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Promoting technology access and learning among underserved older adults

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Abstract

Background: The digital divide highlights technology inequities across different sociodemographic groups. Barriers to using technology (e.g., tablets, computers) might be more pronounced for individuals who have intersecting identities that place them in underprivileged social positions, such as racial/ethnic minoritized older adults with low income. However, there is very little research on practical ways to improve technology access and literacy among underserved older adults.
Research Aim: To address this gap, we propose a novel technology learning framework on increasing technology access and literacy by addressing barriers for underserved older adults.
Methods: To identify barriers that older adults may face to accessing and using technology, we reviewed over 200 peer-reviewed articles. We created a list of the identified barriers and grouped them under 4 generated categories: 1) access barriers, 2) psychological barriers, 3) social support barriers, and 4) age-related physiological and cognitive barriers.
Results: Our new framework merges existing models to help address technology barriers, and it integrates new factors relevant for underserved older adult populations (e.g., transportation, language, immigration status).
Conclusion: We provide policymakers and learning program leaders recommendations for supporting technology engagement and encourage future researchers to test this framework via partnerships with community organizations.

Keywords: technology barriers, older adults, low income, racial/ethnic minoritized populations

Introduction

Access to and use of technology (e.g., Internet, smartphones, tablets, and computers) during older adulthood is of growing importance due to its benefits across a wide range of everyday activities that contribute to the overall well-being of older adults (Charness, 2020; Charness & Boot, 2022; Chen et al., 2022; Heo et al., 2015; Sims et al., 2017; Szabo et al., 2019). For example, technology has been linked to increased social connectedness/engagement and social support among older adults (Barbosa Neves et al., 2019; Czaja, et al., 2018, 2017; Delello & McWhorter, 2017), which can help reduce loneliness (Chopik, 2016). Technology use is also associated with better physical health (Li et al., 2023; Ren et al., 2023; Tavares, 2020). In addition, technology allows older adults to have access to and use a variety of beneficial services (e.g., telehealth; benefit portals; online groceries; online banking; Harerimana et al., 2019; Ware et al., 2017), especially for those homebound or experiencing functional limitations (e.g., Choi & DiNitto, 2013; Harvey et al., 2021). Older adults with limited mobility could use transportation/ride-share apps, such as Uber or Lyft, to increase their independence. Increasing technology access and training has also been associated with improvements in cognition and functional abilities (Chan et al., 2016; Gamberini et al., 2006; Kamin & Lang, 2020; Yu et al., 2022). Understanding how to navigate technology also opens up more opportunities for older adults to engage in lifelong learning via online learning resources, which is favorable for cognitive functioning (Chen et al., 2015; Šatienė, 2015). Therefore, having access to modernized technological tools (e.g., computers, tablets with apps, Internet) and being digitally literate is beneficial, and perhaps even crucial in certain circumstances, during older adulthood.

Despite the benefits of having and using technology, the digital divide demonstrates that there are technology access/usage inequities that affect individuals from older age groups, racial/ethnic minoritized backgrounds (e.g., Latino and Black), and those with a low income (Atske & Perrin, 2021; Mitchell et al., 2019; Smith, 2014; Vogels, 2021). When there is an intersection across all of these sociodemographics, the barriers and inaccessibility to technological tools and literacy compound. Understanding how intersectionality plays a role in the digital divide can help highlight the groups of individuals that are most af-

fected (Fang et al., 2019). For instance, one study investigating the impact of the intersectionality between race/ethnicity and sex among older adults on technology access found that Black and Hispanic females experienced the greatest lack of access to technology in their sample (which included Black, Hispanic, and White individuals from both sexes, Suntai & Beltran, 2023). Another study found that Black older adults in rural areas had lower Internet access than White older adults who also lived in rural areas (Choi et al., 2022), which emphasizes a greater impact of the digital divide in rural communities of Black individuals. These findings demonstrate the significance of having overlapping identities from a minoritized status on digital inaccessibility. Although prior research has looked at ways to improve digital literacy among older adults in general, there is still a lack of research that specifically focuses on providing solutions that are applicable to and geared towards underserved older adults with these intersecting minoritized identities (Chang et al., 2004; Satariano et al., 2014). Addressing this gap is crucial because low technology access among underserved populations exacerbates health disparities, as they are less able to use technology for health purposes (Arcaya & Figueroa, 2017; Mitchell et al., 2019; Tappen et al., 2022; Weiss & Eikemo, 2017). Indeed, technology has been recognized as a social determinant of health (Sieck et al., 2021; van Kessel et al., 2022). Hence, if technology access and skills are increased among underserved older adults, health inequities could potentially be attenuated (Latulippe et al., 2017). Throughout this article, we use the term underserved older adults to refer to low-income, racial/ethnic minoritized older adults. We chose to use the term underserved because according to its definition in the Cambridge Dictionary, it is stated that this term refers to individuals who are not provided with enough access to resources and services. In this case, low-income, racial/ethnic minoritized older adults are not provided with the proper resources/services needed to learn and use technology due to their underprivileged social position. These inequities in technology resource allocation and attention are what perpetuate the digital divide.

Generating novel ways for combating the digital divide among underserved older adults with intersecting minoritized identities first requires a deep understanding of the challenges and barriers that they may encounter in accessing/utilizing technology. As such, this theoretical manuscript begins by describing technology barriers across four categories: 1) access barriers; 2) psychological barriers; 3) social support barriers; and 4) age-related physiological and cognitive barriers identified in the literature. While the general population of older adults may face technology barriers, we emphasize how some of those barriers might affect and be more prominent for underserved older adults who have overlapping marginalized identities. Next, we propose a framework for technology learning that addresses barriers and integrates components to specifically support underserved older adults, unlike prior models. Our proposed framework could lead to beneficial outcomes that contribute to healthy aging. Finally, we provide suggestions for policymakers, learning program leaders, and researchers to improve technology access and learning opportunities to bridge the digital divide.

