Understanding the Role of Technology in Older Adults' Changing Social Support Networks

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Technologies that facilitate communication between older adults and those around them have the potential to strengthen older adults' connections with their support networks. In this paper, we present findings from interviews with 16 older adult participants in the United States about their social network composition and related technology use during a challenging life event, the COVID-19 pandemic, which saw a decrease of in-person meetings and increase in communication technology adoption. Using the convoy model of social relations, we sought to better understand the roles different technologies play in older adults' social connections. Participants chose what communication tools to use depending on social and situational contexts and overcame accessibility issues to adopt new technologies that supported continued engagement with their support networks. However, when others positioned technologies as ways for the older adults to receive social support, they resisted. A more comprehensive view of older adults' evolving social convoys can help designers and researchers better create technologies that help expand and maintain older adults' social support networks. Further, to facilitate older adults' social connectivity, the design of technology should encourage older adults' support networks to see those older adults as support providers, not just potential support recipients.

CCS Concepts: • **Human-centered computing** → **Collaborative and social computing**

Additional Key Words and Phrases: Older adult, Aging in place, Social support, Social network, Social gerontology, COVID-19

1 INTRODUCTION

The older adult (65+) population in the United States is one of the fastest growing demographics and is projected to grow from over 56 million in 2020 to over 85 million by 2050 [35]. Aging in place, or the ability of older adults to live independently in their own homes or retirement communities, is overwhelmingly preferred by older adults. Aging in place allows people to maintain their sense of independence, maintain existing community connections, and lessen the financial burden that is associated with institutionalized care [33,37,49]. In addition to physical health and autonomy, social participation and support is also an important factor in improving one's own perceived ability to live independently [63,81]. Past studies have shown that a lack of social support can be a significant contributing factor in the entry to nursing facilities [22]. More generally, changes in older adults' social networks can often influence their decisions about changing their living situations [73,81].

Digital technology can be an effective tool for older adults to build and maintain social connections, providing meaningful support between family members, friends, and others in their social circle [31]. Compared to analog forms of communication or meeting in-person, technology can help older adults communicate more instantaneously and with higher frequency. While there is a digital gap between older and younger age groups in terms of technology adoption and usage, this gap has been shrinking in recent years as older adults have become an increasingly digital population [28,96]. This is a positive trend since technology can help aging adults continue to age in place [77]. However, some technologies created for older adults, such as smart home devices, are primarily focused on providing physical safety for older adults, which can be at odds with older adults' sense of independence [30].

Giving support, and in particular reciprocal support, has been shown to have a relationship with positive mental health [5,10,26,34,67]. These supportive and/or reciprocal relationships can be with family or non-family. For older adults seeking to maintain or build social connectedness, the benefit from relationships that extend beyond their immediate family can be an effective contributor to their subjective wellbeing and can help alleviate the effect of some negative family interactions [43,57]. In both existing and new relationships, research has shown that older adults are both providers and receivers of social support, and technology has been suggested as an easier way to connect with both family and friends [16]. Researchers have also suggested that these technologies can increase engagement with community groups and improve social connectedness [7,75]. These positive effects have the potential to help older adults maintain high levels of mental health and independence for a longer time.

During the COVID-19 pandemic and accompanying social distancing rules, digital technology use and adoption increased, including among older adults [1,13]. While older adults have been reported to be less open to adopt new technology [96], the perceived benefits of communication technology during this period (and, indeed, lack of alternatives) could have provided an increased incentive for them to include more technology use in their daily lives, especially technologies aimed to increase social interaction and connectedness [1]. The rapid adoption of technologies during the pandemic, and older adults' subsequent uses of those tools, provide a time-bounded perspective into how they used technology and where they found various technologies could or could not meet their needs for giving and receiving support.

Our study used this moment in time to further understand the opportunities and limitations of digital technology as a way for older adults to obtain and provide support, with the goal of making recommendations on how technology use can be evaluated and how technology can be designed to better suit the needs of older adults looking to connect with their support networks.

We investigated 1) How do older adults interact with their support network and what motivates technology use in that process?, and 2) What are the opportunities and limitations of digital technology used by older adults to connect with their support network? We present results from a qualitative analysis of interviews with 16 older adults about their experiences connecting with others in their social networks, both with and without technology. We use the convoy model of understanding how social relationships change throughout one's life cycle [36]. This theoretical framework positions the social circle of a person into a "convoy" of social support. Members of the convoy can include friends, family members, and persons who are receivers or providers of social support. We provide a nuanced analysis of how individuals' social connections cross from friends to family to acquaintances and how they use technology across those connections. We conclude with design implications and considerations for creating technology for older adults that encourage their social support network to see them as providers (rather than exclusively receivers) of support.

2 RELATED WORK

Social support can include 1) informational support, 2) emotional support, 3) tangible support, and 4) social integration [12,39,40]. For older adults who are aging in place, the availability of a support network can provide a number of benefits, including improvement in cognitive function and wellbeing [12,62] and can contribute to their ability to age independently in their preferred living environments [31]. Specifically, communication technology use can have a positive effect on older adults' ability to age in place by helping them maintain and expand their social support network. Technology and internet use among older adults has been associated with a decrease in feelings of loneliness and depression by lessening social isolation [15,16]. Compared to younger demographics, older adults are also more likely to experience positive effects from technology mediated social communication [58]. However, people–including technology designers–can be prone to seeing older adults as needing help, and this can lead to disempowering relationships and technology designs [71]. In this section, we introduce past work on technology use and adoption among older adults in a social context and discuss how the convoy model could help us understand their use of technology in relationship to their evolving social network [36].

2.1 Technology use and adoption among older adults

Despite the shrinking digital divide between older adults and younger demographics in recent years, older adults' technology use remains lower than the population in general [96]. Past examinations of older adults' technology use suggest that perceived value and the ability of technologies to improve older adults' quality of life can be significant factors in predicting how willing older adults are to adopt a technology or service [9]. Common barriers to the use and adoption of technology include lower technology literacy among older adults and accessibility issues that are associated with aging, such as visual or motor impairments. From creating interventions to enhance older adults' technology literacy to proposing more accessible technology design, prior work on this subject has largely focused on the onboarding aspect of technology adoption [44,45,52]. While this is an important aspect in helping to introduce older adults to more technology-mediated communication methods, it can limit our understanding of technology use and design to the older adult user and their end device.

Existing technology adoption models have the potential to help us understand additional dimensions of older adults' technology adoption behavior. One early model that explains factors of technology adoption is the Technology Acceptance Model (TAM) which posits that perceived

usefulness and the perceived ease of use are the main predictors of an individual's willingness and motivation to start using a certain technology [17]. TAM was further extended by Venkatesh et al. to create the Unified Theory of Acceptance and Use of Technology (UTAUT) model, which uses performance expectancy, effort expectancy, social influence, and facilitating conditions as the main constructs that influence the adoption and use of technology [83]. UTAUT also includes individual-level factors such as age, gender, and education level, and it addresses these factors' influence in decision making.

