheme in order to represent the interaction of digital inequalities with other non-digital sources of exposure risk. Conceptualizing these risk profiles in terms of these four quadrants helps us to appreciate the key role of digital inequalities alongside socioeconomic inequalities and other kinds of non-digital disparities.

These disparities are most clear in the case of individuals with *sheltered and unconnected* CERP profiles (in the lower left-hand quadrant of all figures). The *sheltered and unconnected* are at the most danger of exposure risk across multiple life domains. They face exposure in multiple life realms at work and in their households without the benefits of any digital technologies to reduce in-person interaction or avoid shared and potentially contaminated physical space. Their shared living situation makes exposure more likely as they are subject to secondary exposure risk from the individuals sharing their living quarters - an effect of economic disadvantage. Further, they are constrained to engage in face-to-face interaction to meet the needs of their families and communities, as well as consumption of vital services such as medical care (Khilnani, *et al.*, 2020). Therefore, as our study shows, digital inequalities must be studied in dialogue with other inequalities.

Presenting a polar opposite risk profile, the *sheltered and connected* are ideal-typical individuals fortunate enough to be able to mitigate risk across all the life realms, including the productive realms of work and school. Occupying the bottom right-hand quadrant of the figures, people like

Pat, Carlos, Chet, and Jasmine more easily minimize their face-to-face contacts because they can avail themselves of Internet shopping or delivery-based consumer services. At the same time, they use multi-modal digital communication media to carry on their teleworking and remote learning, thus epitomizing how resourced individuals can maximize the use of digital resources as means of reducing COVID-19 exposure risk.

In a contrasting fashion, however, members of the *exposed and connected* CERP show that digital resources alone are insufficient to eliminate risk for last-mile workers, location-based gig workers, and those serving in essential services and medical care. Those individuals (*Maria, Amida, and Jordan* occupying the top right-hand quadrant of the fourfold table) are exposed to the risk of infection at work in their public-facing jobs. While they cannot entirely reduce risk at work, they can however, mitigate other kinds of exposure risk by using Internet purchasing and e-commerce strategies to obtain necessary consumer goods to avoid brick-and-mortar stores, as well as replacing face-to-face interaction with digital communications, thereby lowering their exposure risk to meet consumption and relational needs.

A rarer, but intriguing, type comprises those with *sheltered and unconnected* CERPs who enjoy a lower exposure risk even without access to digital resources. Exemplars *Elijah, Helmut, Karima, and Alexis* (bottom left of the fourfold table) have low risks of COVID-19 exposure despite their lack of digital communication channels. In these unusual cases, however, they are benefiting from some kind of specialized physical isolation — either their own personal physical isolation in the case of *Helmut* or their membership in rural or distant communities in the cases of *Kirima* or *Elijah*. One example of a collectively isolating distant community is the remote Alaskan town of Arctic Village that banned external travel in March 2020 (de la Garza, 2020). In such locales, digital media may be accessible only by satellite or forbidden by intentional community norms.

Significantly, as these CERPs show, while digital resources can play an important role in minimizing COVID-19 exposure risk, CERPs allow us to see how certain digitally enabled services shift exposure risk from consumers to particular workers. This is particularly evident in the case of last-mile workers and location-based gig workers who deliver goods to consumers and end-users. In so doing, they assume greater exposure risk on behalf of consumers. Like medical personnel, these workers shoulder some of the health risks “offloaded” by consumers who decline to or cannot brave the risks associated with shopping in brick-and-mortar venues. Last-mile workers are at the greatest risk of exposure and need the most attention through solutions such as contactless delivery services (Yu, 2020) and provision of protective equipment from gel to masks to gloves (Wikilabour.it, 2020). In this sense we can say that online or digitized consumption simply redistributes COVID-19 exposure risk away from more affluent consumers towards less affluent workers.

Thus, there is a zero-sum dimension to digital inequalities as a means of minimizing collective COVID-19 exposure risk, even if this is not necessarily apparent at the level of the individual. Future research can effectively use CERPs to examine the degree to which these increased risks are incurred differently along the lines of class, race, and education for different kinds of gig and last-mile workers (Ghosh, 2020) in response to the pandemic. In particular, comparative and cross-national work is needed on the plight of these workers. Study is especially needed of those from low-SES backgrounds whose work is essential for subsistence and for whom not working is not a viable option, particularly in countries without state-sponsored safety nets and in developing economies.