Methodology for identifying technology barriers

Our process to identify the technology barriers described in the literature to incorporate in our proposed framework was to search for peer-reviewed articles that focused on barriers to accessing, using, and learning technology among older adults. Our search was not restricted to older adults that are from a racial/minoritized population and have a low income. Some of the studies used for the identification of barriers do include findings from research with more privileged samples of older adults (White, middle-to-high income individuals), since those may also be relevant to underserved older adults (based on their age demographic). The primary database utilized to search for articles on technology barriers was Google Scholar. Our search words included, but were not limited to, a combination of the following: "technology literacy and use among older adults", "barriers to using technology in older adulthood", "access barriers among minority older adults", "challenges with technology in older adulthood", "low-income older adults and barriers to technology use", and "technology learning barriers for older adults". Peer-reviewed articles that matched the goal of this paper were then downloaded and saved into a folder for us to review in more detail until no more nuances were identified in the literature searches. Upon collecting all the articles we could find that discussed barriers to technology access, learning, and use, we reviewed the articles that we downloaded. We reviewed over 200 articles and created a list of the identified barriers. After acquiring a finalized list of barriers, we grouped them under 4 generated categories: 1) access barriers, 2) psychological barriers, 3) social support barriers, and 4) age-related physiological and cognitive barriers. Furthermore, we brainstormed and searched for additional potential barriers that were not discussed in the existing literature that could be present for underserved populations to add to our framework. In sum, we incorporated a mixture of research from the literature that focuses on underserved populations as

well as older adults more generally. Nonetheless, we emphasize the special circumstances within each set of barriers identified that underserved older adults may face. The contribution of this manuscript is to provide a pathway for increasing technology accessibility and learning among underserved older adults to foster positive aging outcomes and combat the digital divide.

Barriers to accessing and utilizing technology among older adults

Increasing digital access and literacy is a crucial step toward improving well-being and health equity across underserved older adults via increased accessibility to telehealth and other beneficial online services. However, there are several barriers that may prevent older adults from using technology. These barriers can be understood across four different categories collectively identified in the literature: 1) access barriers; 2) psychological barriers; 3) social support barriers; and 4) age-related physiological and cognitive barriers. Not all older adults encounter barriers from each category, but when focusing on individuals from underserved backgrounds, the likelihood that they are faced with barriers from multiple categories may be higher. It is important to consider the barriers to technology that older adults from underserved backgrounds experience in order to address them, specifically among those with low income, as this could mean that, at the very least, they encounter financial barriers to accessing up-to-date, reliable service and equipment.

Access barriers to technology

There are multiple reasons as to why an individual might encounter access barriers to technology, including financial means, time, area of residency (rural vs. urban), transportation, immigration, and language barriers, as well as a lack of available opportunities to learn how to use technology in one's community. These barriers might be most prominent, perhaps even unique, in minoritized, low-income communities and be the result of systemic inequities (Mossberger et al., 2003; Van Dijk, 2005). For older adults who come from underserved backgrounds, combating technology access barriers might be the first challenge to overcome.

Financial and time barriers refer to monetary obstacles and time impediments to accessing and using technology. In terms of financial barriers, previous research seeking to understand the barriers to technology among older adults has consistently found cost as a problematic barrier to access up-to-date, reliable equipment and Internet service (Chen & Chan, 2011; Kruse et al., 2020; Peek et al., 2014; Vaportzis et al., 2017; Yazdani-Darki et al., 2020). In one study, it was found that while there are many other barriers that significantly impede older adults from accessing/using technological tools, cost can be the only or primary barrier for some individuals (Morris et al., 2007). Financial barriers tend to be more prominent among racial/ethnic minoritized groups because they are more likely to have a low income and have a higher risk of facing multidimensional poverty than White individuals (Gradín, 2011; Reeves et al., 2016). Yoon and colleagues (2020) investigated the impact that race/ethnicity and socioeconomic status (SES) have on Internet use and found that having a minoritized status in combination with the lowest levels of SES significantly decreased the likelihood of Internet use. The price of technological devices makes it difficult for low-income individuals to pay for and access them (Kim & Gray, 2016). Besides not being able to afford technology itself, there is also the financial barrier of not being able to pay for training courses or instructors that would teach them how to use and navigate technological devices in a safe manner when no friends or family members are willing or available to teach them for free. In terms of time barriers, some studies have found that there are time constraints to using technology among older adults, which can be due to a variety of reasons (Chang et al., 2015; Gatto & Tak, 2008). For example, some older adults (e.g., those with a low income) cannot afford to retire (Francis & Weller, 2021), which compromises their ability to allocate time (and energy) to learn how to operate technological devices outside of their work. Moreover, even when older adults have retired, some might have caregiving responsibilities (e.g., elderly parents, spouse, grandchildren), and thus, have minimal free time. In sum, lack of finances and time may often be present as the leading drawbacks to technology access and usage among underserved older individuals with low income.

While financial and time barriers have been most commonly reported with regards to technology access barriers, area of residency and lack of transportation also contribute to technology inaccessibility. For area of residency, older adults who live in rural areas have been found to have less Internet access than those who live in urban or suburban areas (Lee et al., 2021). Choi and colleagues (2022) identified that in rural communities Black older adults have lower access to the Internet than White older adults. Older adults who reside in rural areas tend to also face a number of transportation barriers (e.g, lack of transportation affordability, availability and accessibility; Dabelko et al., 2021; Yu & Liu, 2024). Not having access to flexible and

reliable transportation can act as an obstacle to attending in-person technology training courses that are not within walking distance (Heinz et al., 2013). Transportation barriers intersect with financial barriers, as those with low income (and oftentimes minoritized racial and ethnic individuals) might not be able to afford flexible and reliable transportation (e.g., a car; Anderson, 2016; Sanchez et al., 2004). Research examining barriers to learning opportunities in general have emphasized transportation as a barrier among some older adults (Hansen et al., 2019; Laal, 2011).