However, some researchers argue that the UTAUT model omits technology adoption factors that are often identified in older adults, such as different perceived needs and technical knowledge of individuals. Examples of models that are adapted from UTAUT for older users of technology include the Senior Technology Acceptance Model (STAM), which takes into account the effect of acceptance factors on different adoption stages by older adults, and the Model for the Adoption of Technology by Older Adults (MATOA), which adds the considerations of biophysical aging restrictions and anxiety toward technology, as well as requisite knowledge [69,86]. Other studies on technology use among older adults have identified accessibility, technology literacy, and social influence as main adoption factors [1,24,52,60,92]. While the inclusion of factors specific to technology use by older adults have been shown to be a more useful descriptor of adoption patterns in this age demographic, more work is needed to understand perceived value and usefulness after initial adoption.

Previous work has found that existing technology adoption models, including STAM, can fail to describe ambivalence about adopting a technology, that is, when older adults lack the inclination to fully adopt or reject a technology, especially when social influence is involved [23]. As technology is increasingly created to extend and increase online social connections, it has become important to better understand technology use and adoption in the context of who older adults communicate with to gain insight on ambivalence in technology adoption.

2.1.1 Technology mediated social support for older adults. CSCW and HCI researchers have examined existing practices and designed novel systems to facilitate social support among older adults and between older adults and other groups, with the most emphasis on support across generations and within families.

Examination of communication patterns among adult children and their older parents found that a greater number of communication channels used correlated weakly with the adult children's communication and relationship satisfaction with their parents, but that communication quality was more predictive of parents' satisfaction than communication channels or frequency [98]. The same study found that any given dyad used about three different channels, which the authors interpreted to indicate that new communication channels either displace or complement older channels within any particular relationship. Additional studies of communication between older adults and their adult children found that technologies to support intergenerational family connection must: facilitate interactions without introducing new obligations, lower barriers to communication without reducing the meaning of that communication, balance creating awareness with maintaining privacy, and support use of preferred media channels [82].

Based on these understandings, researchers have created and deployed systems and technology probes to facilitate intergenerational social support within families. Vutborg et al. deployed a technology probe that supported storytelling to identify design principles for developing close relationships between grandparents and grandchildren over a distance. They argue for the importance of giving grandparents and grandchildren something to talk about, facilitating conversations, diversifying interaction to maintain children's attention, and

supporting grandparents in providing care [85]. Others have explored systems that bridge synchronous and asynchronous interactions, navigate asymmetries in communication media preferences, and address mismatches in availability [53,54]. Across studies, photos show potential catalyzing social interactions (e.g., [25,55,82]) Studies deploying a paper photo album enhanced with audio snippets [66] and a digital photo frame and digital pen and paper connected to Facebook [14] have shown the potential for blending familiar and novel technologies in artifacts to support social interaction.

Research has also considered community settings and structured activities as sites of social support for older adults. A study of older adults in East York, Canada, found that older adults incorporated technology to maintain existing relationships and exchange or coordinate a broad range of social support with friends and family members [68]. They did not, however, use technologies to create new ties. When researchers have focused on interventions intended to create new ties, they have tended to focus on structured activities. For example, researchers examined opportunities for technology to support intergenerational mentorship programs that bring together older adults (reducing their social isolation) and elementary school students (creating learning opportunities for them), noting the importance of reducing barriers to mentors, nurturing supportive and meaningful relationships, and easing the work of organizing such programs [94]. Other researchers sought to support remote gym classes, both for physical activity and as a site around which social interactions can occur [6]. While they found the concept feasible, they noted that, without careful attention to the design of social features, the serendipitous social encounters that might occur in person would not occur in the online setting.

Research into the role of technology in older adults' social support continued through the pandemic. This work found that many older adults adapted to changing circumstances and disruptions to their social routines, working across multiple–and, in many cases, new–modalities to stay connected [70,78]. Many group activities, such as religious services, civic participation, and cultural events [70,95], moved to online settings, while others moved to asynchronous or hybrid formats, such as adopting Snapchat or Instagram, or using Zoom for either a video call or to leave a video message [70]. However, older adults experienced much more difficulty creating new relationships in technology mediated contexts than they did maintaining their existing relationships and connections [70]. Additional challenges included reduced access to in-person technology support and reluctance to seek support from friends and family members for fear of adding another obligation at a difficult time for so many [78]. Further, some older adults described being excluded from technology mediated experiences in which they would have liked to participate due to negative assumptions about older adults' interest in or ability to use technologies [78].

Across studies, the research describes a combination of older adults as being potentially unaware of newer communication channels or technologies (e.g., if not introduced to them in the workplace), but resilient and adaptable to new tools once they learn of them. Though older adults may adopt many technology tools for communication, each individual relationship tends to use relatively few (3-4) channels. While some of the research reflects older adults' roles in giving support to their networks, others depict older adults as more passive consumers of social content or recipients of support. We see an opportunity for research to examine how older adults use different technologies more broadly across their entire, and evolving, social support networks and how members of their support networks can also influence their technology use. To further this line of inquiry, our work seeks to understand communication technology used by older adults through a more comprehensive review of their dynamic social networks.

2.2 Understanding older adults' social networks through the convoy model

Researchers and designers seeking to design to support or facilitate connections among older adults can benefit from ways to model and understand those connections. In this study, we use Kahn and Antonucci's convoy model of social relations as a lens to interpret how the effect on older adults' perceived closeness with others in their social circles is affected by technology and to further evaluate technology in the context of changing social relations [36]. This model of social relations conceptualizes social support using the hierarchical mapping technique [2], positioning members of a person's social support convoy based on the strength of their relationships. Three concentric circles represent where members of a person's social network could be categorized, from the strongest relationships in the center to gradually weaker ties in the outer circles [2]. This model posits that each person's convoy is decided by both personal factors like age and gender, as well as situational factors like lived experiences and environments. The convoy model allows an individual to define the structure of their own relationships with those in their social network without traditional social constraints such as familial or social norms [3,20]. Thus, when evaluating the support convoy, qualitative factors like perceived quality of social relations are also considered, in addition to structural factors like network composition and means of contact.