Synthesis: COVID-19, digital inequalities, and future directions

This article has made important inroads illuminating important connections between digital inequalities and risk of exposure to COVID-19. Our concept of CERPs will be useful to future research on the panoply of risks associated with the pandemic including but not limited to economic insecurity and non-COVID related diminished well-being such as longer-term health problems neglected during lockdowns. Other fertile grounds for inquiry prompted by our study are the intersections between digital inequalities, skills, and competencies that impact social isolation, telework, and learning. As we have seen, digital skills are critical to reduce social isolation and engage in telework. It would be valuable to analyze the success of initiatives transitioning during the pandemic and their success at reducing digital isolation and boosting competencies. Research could examine existing initiatives such as “Future dot now U.K.” and #DevicesDotNow that provide both devices and training to vulnerable populations (Ragnedda, Ruiu, and Addeo, 2019). These issues are also salient to work needed on older adults (Quan-Haase, *et al.*, 2017) in light of the widening gap between younger and older people around the world (Schumacher and Kent, 2020).

As we have seen, learning gaps, as well as skill and competency disparities, are likely to occur among disadvantaged students. Future work should examine how existing “homework gaps” (Santillana, *et al.*, 2020) may translate into larger learning gaps during the pandemic. For students, issues of diminished learning opportunities also may negatively impact students and generate wider learning gaps with potentially lifelong consequences, particularly in terms of entry into the STEM pipeline (Robinson, 2020). In addition, the incarcerated may suffer additional disadvantage from suspension of remote education available to some prisoners, thereby creating negative impact on re-entry.

Another key area for scholarship is the opportunity provided by track-and-trace technologies and digital healthcare monitoring devices to improve the CERPs of individuals in congregate settings and public-facing jobs such as those in our study: older adults in care facilities, incarcerated individuals, students, and last-mile workers. Also, looking forward to the future, the precision and efficiency of digital monitoring may contribute toward better CERPs. Better precision may help prevent the high incidence of coronavirus or any other diseases in congregate settings where privacy is scarce. Privacy is another fertile ground for future research as students and teleworkers alike have reported increased vulnerability when others can see into their private lives and home environments in ways that put lower socio-economic individuals at risk for stigma (Robinson and Gran, 2018), necessitating work on best practices (Chen and Wellman, 2009).

Finally, our research on CERPs shows the difficult decisions created by risk of exposure to COVID-19. Future work must explore the emotional labor (Hochschild, 1979) necessitated by the pandemic. Emotional labor has already been linked to digital inequalities (Robinson, 2018). Therefore, researchers would do well to explore how the shift to telework and remote learning may require emotional labor for differently situated populations such as the potential stigma above related to socio-economic disadvantage among workers who “pay to work” by providing their own resources. Studies should also document the extraordinary emotion work done by gig and last-mile workers.

In closing, this examination shows that enhancing access to digital resources, particularly in the life realms of work, consumption, and social communication could potentially have a major impact in reducing COVID-19 exposure risk for many. With the unequal distribution of costs and important caveats regarding gig and last-mile workers in mind, groups, including the socially isolated, older adults, the incarcerated, students, and teleworkers could benefit from better access to digital resources that may substitute for hazardous in-person activities for work, education, consumption,

and communication. Therefore, we argue that CERPs are the newest frontier in the study of digital inequalities with interest for scholars from many disciplines.

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1. The order of authors reflects the sequence of contributions as follows. "Digital inequalities in time of pandemic: COVID-19 exposure risk profiles as taxonomies of vulnerability" was co-authored by: Laura Robinson, Jeremy Schulz, and Aneka Khilnani (Overview of COVID-19 exposure risk profiles, Digital inequalities Meets COVID-19: Taxonomies of vulnerability, and Implications of unequal risks and costs: CERPs as taxonomies of vulnerability); Hiroshi Ono (Social isolation), Shelia R. Cotten (Older adults); Noah McClain (Incarceration); Lloyd Levine (Education); Wenhong Chen and Gejun Huang (Telework); Antonio A. Casilli and Paola Tubaro (Gig, platform-, micro-, and last-mile workers); Matías Dodel, Anabel Quan-Haase, Maria Laura Ruiu, Massimo Ragnedda, Deb Aikat, and Natalia Tolentino (Implications of unequal risks and costs: CERPs as taxonomies of vulnerability and synthesis: COVID-19, digital inequalities, and future directions).

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