Immigration, language, and limited technology learning opportunities in one's environment are barriers to technology that may be specifically faced by underserved older adult populations coming from marginalized communities. Immigrants are less likely to own or use technology than U.S.-born individuals, and language proficiency has been identified as playing a role in this digital disparity (Chen et al., 2020; Cherewka, 2020; Livingston, 2010; Ono & Zavodny, 2008). Studies have found language as a barrier to using technology for older adults who primarily speak a language other than English (e.g., Spanish; Lopez et al., 2013). Lack of English proficiency among Latinos has been linked to lower Internet usage overall (Lopez et al., 2013; Chang et al., 2015). Although technological devices support various languages, non-English speakers face the challenge of technology training courses being primarily offered in English, limiting their opportunities for formal learning. In the same vein, lacking technology learning and tutoring options within one's community, including work, can be a barrier to learning how to use technology (Githens, 2007). Besides the relevancy of language, immigration status may prevent undocumented Latino older adults from joining technology learning programs, due to fear of legal consequences (Rodriguez et al., 2025; Rodriguez et al., 2017). This is not surprising, as there are several studies demonstrating that fear has a negative impact among undocumented Latino immigrants when it comes to accessing resources and services (e.g., Berk & Schur, 2001; Held et al., 2020). Altogether, immigration-related factors can give rise to barriers that hinder the ability of underserved older adults to access and use technology.

The accessibility of technology training opportunities is also influenced by how well those opportunities match the technological needs/desires of the older adult and the awareness of those opportunities from members in the community. For example, although there might be services in some communities that offer technology classes/training, they might be limited to offering training for a specific type of device, which might differ from the device an individual wants to learn to use. There might also be a mismatch between the types of technology-related skills an older adult aims to learn and the ones being offered at a specific location. Older adults might also not be aware of such instructional opportunities in their community, even when available, as reported in a qualitative study with low-income Latino older adults (Rodriguez et al., 2025).

Psychological barriers to technology

Psychological barriers to technology use for older adults can involve an array of emotional and perceived mental limitations that prevent them from engaging with technological devices, even when monetary funds or actual devices are available. These barriers relate to the following components: a) pessimistic attitudes or perceptions of technology; b) feelings of mistrust, fear, and anxiety of technology usage; c) perceived low self-efficacy; and d) other emotional stressors and losses often encountered during the older adulthood stage of life (e.g., death of a loved one; retirement). Any one of these psychological barriers can negatively impact an older adult's motivation to learn or use technology, and motivation itself is an essential factor of technology adoption (Lee & Lyu, 2019; Young et al., 2014). Indeed, Chiu and Liu (2017) found that the most prevalent cause for technology withdrawal among older adults was due to psychological barriers, aside from a lack of available time. As such, it is necessary to be aware of and consider psychological barriers when aiming to close the digital divide among older adults, especially underserved groups.

Perceptions regarding the level of utility and complexity/ease of use can determine whether an individual chooses to engage with technology. When an individual has negative perceptions and attitudes regarding technology, it can act as a barrier against technology use. This barrier is of particular concern among older adults, given that they are more likely to hold negative attitudes and perceptions about technology in comparison to their younger counterparts (Chen & Persson, 2002). In regards to perceived usefulness, studies show that older adults who do not use the Internet typically do not see a purpose or benefit from doing so, leading to a general lack of usage interest (Carpenter & Buday, 2007; Melenhorst et al., 2006; Morrell et al., 2000; Wagner et al., 2010). Several studies have found that perceived utility and value of technology, together with interest, are some of the strongest predictors of technology engagement and adoption (Berkowsky et al., 2018; Demiris et al., 2008; Kang et al., 2010; Wild et al., 2008). When there is a lack of perceived usefulness, which stems from the idea that it does not fulfill a given need

or is not relevant to their life (Chen & Chan, 2013; Ito et al., 2001), technology disengagement occurs (Hanson, 2011; Selwyn et al., 2003).

Alongside perceived usefulness, perceived complexity or ease of use has also been identified as having an important effect on technology acceptance among older adults (Porter & Donthu, 2006). Those who are more willing to use and embrace technology tend to perceive technology as being easy to use (Adams et al., 2005; Demiris et al., 2004; McLeod, 2009; Mitzner et al., 2010). Some older adults have described that they see technology as being too complex for them (Vaportzis et al., 2017), which can foster technology withdrawal. Finding technology too complex may also be related to having prior negative experiences with technology that have led them to feel frustrated. These frustrating experiences can result in older adults giving up on technology altogether. Perceived lack of benefit and complexity of use represent two key psychological barriers that must be mitigated, as it has been reported that they can have a stronger effect on neglecting technology than access barriers (Porter & Donthu, 2006).

Another salient psychological barrier to technology usage encompasses experiencing technology-related anxiety and feelings of mistrust or fear regarding cybersecurity (e.g., privacy, scams, and identity theft). Regarding technology-related anxiety, the literature often discusses this concept in terms of computer anxiety, and has been documented as a barrier to technology engagement across numerous studies conducted with older adults (Cody et al., 1999; Czaja et al., 2006; Di Giacomo et al., 2020; 2019; Ellis & Allaire, 1999). In general, older adults experience computer anxiety at higher levels than those who are younger (Laguna & Babcok, 1997), resulting in greater technology reluctance among those who are older (Czaja et al., 2006; Jung et al., 2010; Mayhorn et al., 2004). Relatedly, concerns about cybersecurity may also aggravate technology anxiety and prevent technology use (Kim & Gray, 2016). Some older adults have expressed that they avoid using technological devices because they are afraid of getting hacked or clicking on something that would compromise their privacy or corrupt their device with viruses/malware (Yazdani-Darki et al., 2020; Gatto & Tak, 2008). Furthermore, older adults have also shared that they do not trust the Internet because they fear that they will get scammed online and have their identity or credit card information stolen (Fischer et al., 2014; Gallo et al., 2022; Gatto & Tak, 2008; Seo et al., 2019). These fears are not unreasonable, as more than 5% of older adults become victims of scams and fraud yearly in the United States (Burnes et al., 2017), although younger adults also are victims of scams and fraud (e.g., Paat & Markham, 2021). To address older adults' technological concerns, it is crucial to validate their fears and educate them on avoiding cyber threats, similar to approaches used for younger populations (particularly via work-related training).