The convoy model has previously been used to describe continually evolving social networks at different life stages, such as the study of child and adolescent social development by Levitt [46] and the social networks of aging adults [20,42]. Under this model, older adults' convoys differ from younger people's convoys. Although the network size and support given/received remain similar as a person ages, older adults see a general narrowing in the scope of their convoys as they get older, generally positioning more family members at the center [4]. These studies demonstrate the model's ability to represent social relationships that are in constant development. Figure 1. shows a hypothetical adult's social convoy reflecting this pattern as they age. This visualization could be especially useful when evaluating social connections that are shifting as technology usage is intermingled with existing and new relationships.
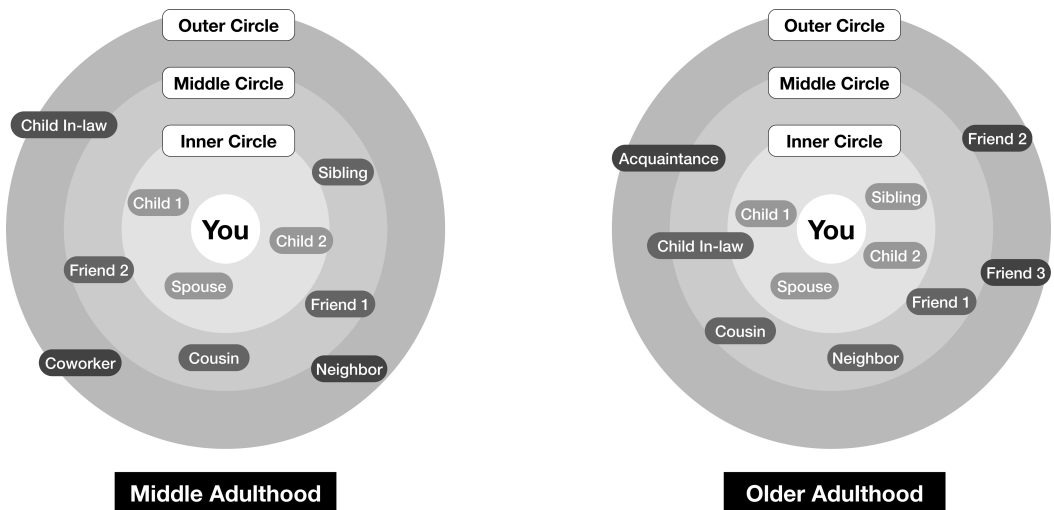

Figure 1. Hypothetical example of an adult's social convoy transition

The convoy model places an emphasis on social relationships that are both positive and avenues for reciprocal support. In this study, we used this model to characterize older adult participants' social networks and the role of technologies in maintaining or strengthening existing relationships and in fostering new connections.

2.2.1 Older adults' social support networks evolved during the pandemic. The convoy model posits that a person's social convoy will evolve with age and life events. The COVID-19 pandemic was one such event that additionally brought a significant change in older adults' access to their support network. The pandemic brought an enormous transition in how older adults were able to connect with others, and who they were able to connect with, altering their social convoy. We saw an increase in older adults' isolation as social distancing rules were enacted [41,76]. As a population that faced greater risk of severe illness and death resulting from COVID, older adults experienced increased levels of social isolation and stress factors that led to increased levels of anxiety and depression [76]. Many organizations sought to introduce older adults to virtual offerings that took the place of in-person events or meetings [97]. This precipitated an increase in older adults' initial adoption of new tools, such as Zoom, to remain connected to others in their social networks. Despite being increasingly tech-savvy as a population, the pandemic also saw a widening of the "gray digital divide" due to a lack of technology support or digital exclusion [78]. Smart technology was seen to help with themes of meaningful relations, rewarding activities, spirituality, health and safety-related support, self-growth, and physical activity [32]. Previous research showed that while older adults "neither became more support providers nor more support receivers during the pandemic," the support roles and methods of older adults changed, such as seeking tangible support and providing emotional support in new areas [59]. In contrast to before the pandemic, when family members giving support tended to value older adults' safety over their sense of autonomy, older adults also became increasingly safety conscious during the pandemic [59]. This, in turn, increased the need to access healthcare, food, and other goods and services in an online or hybrid environment [93].

3 METHODS

We conducted a remote interview study with older adults living independently. We invited people living in the United States, aged 65 to 80, and were not receiving full-time nursing care (i.e., living in their own homes or retirement communities), to participate in our study. We sought to understand their technology use in the context of their social circles and support networks, as well as to understand the role these technologies play in their support network to maintain strong and weak social ties. We conducted remote semi-structured interviews with enrolled participants over video conferencing (Zoom) or phone calls.

3.1 Participants and recruitment

To recruit participants, we used two different methods. The first method posting our call for participants on a recruitment website and social media. Most participants from this channel were somewhat familiar with technology and were comfortable using technology to communicate with their social circles. We used a second recruitment method to diversify our participant pool in terms of their technology use. For this method, we contacted senior centers in the states of Washington and Oregon and sent out digital flyers with details of our study. Interested participants were asked to contact us via email. Both groups were then asked to respond to screening surveys before being scheduled for interviews. Because this study was conducted remotely, there are significant limitations in the recruitment and interview formats due to social

distancing rules. The pool of potential participants was restricted to those who could respond digitally, and although we attempted to reach a more diverse group of participants through semi-offline recruitment methods such as flyers shared with senior centers, at the time these centers were largely limited to email newsletters to reach their members. Many participants in this study were using a range of computing devices such as smartphones, tablets, or laptops that they used to communicate with others. We interviewed participants through video conference calls. Participants who preferred phone calls were provided a number that connected them to the conference call. Consequently, our study may have attracted a participant pool consisting mainly of older adults who were already relatively comfortable with using technology and online platforms or had an interest in technology.

Potential participants were sent a document explaining their informed consent over email and a screening survey to gather eligibility and demographics data. Our study was approved by the university IRB and followed all COVID-19 related protocols. Verbal consent was obtained before commencing each interview. Our interview protocol covered participant support networks, preferred modalities for engaging with others, technology experiences, and how this changed during the pandemic. We also asked participants about their relationships and communication modalities with each person they listed in their support network. Each interview lasted between 30 to 45 minutes. We compensated each participant with a $25 electronic gift card for each session.

We recruited 16 participants, with ages ranging from 65 to 76 (mean age = 70.8 stdev = 3.1, 12 females) as detailed in Table 1. Of the 16 participants, six participants lived alone, and there was a range of low to high socioeconomic status (Table 1).

Table 1. Participant demographics

Age	Gender	Race	Living Situation	Current / Former Occupation
74	Female	Caucasian	No data	Administrative
67	Female	Caucasian	Living with a partner	Attorney
69	Female	African American	Living with a partner	Program manager
68	Female	African American	Living alone	Not specified
72	Female	African American	Living alone	Teacher
69	Female	Asian	Living with a partner	Letter carrier
67	Male	African American	Living with a partner	Not specified
71	Female	Caucasian	Living with a partner	Registered Nurse
65	Male	Pacific islander	No data	Mathematician
74	Female	Caucasian	Living with a partner	Mental health therapist
74	Female	Caucasian	Living alone	Technical writer
72	Female	Caucasian	Living with family	Environmental Engineer
73	Male	Caucasian	Living with a partner	Computer systems analyst
72	Male	Caucasian	Living alone	Non-profit business manager
69	Female	Caucasian	Living along	Dancer, dance teacher
76	Female	Other	Living alone	Educator

3.2 Analysis

Interviews were recorded and transcribed by members of the research team. Interview transcripts were analyzed using a grounded theory approach [11]. Two members of the research team independently conducted open coding focused on technology use with social circles, communication patterns, and support networks. We wrote memos using the codes we generated and grouped them into higher-level themes. The research team then conducted iterative coding

and memoing to refine the high-level themes. To gain a better understanding of older adults' technology use in the context of older adults' social support network, we also applied the convoy model to visualize each participant's social convoy and technology use. From the interview data, we mapped participants' self-identified social networks using the convoy model, with those they considered in their "inner social circle" mapped to the inner circle, and others mapped according to their perceptions of closeness. We also included participants' modalities (e.g., text messaging, video chat, in-person meeting, etc.) of connecting with their convoy.