Perceived self-efficacy, defined as an individual's view regarding their own ability or competence to carry out a behavior or task (Bandura, 1977; 1994), is also a powerful predictor of participation in technology training classes and utilization among older adults (Berkowsky et al., 2018; Czaja et al., 2006; Jung et al., 2010). Lacking confidence in one's ability to learn how to navigate technology is a barrier that can lead to technology avoidance (Chen & Chan, 2013; Mitzner et al., 2010; Vaportzis et al., 2017). Some older adults have described that they feel too old to learn new technology, suggesting that they can hold perceptions of low self-efficacy based on their age (Chen & Chan, 2013; Turner et al., 2007). Low-income Latino older adults have reported that they feel they are not smart enough to learn technology (Rodriguez et al., 2025). Additionally, some older adults have indicated feeling that they are not competent enough to handle a technological device without accidentally breaking it or making mistakes (Barnard et al., 2013). Some state that technology is better suited for younger individuals (Yazdani-Darki et al., 2020). These negative self-efficacy views toward learning new technologies in older adulthood are cultivated via ageist stereotypes that say older adults are beyond their years to learn new skills (McDonough, 2016; Wandke et al., 2012). One study showed that groups of underserved older adults are at higher risk of experiencing and are more vulnerable to the effects of ageism than privileged older adults (Chang et al., 2020). Experiencing higher ageism has also been associated with lower self-efficacy for technology use (Rosell & Vergés, 2021). Due to the impact that low perceived self-efficacy can have on the willingness of older adults to learn and use technology, it is critical to promote positive views on aging in society, especially about learning.

Aside from the psychological barriers mentioned above, during the older adulthood stage, individuals also face specific stressors and losses that can potentially affect their motivation to learn new technologies. Two primary losses in older adulthood involve retirement and the death of loved ones (Papalia et al., 2007), both of which can impose great emotional distress on older adults and result in poor mental health outcomes (Dave et al., 2008; Mandal & Roe, 2007; Rhee et

al., 2016). Concerning retirement, negative outcomes may include experiencing a decrease in their sense of self-identity, purpose, competence/usefulness, self-esteem, and increased loneliness (Bleidorn & Schwaba, 2018; Chase et al., 2003; Lewis & Hill, 2020; Morrison et al., 2020; Segel-Karpas et al., 2018). In terms of bereavement, experiencing the loss of a loved one, in particular that of a spouse, has been recognized as one of the most stressful life events (Karantzas & Gillath, 2017). This stressor elicits a range of negative emotions that are linked to unfavorable mental health outcomes (e.g., depression; Edelstein et al., 2010; Shah & Meeks, 2012). In general, studies on academic motivation have shown that poor mental health is associated with lower motivation to learn (e.g., Elmelid et al., 2015). Therefore, undergoing retirement and bereavement, which occur with more frequency in aging years, can jeopardize motivation to learn how to use new technologies among older adults.

Social support barriers to technology

Social support is vital in promoting technology use among older adults (Damodaran et al., 2014; Tsai et al., 2017), and it is represented in the form of available instructors (whether formal or informal) and encouragement from relatives, friends, or peers. When evaluating barriers to technology, older adults have mentioned that they lack instructional support and guidance to technology learning (Vaportzis et al., 2017). A qualitative study identifying barriers to learning in low-income Latino older adults found that relatives of older adults can sometimes discourage them and prevent them from learning new skills in general because they feel that they are too old to do so (Rodriguez et al., 2025). Lack of instructional support relates to the aforementioned financial barriers, as monetary funds are often needed in order to pay for professional technology training services.

During the initial stages of learning new technology, older adults need the most support because, when they first fail at a given technology-related task, they may easily choose to give up altogether (Stephenson, 2002). In this manner, receiving guidance from a technology trainer can help them not only improve their performance on technology-related activities (Czaja et al., 2013) but also encourage them to keep trying despite encountering potential frustrations or mistakes (e.g., Tsai et al., 2017). Receiving training does not have to be from a formal instructor, as they can also be taught how to use technology informally by friends or family members (Gallo et al., 2022; Luijkx et al., 2015). However, it may be most effective to have a trained, formal technology instructor. For instance, friends or family may just complete tasks for older adults instead of properly teaching them, or older adults may have difficulty focusing on instructions that are too complex (e.g., Yazdani-Darki et al., 2020). Formal instructors are typically more qualified and better prepared in providing professional scaffolding techniques that facilitate the learning process for older adults (e.g., Kavanaugh et al., 2013; Tambaum, 2017; Vygotsky, 1978). In addition, relatives and peers also have busy lives of their own and cannot always provide adequate instructional support for the older adults when immediately needed (e.g., Tsai et al., 2017). Apart from guidance, enthusiastic support from loved ones aids older adults in becoming more motivated to engage with technology, and to persist through the challenges they might face while learning (Damodaran et al., 2014; Morrell et al., 2001; Tsai et al., 2017). Overall, a lack of social support can negatively influence older adults' technology acceptance and use (Foster & Sethares, 2014; Peek et al., 2014).

Age-related physiological and cognitive barriers to technology

Aging consists of several physiological changes that can affect vision, hearing, and cognition, all of which present functional challenges to technology use and learning for older adults. Normally, visual acuity declines with age, and this decline leads to potential problems with reading and light sensitivity (Kosnik et al., 1988). Such visual decline induces difficulties for some older adults when trying to use technology (Piper et al., 2017), especially devices that use only small print. Hearing also declines with age (Bergman, 1971; Gates & Cooper, 1991), and experiencing these decreases in sensory functions has been shown to act as a barrier to activity engagement among older adults (Scott et al., 2023). Suffering from hearing loss can specifically make it difficult for older adults to follow along in a technology training course. Furthermore, changes in cognition during older adulthood could include decreases in working memory, spatial visualization, processing speed, and attention (Charness & Boot, 2009; Echt & Burridge, 2011; Park & Reuter-Lorenz, 2009; Salthouse et al., 1989). These cognitive functions are essential for learning novel skills and navigating new technology, and their decline can result in slower learning rates and challenge older adults' ability to use new technology (Charness et al., 2001; Czaja et al., 2006; Czaja & Lee, 2007; White et al., 1999). Importantly, research studies show that racial and ethnic minoritized older adult groups suffer from higher rates of cognitive decline in contrast to majority older adults (Masel & Peek, 2009; Weuve et al., 2018). Also, having lower financial resources can result in experiencing a greater

cognitive load due to facing economic stress, leading to lower cognitive functioning (Mani et al., 2013; 2020). Consequently, cognitive health disparities need to be taken into consideration when it comes to teaching underserved older adults new technologies.