4 FINDINGS

Participants used a wide range of technologies, such as smartphones and tablets, with some also using laptop and desktop computers to communicate with a range of social connections. While not all participants detailed all apps they used, the overall set of participants used a diverse range of services and apps for communications. Fifteen participants regularly texted with others. All used the default texting apps on their phone (SMS or iMessage on iOS, SMS on Android and feature phones). Three participants also used third-party apps to text, including WhatsApp, Facebook Messenger, Signal, and direct messaging on Instagram and Twitter. All used email regularly, with three participants using iPads for email. Participants also reported using different video calling apps. Participants most often described using Zoom and FaceTime for video calls, and a few described using other services like Skype, Facebook Messenger, Google Hangouts, and telehealth platforms for video calls. Across their application use, participants described similar barriers to technology use as in past studies, but these usability issues and other barriers did not prevent participants from using these technologies. Some participants also used accessibility features to overcome usability issues.

We also explored the role of technology in older adults' support networks using the convoy model. Technology-mediated social support among older adults was similar to what was previously found for in-person support. In-person interactions were highly valued, and participants preferred meeting with family, friends, and community members in person in most cases. The pandemic led to a greater reliance on technology for social interactions and was able to help many participants remain in contact with their support networks. Technology was able to facilitate some types of communications, such as frequent check-ins and support through asynchronous communication methods while other types of technology often fell short in replicating the experiences and connections provided by in-person interactions. Participants valued technology as a way to augment their existing relationships but preferred in-person contact for deeper connections and support.

4.1 The expanding role of technology in connecting older adults and their social networks

Participants reported that technologies had become an increasingly common way to connect with their social circles, get information, and access online services. While participants recalled situations where they faced technology adoption barriers, they found these barriers did not significantly affect their use or adoption of these services or technologies. Participants also, on the whole, had technology usage patterns that changed over time, both because of the pandemic and other forces, reinforcing that technology adoption is more of an ongoing process than a static decision-making moment.

Case 1: P4 was a relatively advanced user of technology compared to other participants. For P4, using technology to communicate with her social network led to an expansion of her social

circle. P4 had already been regularly using technology as a way to communicate with family and friends for several years, partially because of her need to connect with her geographically dispersed social network. Taking advantage of this large technology-mediated network with her family members, P4 was able to develop additional contacts over the Internet for the non-profit organization with which she worked. P4 refers to them as *"professional colleagues,"* and some of those relationships have become part of her social circle.

Case 2: P11 expanded the range of technologies and platforms she used, adding in tools used by others in her social network to facilitate connection. As P11 started to use texting more to keep in touch with her social circle, she found that some people could only be reached using her smartphone. While P11 preferred typing on her iPad's large keyboard, this limited her to only compatible apps, such as iMessage. To message others through her smartphone, P11 started using the text-to-speech functionality to overcome the limitation the smaller keyboard posed: *"I don't use my thumbs as I think a lot of old people don't, and so I am starting to use … the [dictation] feature [more and more]."* She also used email and text messaging to arrange in-person gatherings with friends at restaurants, which transitioned to Zoom meetings or outdoor meetups during the pandemic. However, she noted that despite regular Zoom calls with family members in the beginning of the pandemic, *"it hasn't [been] happen[ing] recently,"* suggesting that frequent use of video calling did not become part of her social interactions with her family in the long term.

Some participants, especially those who adopted technologies after they left the workforce, reported issues with learning to use their devices and keeping up with changes in the products. A few participants were cognizant of the limitations of the devices that they owned and used them selectively depending on the situation. P4, a multilingual user, says that *"because our phones would automatically correct [the] spell[ing], most of the time when we [start] texting we end up calling one another."* In other cases, their knowledge gap of online communication conventions caused them to feel less welcome in a digital space. P12 mentioned that their lack of knowledge of the acronyms and internet slang can hamper their desire to text and use social media, *"I know why [people like to shorten phrases] because there's a limit to how much space you have, but … there's no place to look those up really … I don't feel comfortable [enough to look them up like how] … I can look a word up in a dictionary."* In some cases, digital systems are imposed on older adults for vital services like healthcare or finance when institutions create services that they believe can best support users. P10 says, *"For a surgery there's stuff every week that they need to … [show me] results. I've told them, 'please send [it to] me in hard copy' so I can just get all the results from my labs with a hard copy, … and they just don't do that. It gets lost in the crunch."* This can be even more frustrating when these technologies fail to function as designed, as P10 further describes: *"[A technical issue with logging on] has been a huge hassle for me because I have to somehow get through to Kaiser or the clinic and somebody else will open up MyChart and try and let me know of certain key things that are happening, and that's the only way I can access MyChart now."*

When participants encountered these issues, they often struggled to find reliable sources of support for issues with their digital technology. Usability gaps can place the burden on family members and friends to provide the needed support. Prior work suggests that peer tutoring can be an effective means to teaching technology [91], and we saw this with participants like P16, who played a significant role in helping peers with technology: *"I actually help [my friend] with all of his technology … [For example,] when he was buying his house, … the real estate people here now have all of their forms and stuff online."* However, other participants also described situations in which fellow older adults had experienced frustrations with others asking for help with their technology use. P10 recalls, *"… my friend <name> used to teach technology, but … now doesn't like*

technology at all. He ... really resents it when people assume that because he taught a lot of technology that he'll help friends with it. He finds it very tedious and boring."

Although participants reported ongoing struggles and frustrations with adopting, using, and learning technologies, most did not find these issues to be a major factor influencing their communication technology use or their perceptions of it. Participants (P1 - P3, P5, P8 - P13, P16) often chose their preferred technology or service based on the situational context, such as the desired brevity of the conversation or when they expected a reply. P13 says, *"I think that both email and texts have allowed me to maintain a more superficial [and] frequent communication ... [However,] meaningful communication for me, very rarely happens via email and never by text ... and I prefer phones with people who are out of town and I have a strong preference to be together in person with people who are geographically closer to me."* Asynchronous technology, such as texting and emailing, was a particularly effective way for many participants to provide and receive support from others without the obligation to respond with immediacy. P16 says, *"You send out a text and ... they can reply whenever they have the time ... I can send it out, you know, at three in the morning and they don't necessarily [need to see it immediately] ... I don't expect a response right away."* This behavior points to the importance that this type of low stakes asynchronous technology can have for strengthening ties among those in the middle circles of older adults' social convoys, and it shows how choosing modalities can provide different opportunities to connect that would otherwise have been missing. Some also chose what technology to use based on what others in their convoy used. P12 became a frequent user of texts during the pandemic because *"it just seemed like that's what people were doing,"* while P4 started using FaceTime because *"[my family] was always very pleased when I'm making an effort [to use video calling]."* Some participants also chose to omit certain technology entirely from their lives based on how connected they wanted to be to others. For example, P15 limited their online communications to emailing and video calling through a computer and made the decision to not acquire a smartphone, explaining that *"I don't want to be accessible all the time ... my life is very, very full ... I know everybody says you can just turn it off ... Some of us have a harder time [ignoring notifications] ... we are compelled to look, and I don't want to be compelled."*

For many participants, digital communication in different forms had become an integral part of how they connected with their social convoy, and the adoption of these channels was further accelerated by increased technology use during the pandemic both by people around them and by themselves. These digital ways of connecting socially can facilitate creating new connections and/or reinforce weaker ties. In some cases, technology-mediated communication was the primary reason another person was part of an older adult's social convoy, while in others technology served a secondary role by facilitating other ways to connect. To better understand what roles different technologies are playing in helping to construct and maintain older adults' social networks, we used the convoy model to visualize technology use in the context of participants' relationships with others in their social convoy.

4.2 How technology use intersects with older adults' social support convoys

Similar to offline social support categories described in previous research [12,39,40], technology-mediated social support among older adults in our study also spanned 1) informational support, 2) emotional support, 3) tangible support, and 4) social integration. Participants commonly used in-person interactions to provide tangible support to others, such as volunteering at local events or giving away food or other items to neighbors. P2 says that they used to do *"volunteer work just a little bit, three hours on Saturday at an art center"* but found that opportunities to give support

were scarce during the pandemic because *"there's not really too much you can do online."*Emotional and informational support were the most common ways that participants connected with the inner and middle circles of their convoys through technology. Participants continued to provide and receive tangible support in their communities during the pandemic, with older adults in some cases finding contactless ways to do so. Tangible support through online only means was relatively limited, often serving as a way to coordinate in-person tangible support or to send financial support. P5 says that when they want to send some money for the grandchildren, they would use an online service because *"everybody uses Cash App or Zelle or ..., PayPal, whatever, and we exchange money that way."*P7 also found it convenient to provide financial support for family members in need: *"It doesn't even take a minute, you know, because I could just transfer money to her bank [online]."*

The convoy model can provide insights into these patterns of providing and receiving support by representing the closeness of a relationship which can then be compared with the types of support provided in different directions. Figure 2 presents example mappings of participant social convoys. Consistent with previous studies, participants had a tendency to consider their family members, such as their siblings, children, and grandchildren, to be in their inner circle. In the middle, participants commonly identified friends, neighbors, and others with whom they had a common interest. In the outer circle, participants identified distant family members, service providers they rely on, and others at groups/organizations that they were a part of (e.g., book club members, co-workers, and senior center acquaintances). In our mapping, we also included the modality of participant interactions with others in their social convoy. Communications and interaction methods varied greatly among participants. Some participants chose to use similar modalities across all three circles, while others chose one or more modalities based on the frequency, length of communication, and needs of the other person. Video calls were largely reserved for family members who were at the center of participants' inner circles. Other than partners or family members who lived with them, in-person support was most commonly seen between participants and their middle and outer circles. People who participants only contacted online, often exclusively through social media like Facebook groups, were largely relegated to the outer circle.

Participants did not always communicate most frequently with those who were at the center of their social circles. Although a few participants were in touch with their intergenerational inner circle family members on a near daily basis, many more reported friends and friend groups as being the people who they are in contact with the most, ranging from daily to a few times each week via text messaging or phone calls. A similar preference for "intimacy from a distance" has been shown in previous research, where older adults maintained strong and intimate ties without being heavily involved in their children's lives [64,80]. The preference for this type of behavior could also be explained by previous research indicating a strong relationship between friendships and positive subjective wellbeing [48,65,89], especially for expressive support.
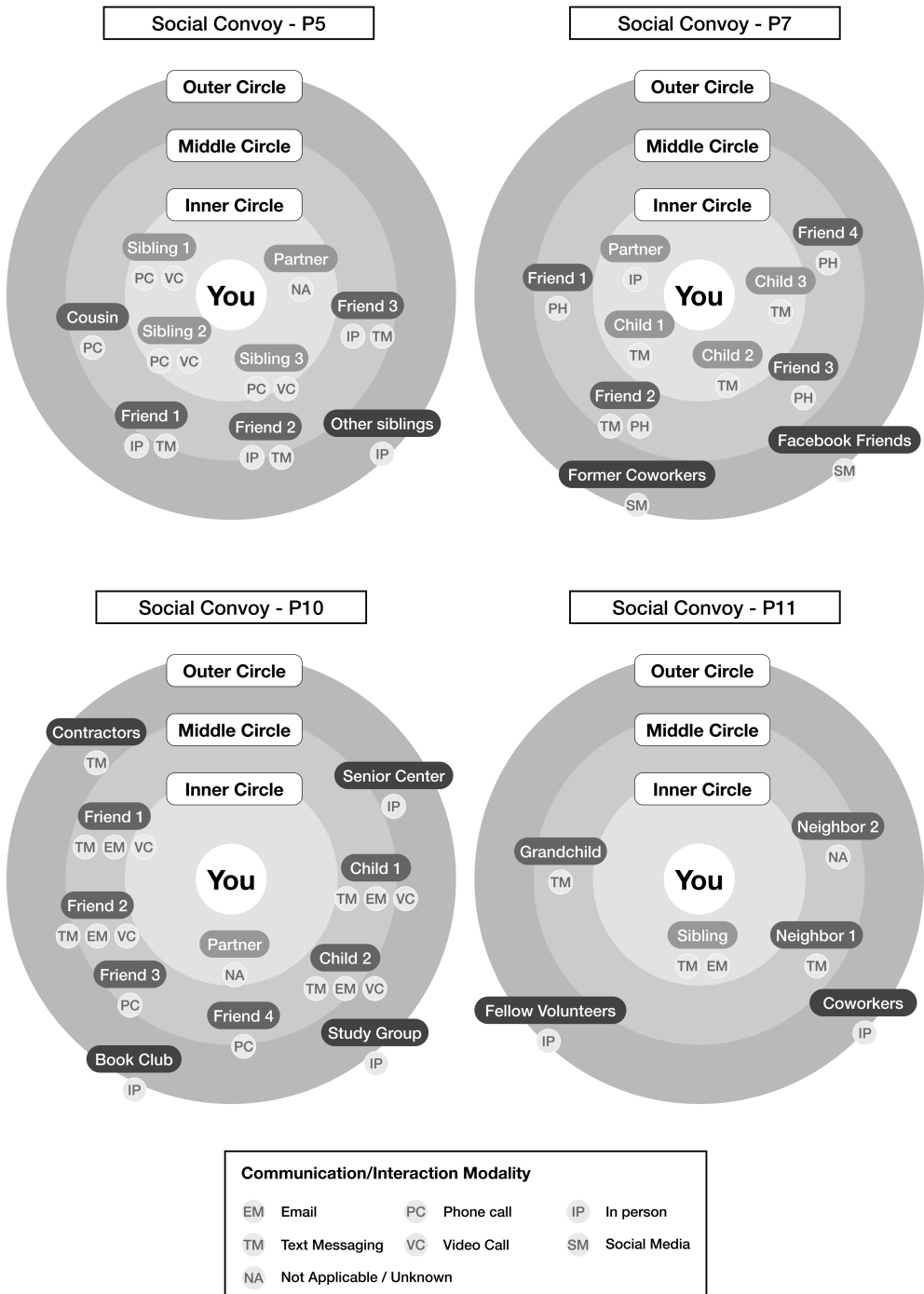
Figure 2. Examples of the social convoys of participants with associated interaction modalities