Illness is also a well-documented physiological outcome of secondary aging. Chronic illnesses often develop in later life (e.g., hypertension, osteoporosis; Buford, 2016; Ettinger, 2003) because there is an increase in physiological vulnerability (Troen, 2003). These physical declines end up negatively impacting the health of some older adults. Health problems can limit the physical functionality of older adults to learn/use technology (Ang et al., 2021; Chiu & Liu, 2017; Kouvonen et al., 2022; Yazdani-Darki et al., 2020). For example, there are certain illnesses in older adulthood that can cause issues with motor skills, such as hand tremors (e.g., Parkinson's disease; Jankovic & Kapadia, 2001) and pain or weakness in fingers (e.g., arthritis; Carmeli et al., 2003). These illnesses make it troublesome for individuals to hold objects; hence, they induce barriers to handling and interacting with technological devices (e.g., tablets/smartphones; Charness & Boot, 2009; Yazdani-Darki et al., 2020). Additionally, it makes sense that when an individual is dealing with an illness, they might be depleted of motivation and energy to learn how to use technology. Health-related barriers may be of particular concern for older adults who have a low income and are minoritized as they tend to suffer from higher rates of illnesses and have less access to proper healthcare in comparison to higher income and majority older adults (Fiscella & Williams, 2004; Richardson & Norris, 2010; Yearby, 2018).

In combination with age-related physiological and cognitive changes, there are also design barriers to technology engagement among older adults. Technology manufacturers and website designers often do not take into consideration the special technological accommodations needed for older adults based on the changes they undergo in aging (Charness & Boot, 2009; Fischer et al., 2014). Poor technology design for older adults can be followed by poor technology performance (e.g., not being able to operate a given technological tool) as the demands of the technological device might not match the capabilities of the older adult user (Fisk et al., 2009; Rogers & Fisk, 2010). For example, older adults have complained that they struggle with features on technological devices (e.g., unlabeled and small buttons), discouraging them from using technology (Mitzner et al., 2010; Vaportzis et al., 2017). Not properly accounting for age-related physiological changes as new evolving technologies are created contributes to the ongoing digital divide.

Framework for accessing and learning technology

Several models aimed at predicting technology adoption have been created, such as the Technology Acceptance Model (TAM, Davis et al., 1989), and the Unified Theory of Acceptance and Use of Technology model (UTAUT, Venkatesh et al., 2003). However, these prior models have received criticism in the past because they often fail to fully account for the barriers that might impede some individuals from accepting or adopting technology (e.g., cost; Chen & Chan, 2011). Also, these models were created within the context of the workplace and were not particularly made for older adults. Recently, improved and more robust models that focus on older adults, like the Center for Research and Education on Aging and Technology Enhancement (CREATE) model (Czaja, 2006), the Senior Technology Acceptance Model (STAM, Chen & Chan, 2014), or the Model of Technology Adoption by Older Adults (MATOA, Wang et al., 2017), have been built to include all of the possible factors that would determine their level of technology acceptance. While these models continue to grow as more factors are identified in technology-related studies, there are still some gaps in knowledge on how to successfully close the digital divide among underserved older adults, in particular. For instance, prior models are not geared toward older adult individuals who have intersecting sociodemographics that place them in underprivileged social positions and that encounter systemic inequities that accentuate or give rise to additional technology barriers and challenges (Fang et al., 2019). In this paper, we propose that to effectively increase technology training and engagement among underserved older adults, we need to implement a framework that recognizes the impact of systemic inequities. Such a framework should also adequately represent and address barriers to accessing and learning technology. We also propose that doing so could lead to positive aging outcomes among underserved aging populations.

Our proposed framework is driven by and implements components from prior theories/frameworks that focus on addressing barriers to resources for learning and accessing technology among marginalized groups of older adults. First, we are using the Social Justice Framework for Bridging the Digital Divide proposed by Fang et al. (2019), which was built using an intersectionality lens to consider how the interconnectedness of several sociodemographic factors contributes to inequities in technology access and use. This framework emphasizes how the various com-

binations of sociodemographic factors generate different privileged and underprivileged social positions that have an impact on the access and use of technology, fostered by barriers and facilitators faced by distinct social groups (Fang et al., 2019). Second, we are drawing from the learning engagement framework proposed by Rodriguez et al. (2022), which suggested a general pathway for increasing novel skill learning among low-income and minoritized older adults with the goal of increasing their cognitive and functional abilities, and in turn, achieving healthy aging. In this framework, it is noted that there are resource barriers that can limit the feasibility of low-income and minoritized older adults to engage in learning new skills. These include resources that indirectly affect one's ability to engage in learning a particular skill (e.g., finances, health, time) and resources that directly relate to the skill (e.g., tablets, instructors). The framework proposes that in order to encourage engagement in learning new skills, it is necessary to increase the learning motivation of older adults and mitigate any learning resource barriers they might face. By applying this novel skill learning framework alongside Fang and colleagues' approach (2019), with a focus on technology as the skill being learned, we can help increase technology access and usage among underserved older adults. We are combining the conceptualizations of these two frameworks to create a new one that specifically outlines a path for tailoring technology learning opportunities among older adults with intersecting underprivileged social positions that face barriers to technology (*Figure 1*). Nonetheless, this framework employs a holistic approach and can be used for older adults in general and those with more privileged social positions who might also encounter some of the barriers described above.