4.2.1 Technology became a way to provide and receive support among older adults and their support networks. Respondents acknowledged that keeping up with relationships and frequently interacting with others was an important way to feel connected and be an active member of their social circle. Participants reported both receiving and providing support to different people in their convoy. Prior to the pandemic, some participants were already regularly interacting with their support networks through both in-person meetings and online interactions. Digital tools were useful for facilitating asynchronous but frequent check-ins with friends and neighbors, while in-person interactions were a key element in strengthening their strong ties. Participants often provided regular and frequent emotional support to others through asynchronous digital communication. Many participants' routines included reciprocal check-ins with friends over asynchronous communication methods such as text messaging or email. This type of support provided a way for older adults to be a part of each other's lives, helping to alleviate emotional burdens or issues with little obligation attached to each interaction. Asynchronous communication methods were favored by most participants as ways to access and provide more frequent and casual emotional support, while synchronous methods were used for more in-depth conversations or those needing more immediate responses. One participant reported playing online word games with text chatting features to frequently maintain contact with friends who lived some distance away. The back-and-forth nature of the gameplay coupled with the integrated texting served as a casual but persistent motivating factor in sparking continuous conversation about their daily lives.

> [My friend and I have] sort of adopted this routine whereby we chat with each other [once] per day while we're playing Words with Friends. So she'll send me a chat, let me know what's going on in her life, and then I'll respond. And so it's a way of keeping up with each other and also checking in with each other. (P11)

Many sought to replicate their support networks entirely through online means during the pandemic to varying degrees of success. Regular digital interactions with family members and friends were frequently mentioned as an important way to stay connected. Technology provided a quick and easy way to hear from each other in the safety of their own homes.

While past research has shown that social media can play a role in connecting older adults to their social circle [8], participants reported little or no time spent on social media. Social media was seen by many to have the potential to help them communicate with others and acquire information on topics of interest. However, despite acknowledging the potential benefits, most expressed little interest in investing much time to keep up with everything through social media. Most social media use was limited to private online groups where family and/or friends congregated to share about their lives. Some also used social media to consume content created by friends and family who post to the platform. In other words, they do not interact heavily when they log on.

4.2.2 Older adults' support convoy encouraged technology uses in ways that cast older adults as support recipients. Most participants who adopted technology of their own volition had positive attitudes about how technology helped them stay connected with their support network. However, participants also recounted instances where they or a peer had family members who attempted to influence their choice to adopt certain technologies, sometimes even after participants had evaluated the pros and cons and made a choice about what to adopt or not. Their choice to refrain from using certain technologies was perceived by some of their support network as them missing out on opportunities to receive support from others. Members of the social convoy who pushed for adoption of specific technologies wanted the older adults to have access

to what they perceived to be important avenues of connection and social support; participants experienced this as putting them, primarily, in the role of support receivers who are incapable of making choices about what technologies work best for them.

When asked about their limited social media use, P11 says that they "made a conscious decision that I just didn't want to use Facebook, because it's such a time sink … I just feel it's too much information. I don't have to know every little detail, I guess I like to choose." They made this choice with awareness of the informational and emotional support they could potentially receive from social media. "I'm sure that if I would engage in social media, I would have more interactions with people." However, some of P11's family members insisted that social media would be beneficial and continued to urge P11 to use it: "I know that some family members get upset with me because I'm not on Facebook and they'd say, 'well, if you were on Facebook, you would know this.'" In another example, P3 mentioned that one of their friends had to start using technology during the pandemic after being persuaded by their family member who wished to better connect with them during the pandemic: "one of my friends … was at zero technology wise, but during the pandemic, she had to pull out her laptop and learn how to use it. Her daughter forced her to." In this scenario, the older adult's increased technology use primarily fulfilled their family member's desire to provide support – while at the same time potentially disregarding their own wishes.

P15 had an aversion to constant digital connection and decided not to get a mobile phone. They instead preferred that their digital connections with their social support network occur intermittently through a computer. Although they acknowledged that this had drawbacks in the pandemic when in-person interactions were constrained, P15 still preferred this intermittent online interaction. Despite this clear preference, P15's social convoy continued to question the decision: *"Almost everybody has a cell phone. I'm one of the few [who don't], and I get lectured all the time by family and friends."*

Participants also described resisting technology when others pitched it as a tool for receiving support, as adopting it would threaten their sense of independence. P14 noted that their desire for independence can lead to less connection overall, describing "*a tendency, like a lot of men of my age, to be reluctant to accept a lot of* support, *which tends to increase isolation of course."* P14 described experiencing significant grief early in the pandemic, but not being willing to give up independence to access support. In this same way, motivating the introduction of technologies to older adults by describing them as a way for them to access and receive support will likely face opposition: to adopt the technology would mean acknowledging reduced autonomy or greater need.

4.3 In-person interactions remain indispensable for older adults

Most participants preferred in-person interactions over most other forms of connectedness with their convoy. Multiple participants mentioned that physical interaction with others, regardless of whether they are the provider or receiver of support, alleviated feelings of loneliness. In-person support can materialize in the form of interactions with the strong ties in their social network, such as meeting with family or having food with friends. It can also come from weak ties, such as interacting with casual acquaintances in their social network such as grocery store staff or fellow volunteers at community events.

4.3.1 The pause on in-person meeting during the pandemic highlighted its importance. Prior to the pandemic, in-person social interactions with others in participants' convoys played a significant part in providing emotional and tangible support. While technology was widely used

to plan and coordinate with each other for social events, the actual interactions themselves were devoid of much technology use. In addition to planned activities, most participants recounted positive experiences from impromptu meetings that created openings for further opportunities to interact with others. Many used routines such as daily walks or meetups as a means to actively reach out to others and maintain their existing relationships.

> *I can walk out on my road and visit good friends. I'll just go over there, and if they are home I will visit. If they are home and free I will visit and otherwise it's just my daily walk.* (P15)

Participants also noted that an important reason for creating opportunities to meet in-person was the need to hear about what is going on in each other's lives, a form of emotional support. While many participants were also communicating with their support network using technology for the same purpose, the strong desire to meet and talk in person remained. For example, P10 notes that she has three close confidants with whom she meets regularly just so they could talk with each other: *"we kind of call ourselves a squad … we like to talk a lot about political stuff and everything."* Notably, participants also reflected on the kinds of interactions where they were provisioning tangible, informational, or emotional support for others. In-person interactions often involved situations where they stepped into the role of support provider. This kind of interaction was particularly helpful when other older adults counted on the participants as the primary source of social support.

> *I've discovered that for [a friend who was disabled and battling cancer], and I laugh when I say this, I'm her party friend. I've never been a party person, but she and I will go out for a martini at three in the afternoon because that makes her feel good, not the alcohol, but [that] we're out, we're in a bar … [usually] she can hardly leave her house at all.* (P8)

Older adults also value the connections they have with people outside the circles in their social convoys, such as staff at establishments they frequent. While this could be little more than casual conversations, some participants also mentioned that these meetings provided an avenue to alleviating loneliness at home.

> *I know all the checkers [at the nearby grocery store] pretty well … We talk about stuff. We talk about Trump and, you know, we talk about the climate crisis and stuff like that. I mean, especially the ones who are, you know, quite a bit younger. They're my favorite people to talk with.* (P14)

Through a diverse range of interaction with family and community, in-person interactions played an important role in building and maintaining relationships and improving mental wellbeing. However, the pandemic brought a significant decrease in the frequency of physical interactions that were available to participants, and while many still tried to carry out similar activities or continue past routines, many opportunities for social interactions were lost. This included both intentionally planned gatherings and occasional interactions that would have otherwise been possible before the pandemic.

> *I don't feel as comfortable interacting directly with somebody, you know, I'll leave something somewhere, I'll send a text message and say, uh, come pick this up or I'm gonna drop this off, or, you know, that sort of thing.* (P12)

Despite the health risks presented by the pandemic, study participants still sought to maintain some physical interactions with others in their social network. These findings emphasize the importance of in-person support to older adults. Most participants were well aware of the

disproportionate impact COVID-19 had on older adults, but they still insisted on creating opportunities to meet with others in person. P14 says, "*Even during the height of the pandemic, I did spend time with each of my sisters and I spent time with my friend <name> downstairs.*" Despite the possibility of communicating via technology, maintaining in-person social support was perceived to be an essential need.

4.3.2 *Technology-mediated experiences often provided unsatisfying replacements for in-person interactions.* During the transition to mostly online events and later in the gradual re-starting of in-person events, respondents often continued to approach social interactions with the same levels of expectations and needs regardless of whether they were through technology mediation or in-person contact. However, while technology was able to provide tools that could facilitate different forms of communication, it was often inadequate for creating experiences that approximated what older adults expected for social connectivity. Participants reported using technology to cultivate existing relationships, although participants generally did not show interest in meeting new people online or cultivating deeper connections with more casual acquaintances through technology.

Video conferencing exemplified this dynamic. Some participants were first introduced to video conferencing as a way to interact with other people due to the onset of the pandemic's stay-at-home orders. Participants replaced many in-person social meetings or events with online video conferencing solutions like Zoom or FaceTime as the pandemic started. Some already had devices capable of video calling and became familiar with the apps and software needed. However, for many, video calling did not live up to its promises of creating a more socially connected atmosphere compared to other technologies. Most felt it was a sub-par experience when it came to attending social events, especially with people who were not part of their social circle, even after they were able to overcome the initial technical difficulties. For some, it was even less pleasant compared to texting, emailing, and audio-only phone calls, with respondents explaining that it felt like a detached and non-corporeal version of in-person meetings, especially for larger gatherings.

> It's the video. It's distracting to me. I can't really concentrate and focus when there's the TV going on, right? [Video conferencing] feels like TV to me. (P16)

Technology-based communication also largely removed opportunities to expand older adults' social circles and support networks. Participants reported several instances where casual in-person interactions developed into stronger relationships. P8 recounted that a delivery driver who frequents their house became a friend after getting to know them more: "*Because I'm home, we started chatting. He met my granddaughter one day. He brought her a toy. So it's a funny way to make friends.*" There were many fewer examples of these lightweight social connections being cultivated through online interaction. P14 reported connecting with and getting to know someone by meeting through an external program designed to pair up older adults with youths. They explain, "*The most fulfilling thing I've been doing through the pandemic has been once a week. I have a zoom meeting with a young woman who is in the process of applying to college. She's brilliant. She's going to be an engineer.*" This suggests that more structured formats may be more useful for developing social connectedness through technology.

Services participants relied on had also become increasingly integrated into digital platforms. At times, this streamlined interactions or offered more choices in how to access services. However, in other instances, the shift to digital replaced other ways of accessing services or reduced access to in-person support. Some participants described frustrations with keeping up with these changes and feeling like they had to regularly make sure they could still access them.

They felt these changes in modalities for accessing services to be disempowering, at least in the short term as they sought to adapt and learn any new technologies. Additionally, some participants who valued in-person interactions, including opportunities for connection and conversation, continued to put in extra time and effort to facilitate these interactions when possible.

> *They always want me to do online banking, but I just don't wanna do it. I mean, my partner does it, but I really like going in and just seeing the tellers, 'cause there is this really cool [person] whom I love and it's really fun to see her and we always ask how each other's doing and I just like the human interaction.* (P10)

Across all types of communications technology use, participants used them as an extension of their existing relationships and social circles. Technology remained most useful for maintaining established relationships. While past work suggests that older adults' main barriers to adoption were a lack of technology literacy and usability concerns [24,87], these results provide an additional perspective. When technology was used out of necessity to replace an in-person experience, as during the pandemic, it did not facilitate more than a surface level connection even after most usability issues were overcome.

5   DISCUSSION

Our goal in this paper is to present an analysis of older adults' social networks and associated technology use during a significant life event using the convoy model. Older adults can be resilient and adapt to challenging life circumstances, and this was the case with new technologies during the pandemic [21,79]. Our participants adapted their support network during the pandemic by increasing both the types of technology they used and the frequency with which they used these technologies to communicate with others. While the pandemic drove the adoption of some technologies, such as video chatting, many participants in our study were using services like texting and email before the pandemic. Despite some initial onboarding difficulties, most learned and adapted to additional channels for virtual communication. While participants experienced technology adoption barriers such as technology literacy or accessibility issues similar to those described in previous work [44,45,52], they were not a significant factor in how communication technology was adopted among our participants.

Instead, perceived value and improvement in quality of life, factors previously identified as also significant in older adults' willingness to adopt technologies [9], featured prominently in participant narratives of why they started to use certain technologies. Our findings show that digital literacy and accessibility issues were not always the primary barriers to older adults' adoption of a technology. While these issues were experienced by some participants in our study, they did not become the primary reason certain technology was selected over others.

That said, we note selection effects in our recruitment and limitations that may have for our findings. While potential participants could participate either by Zoom or phone call, much of our recruitment occurred on digital platforms. Consequently, our recruitment likely favored older adults who had at least some comfort with technology mediated interactions while deterring potential participants who experienced barriers to video conferencing or who preferred not to use the phone. Future research should seek out and continue to learn from older adults who continue to experience barriers with technology use or who more strongly prefer not to engage in technology-mediated interactions.

In our discussion, we highlight the importance for designers to move away from framing older adults as primarily recipients of support and toward better understanding their role as both provider and receivers of reciprocal support in their social network. Using the convoy model, we can better evaluate technology's role in facilitating older adults' social connections, while the model can also help us understand their social support convoys as they evolve.