Our proposed framework, as shown in *Figure 1*, depicts how individuals with sociodemographic marginalized identities (e.g., being an older adult as well as having a low income and a racial/ethnic minoritized identity) may experience a multitude of interconnected barriers, which are particularly relevant to one or more elements of their identity. It emphasizes the need to address those barriers by implementing approaches that mitigate them (described in detail in the next section). It also highlights the importance of engaging in learning technology-related skills that are meant to help maximize the gains of technology use. Lastly, it lists the potential direct and/or indirect beneficial outcomes (at the individual and societal level) that can be derived from effectively learning and using technology that contributes to healthy aging. At the individual level, benefits include increased cognitive and functional abilities, connectivity, and physical and mental health (e.g., well-being). At the societal level, we could see a narrowing of the digital divide that is based on the intersectionality of age, socioeconomic status, and race/ethnicity.

The following sections discuss how the technology barriers can be addressed to feasibly facilitate engagement in technology learning and usage among underserved older adults by our proposed framework.

Addressing technology barriers

Providing access. To address access barriers, our framework suggests that underserved older adults must be provided with financial support for the training and tools needed to learn technology or have learning programs that supply these resources for free or at a low cost. In the past, there have been programs that provide technological tools (e.g., Internet) at no cost for low-income households, such as the Affordable Connectivity Program (which recently announced that, due to a lack of funds, its program is closing its services; Brodkin, 2024). There are also emerging programs that give free technology and training to low-income older adults in some communities, as seen with the Senior Learning and Accessibility Technology Evaluation (SLATE) project conducted by the Riverside County Office on Aging in California (Ferguson et al., 2023). Additionally, for individuals with transportation issues to attend training, technology learning programs should provide flexible transportation that is able to pick up and drop off learners. Other programs that offer different services have taken into account transportation barriers for those who do not have a car, the ability to drive, or a driver's license, and have incorporated solutions to address them. For example, Medicaid can arrange and provide individuals with a ride to their medical appointments if they are unable to make it on their own. There are also programs that are specifically dedicated to assisting older adults with transportation services (e.g., Elder Helpers; National Aging and Disability Transportation Center). Technology learning programs could partner up with available transportation resources to offer rides to their participants if they do not have their own transportation system available. Programs for technology learning should also provide flexible meeting times for individuals who still have working schedules or other responsibilities to attend to. To address access barriers related to residential areas, there needs to be an increase of opportunities across urban and rural areas that are popularly known and easily accessible to individuals. Collaborating with community organizations to help provide safe technology learning spaces

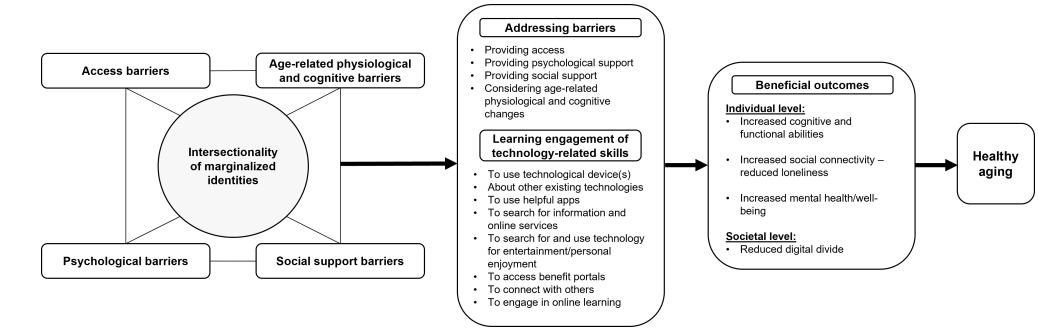

Figure 1. Framework for accessing and learning technology among underserved older adults

for immigrant older adults who may have concerns regarding their immigration status should also be considered. Technology learning programs should also be offered in other languages aside from English for individuals who are part of non-English speaking communities. In addition to considering language, technology learning programs need to consider what is culturally relevant for those participating and integrate that within the learning environment and learning curriculum. Incorporating recommendations for culturally relevant teaching practices within this framework would entail: having the learning setting represent those present, making the learners feel included and welcomed, identifying and using strengths within a learner's culture to facilitate their own learning (e.g., resources and people), and respecting and understanding learners' cultural values and traditions (Garcia & Boyd, 2019; Wages, 2015). For example, tailoring the learning program for Latino older adults can involve the use of comunidad and familism to help them learn new technology, as they often rely on the strength of familial and community support as part of their cultural values (e.g., Dominguez et al., 2020; Guzman, 2022; Sabogal et al., 1987). In practice, this integration could be displayed by asking a family member or close friend to join the older adult in learning new technology. Promoting these technology learning program opportunities in the right settings is also important to bring awareness to the community. For underserved older adult communities, targeting churches, community centers, and other frequently visited places by these individuals would be ideal. Overall, we can draw from concrete examples of programs that have implemented some of the components we are discussing in our framework to affirm the feasibility of addressing technology access barriers.

Providing psychological support. Motivation to engage in learning technology can be hampered by the psychological barriers we previously discussed: pessimistic attitudes or perceptions of technology; feelings of mistrust, fear, and anxiety of technology usage; and perceived low self-efficacy. To combat pessimistic attitudes or perceptions of technology, our framework suggests informing older adults about the benefits and utility of technology while offering them guided help to boost their motivation to engage with it. To mitigate technology fears and anxiety, technology learning programs should always provide older adults with ways to look out for and safely avoid cyber threats. Lastly, it is necessary for learning programs to improve older adults' self-efficacy, disprove negative myths/stereotypes about aging, and provide them with an environment that openly allows for and accepts making mistakes when learning technology. To help increase self-efficacy, facilitators could highlight prior experiences and point out how they have likely already used and have some level of technological skills. For example, even if they only know how to make a phone call via cellphone, that is already a technology skill that they have learned and know how to do. Thus, they can feel confident that if they were to learn additional technological skills, they could do them just as they have before. Motivational lectures that highlight these points are necessary, and they have been successfully implemented in prior interventions that teach older adults new skills (e.g., Leanos et al., 2023). For older adults navigating through emotional stressors due to experienced losses or changes in their environment, providing them with information regarding psychological resources and services could help them be more committed to learning technology.

Providing social support. To ensure that older adults receive the proper guidance and social support as they learn technology, our framework suggests having formal instructors to teach them, while also involving close relatives or peers to some extent in their learning (when possible). For instance, discussing the importance of learning technology in older adulthood and the feasibility of it with the individuals who have the most

impact on the older adult could be beneficial in getting them on board to support and encourage them. Receiving encouragement from family and peers has been identified as a powerful predictor of technology use (Friemel, 2016). When thinking of older adults who come from collectivistic cultures (which tend to be individuals from minoritized backgrounds), they are more interdependent on family/loved ones. As such, they may feel more inclined to engage with technology if the people they care about are there to support them as they learn. In these cases, technology learning programs should promote ways to incorporate this type of support into their curriculum, besides instructional support from a formal teacher. One study with a predominantly diverse sample of low-income older adults showed that receiving technology training and support led to significant increases in comfort with computers, proficiency, and self-efficacy among participants (Czaja et al., 2018). Having guidance in using new technologies is also increasingly necessary, as they rarely include clear paper instructions and often require scanning QR codes or watching online tutorials, demanding proficiency in other technologies. It would also be potentially more valuable to have the technology instructor share the same intersecting sociodemographic identities as the older adult learner, as has been previously proposed by other researchers (Suntai & Beltran, 2023). This approach could help create higher trust, inspiration, and even self-efficacy by having someone who reflects them as a successful technology user.

Considering age-related physiological and cognitive changes. For age-related physiological and cognitive barriers, our framework notes that older adults need to have good enough health to be able to engage in technology learning. If there are health concerns that an older adult is navigating through, they should have proper healthcare access that allows them to receive treatment and assistance. Learning programs should account for health-related issues by accommodating older adults based on their needs. For instance, programs could offer at-home technology training or create learning environments that are tailored to comfortably host older adults. Accommodating older adults' physiological needs has been proven feasible, as seen in the SLATE project, which provides at-home visits to train older adults with disabilities on how to use technology (Ferguson et al., 2023). For programs offered in groups, it is important to ensure that older adults with hearing impairments have or receive hearing aids to help them follow along with the instructor. Our proposed framework also suggests that well-designed technological tools that keep older adults' physiological and cognitive needs in mind should be made and provided to them for them to be more successful in engaging with and learning to navigate technology.

Learning engagement of technology-related skills and beneficial outcomes

As mentioned, our framework highlights the key technology-related skills that should be taught to older adults and the potential benefits derived from learning such skills. Given that a large number of online services and tools (e.g., patient or benefit portals, health apps, assistance programs) are deemed to have a positive impact on health, technology inclusion is acknowledged as a social determinant of health (Sieck et al., 2021). Furthermore, health information technology (e.g., telehealth) is an increasingly used tool by both health care professionals and patients that is not only useful for storing, sharing, and analyzing health information but also for managing and preventing chronic diseases (Bates & Bitton, 2010; Fan & Zhao, 2022). Thus, we propose that older adults should be taught how to search for and navigate health-related online services, information websites, portals, and apps. Being knowledgeable about online health features and resources can potentially lead to improvements in health. Studies have shown that increased Internet use could reduce the risk of some chronic diseases (Li et al., 2023; Ren et al., 2023). Relatedly, technology use is also linked to positive mental health outcomes and increased well-being (Cangelosi & Sorrell, 2014; Chen et al., 2022; Heo et al., 2015; Szabo et al., 2019). Moreover, older adults should be taught how to use other helpful online tools that assist them with activities that facilitate their functional independence, such as apps or programs that provide banking services, transportation, and meal or grocery food delivery (e.g., Meals on Wheels). Another important skill to learn is how to connect with others via online platforms, as this can help promote social connectivity and decrease loneliness (Barbosa Neves et al., 2019; Chopik, 2016; Czaja, et al., 2017, 2018; Delello & McWhorter, 2017). Older adults should also be trained on how to access and engage in learning via online platforms and available learning resources to promote lifelong learning, which is also associated with gains in cognitive functioning (Chen et al., 2015; Šatienė, 2015). Higher frequency of Internet use is associated with better cognition (Kamin & Lang, 2020; Yu et al., 2022). Hence, if older adults are taught to learn new skills (e.g., a new language, to paint) through online resources, this could optimize their cognitive engagement, leading to increased cognitive abilities (Leanos et al., 2023). Another salient aspect of technology learning would be educating older adults about other technology tools and devices that could benefit them,

which would serve as a GPS for learning what to learn (as suggested in the CALLA-X framework of skill learning, Wu & Strickland-Hughes, 2019). While we believe that the mentioned skills are important to cover when teaching older adults to use technology, programs should also focus on teaching older adults the technology-related skills that they are interested in or want to engage in for personal enjoyment. Teaching skills that they desire to learn will serve as motivation to learn to use technology in the first place. Altogether, these skills and the beneficial outcomes described can help cultivate healthy aging. Besides the individual benefits that could be appreciated from implementing the skills mentioned, the framework could also help ameliorate the observed digital disparities.

Future Directions

Research has shown that there are many positive outcomes of technology usage among older adults (Sims et al., 2017; Szabo et al., 2019). However, as reviewed, not all older adults have the privilege of engaging in technology usage due to a multitude of barriers (e.g., access, psychological, social support, and age-related physiological and cognitive barriers). These barriers might be more frequently present among those who come from underserved backgrounds (e.g., low-income and are racial/ethnic minoritized older adults), feeding the digital divide (Atske & Perrin, 2021; Mitchell et al., 2019; Smith, 2014; Vogels, 2021). To increase technology access and usage among underserved older adults, we proposed a novel framework for learning technology that addresses the described barriers and focuses on teaching older adults what we consider to be the most helpful features of technology (e.g., using service apps, accessing benefit portals). Learning these technology skills could result in beneficial outcomes that also contribute to healthy aging. The proposed framework suggests that increasing technology access and literacy among older adults could lead to positive cognitive, functional, and psychological aging outcomes as well as address the digital divide.

For future directions, we provide three main suggestions (described in the following paragraphs): 1) the framework needs to be empirically tested with underserved populations of older adults, 2) it is necessary to partner with community organizations to test the framework across communities via learning programs or interventions, and 3) involving policymakers in helping make technology more accessible for all is necessary to accomplish bridging the digital divide

In order to assess the effectiveness of the proposed framework, it is necessary to test it via interventions that implement it with diverse populations of older adults, especially with underserved individuals (who are often also underrepresented in research, Konkel, 2015; Thalmayer et al., 2021). To test this framework, researchers would have to assess the needs of their participants regarding their access to resources and their level of motivation to effectively tailor the technology learning opportunity for them. Incorporating the feedback and experiences from underprivileged older adults is most important in examining the value of this framework to help further adjust and improve its application as it becomes adopted and used in future work. Findings from testing the framework can be used to encourage the creation of more technology learning programs and accessible opportunities for older adults using a similar approach.

Establishing partnerships with community organizations and engaging in community-based participatory research (CBPR) to create and carry out technology interventions is necessary to access underserved communities (Chang et al., 2004; Ferguson et al., 2023; Unertl et al., 2016; Stonewall et al., 2017). Considering that community organizations are more trusted and have better access to individuals in the community, they serve as the main source for researchers to reach populations that are otherwise very difficult to reach. In addition to increasing participant recruitment from underserved populations, community partnership in research yields many other benefits, such as ensuring that the research is conducted in a culturally relevant manner, expanding project objectives, and increasing the quality and impact of research outcomes (see Jagosh et al., 2012 for a review). For these reasons, future research aiming to efficiently and successfully test the proposed framework with underserved older adults will need to establish partnerships and collaborate with community organizations to conduct CBPR. To ensure that community organizations involved in the implementation of this framework are conscious of the stigma that exists toward underserved older adults, an awareness campaign aimed at mitigating ageism and negative stereotypes should be conducted with the community collaborators and related personnel as a first step.

The proposed framework highlights ways in which barriers to technology access and usage could be mitigated with proper training and a system of supportive components. However, the assistance of policymakers is essential for the success of this framework in bridging the digital divide. In particular, policymakers should focus on addressing financial, healthcare, and transportation barriers that older adults from under-

served communities experience (e.g., Sanchez et al., 2004; Yearby, 2018). Moreover, more funding is needed to create more technology learning programs that provide free tools and training that are easily accessible for underserved older adults across communities. Additionally, current leaders of technology learning programs for older adults should take into account the barriers that some populations might face to attending and engaging in their programs to make it more inclusive of diverse older adults.

Limitations

We acknowledge that potential criticisms may also arise from the proposed framework. For instance, some might argue that treating individuals or assuming needs based on identity categories could have a disempowering effect on these individuals. However, this framework should not be used and applied to a community/group of people based on assumptions. Instead, components from the framework should be applied and modified where appropriate and based on individuals' needs and technology learning desires. It should be methodologically understood that assessing what a community wants and needs is a principal step before the implementation of an intervention driven by any theoretical framework. As researchers, we need to remember that theoretical assumptions cannot always be applied to every individual or community, and that taking the time to first understand and learn from a community should be a priority.

Another potential criticism of the proposed framework is that it takes on a deficit-approach lens because it is rooted in the literature that discusses the lack of access to resources and barriers to technology that underserved groups may face. Unfortunately, the current literature on technology learning and older adults from different backgrounds does not focus on or cover identified strengths. We agree that more research that utilizes a strengths-based approach to assess ways to increase and encourage technology learning among underserved older adult populations is also needed (e.g., Silverman et al., 2023), as opposed to primarily or solely focusing on the barriers or limitations. Although it is important to identify barriers and challenges to technology access and usage to address these issues, it is equally important to identify the strengths and resources that already exist within a community that can empower underserved older adults to engage in technology learning. Understanding what empowers a community will help researchers build even more effective technology interventions that incorporate identified strengths, which may result in better and more beneficial outcomes for participants. For example, some underserved older adults might be more motivated to learn technology to keep or find a job to make more money (e.g., Rodriguez et al., 2025), which could be key in helping them remain resilient throughout the learning process. Tackling the digital divide does not only require addressing barriers to technology but also drawing from the strengths that our marginalized communities already possess. Lastly, an additional limitation to the proposed framework is that it has not yet been empirically validated. Although we provide examples of how the components of the proposed framework can feasibly be implemented, it is necessary for the framework to be empirically tested. Thus, we are proposing that future research implement this framework to test its effectiveness and efficacy.

Technology learning is key to navigating our current world as new technological tools are increasingly being inserted in many public spaces of regular use that may be frequented by older individuals, such as doctors' offices (to sign-in or make appointments), the bank (ATM), grocery stores (self-checkout), restaurants (food ordering and payment via a tablet), among other places (Suntai & Beltran, 2023). The pace of novel technological developments, implementation, and diffusion is full speed and will continue to increase, making the digital divide an ever-growing issue that must be urgently and consistently addressed. Otherwise, not actively addressing this problem can perpetuate an even wider digital divide.

Conclusion

Technology access and literacy among older adults could be useful for fostering cognitive growth and functional independence, increasing social connectedness, decreasing loneliness, and boosting health and well-being. Despite these benefits that can contribute to healthy aging, the digital divide prevails as certain sociodemographic groups face barriers to accessing and using technology. Underserved older adults are especially affected. Therefore, after reviewing potential barriers to technology, we proposed a new skill learning framework to provide support for underserved older adults for accessing and learning technology by mitigating barriers. Integrating this framework in technology interventions for underserved adults is necessary to generate findings that reveal its effectiveness and ways in which it could be improved. Researchers should partner with community organizations to execute this framework successfully.

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Conflict of Interest
We have no conflict of interest to declare.

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