5.1 Designing technology to encourage social convoys to see older adults as support providers in addition to support recipients

In addition to being recipients of support from their social network, participants in our study were highly motivated to provide support to others in their social network despite the limitations imposed by the pandemic. Participants such as P8 (Section 4.3.1) provided emotional support through asynchronous digital communication methods like texting and email, allowing them to be part of others' lives and alleviate emotional burdens. Informational support was provided to friends and family through sharing advice, information, and knowledge. Older adults were also providing tangible support contactlessly. Participants such as P5 and P7 (Section 4.2) sent financial support to struggling family members, while P12 (Section 4.3.1) left groceries and other items for neighbors. Later, when restrictions were lifted, they went back to volunteering or helping organize events in their local communities. Participants were eager to provide support to their social convoys, even adopting new modalities to deliver support to others. Many also played a vital part in maintaining the wellbeing and connectedness of members in their social networks, showcasing the reciprocal nature of support within older adults' social relationships.

This can contrast with how others in older adults' social convoys see the role of technology, and even older adults themselves. Participants such as P15 (Section 4.2.2) recounted incidents wherein their personal technology preferences or choices were overlooked by members of their support network, who held the belief that adopting those preferences might hinder the receipt of beneficial support. This approach by family members or others in their support network seemed to emphasize the notion of older adults as solely being recipients of support. One possible explanation for this perspective can be attributed to a deficit-based view of successful aging that has been documented in research. Such a portrayal of aging can contribute to a negative perception of receiving support and the aging process [61,88], ultimately influencing the way technology choices are made by older individuals. When technologies are perceived mainly as tools for providing support, this perspective can deter older adults from embracing them because of the belief that using such technologies implies a loss of autonomy. This reluctance can in turn contribute to heightened social and digital isolation, especially during challenging periods like the pandemic [74]. When an older adult's support network views them as primarily support recipients, this can also further reinforce the extent to which they and others see them as having (only) needs, limit the extent to which they perceive their strengths, and, ultimately, disempower older adults [71].

As other resources have argued, an asset-based view of aging can enhance the experiences of older adults, their support networks, and their communities [38,90]. When older adults' support networks take a limited view of them as people in need of support, it misses what older adults can and do contribute to their social networks and communities. HCI has, broadly, noted the need for asset-based approaches to design [90]. Many of the social support systems we highlighted in the related work apply this approach, such as by seeing older adults as remote caregivers and important relationships for children [85] or as potential tutors [94]. However, the experiences of participants in our study suggest that in many cases this view is not shared by their social convoy.

A key issue, then, for designers and researchers is: how can design encourage the social convoys of older adults to also see and engage with older adults as providers of support, not just recipients? Designers may find inspiration in the past work that has developed systems to connect older adults with others as support providers, such as by suggesting potential roles or activities that draw on the information, emotional, and tangible support older adults might offer, thus potentially disrupting disempowering relationship dynamics. Additionally, technology designs, like the virtual gym classes developed by Baez et al. that support people with different abilities in engaging equally in shared activities [6], may set the stage for further, reciprocally supportive interactions.

5.2 Using the convoy model to evaluate technology use among older adults

Through the lens of the convoy model, and annotating interactions by modality, we can see that participants in our study relied on technology for a significant portion of their communications with their social support convoy during the pandemic. In some cases, technology became, at least temporarily, the sole way of connecting older adults with members of their support network. For many participants in our study, technology created new opportunities to give and receive support from afar, creating new possibilities for forging or rekindling relationships that, prior to the pandemic, had diminished in favor of more proximate relationships. In line with previous work on the effect of technology on social relationships, participants were able to use technology to maintain closer connections with their social convoys, which previous work notes should increase the positive effect the convoy has on older adults' subjective wellbeing [51].

In mapping communication modalities to the convoy model, we were able to see how the social context of technology use affected both older adults' adoption and use of technologies, as well as how these technologies shaped social convoys in return. By overlaying technology use patterns on the convoy model, we were able to see individualized technology usage preferences for each participant in addition to patterns that appeared for the participants as a group. This supported not only understanding how support networks can be affected by technology as a whole as previously suggested by Fuller et al. [20], but also how varying types of technology interactions could have different effects on the social connections and support networks of older adults. Through our analysis using the convoy model, we found that perceived value and quality of life improvement were often deeply rooted in a social context and dependent on with whom they were communicating. Participants often chose communication modalities based on who they were contacting and in what context. For example, someone might prefer a video chat for an hour-long family gathering but prefer text messaging for a quick daily check in with a friend, while preferring the ability to compose and revise offered by email for thoughtful or high-stakes communication.

In contrast to their adoption of technologies for communication with existing relationships, the older adults in our study rarely used platforms built for public conversations and meeting other people, such as online forums and social media services, or they only used them in a more private scope (e.g., within private groups of friends or family). The convoy model could be useful in evaluating what kinds of new connections different technologies and services can facilitate and how communication patterns evolve with different technology use. Additionally, it has been previously pointed out that the convoy model could be useful in examining social ties that are enabled by technology for those who are separated by remote geographical distance [20]; our findings indicate that the model also can provide insight into relationships that are maintained by a hybrid of in-person and technology-facilitated social support.

Finally, though our study focused on social support, participants also talked about how services such as banking, medical care, and retail shifting to technology mediated forms could create temporary disempowerment, also consistent with previous research [27]. While some participants put in additional effort to continue accessing these services in-person–in part because of the incidental social interactions that resulted–those who wanted to access them through technology mediated platforms could do so, after a period of adjustment. Depending on their previous experiences with technology, this can involve accessing support from others within their convoy, and, once they learned the service, also providing support. In this way, organizations planning to transition to or augment services with technology mediated systems may benefit from using the convoy model as they develop, rollout, and support programs.

Our study only evaluated the social convoys of participants by interviewing older adults about their technology use and social networks at a single point in time. However, with the convoy model's ability to represent how a person's social support convoy might transition over time, further research might include more longitudinal work that evaluates how introducing different social communication technologies into older adults' lives might affect their underlying social support network over time. Future work creating and designing social communication or social support technologies for older adults could also benefit from evaluating these technologies using the convoy model. Researchers and designers could compare users' social convoys before and after introducing a service or a piece of technology into their lives. This can potentially give researchers insight beyond how technology affects a single user, putting the emphasis instead on changes to the social convoy as a whole.

5.3 Designing technology for effective reciprocal support in evolving social convoys

Despite transitioning to digital platforms during the pandemic for many formerly in-person meetings and events, participants in our study overwhelmingly preferred in-person interactions over the digital solutions they used to attempt to replace them. Based on the level of participants' technology use, it seems older adults found digital technologies did not facilitate the kinds of communication and connection they most needed to restore their sense of social connectedness. Most wished to maintain some level of support reciprocity that came from face-to-face interactions, and most participants tried to maintain some level of in-person interactions throughout the pandemic. Part of the reason in-person meetings remained indispensable for many participants was because they often led to other spontaneous social interactions that increased and deepened social ties.

While digital communications can have positive effects on older adults' mental health, participants in our study also reported negative experiences after using technology to connect with others. For example, when participants used video calls to replace previously in-person encounters, many felt that the digital attempts to replicate real-life experiences on-screen created a sense of being always connected yet unable to truly have the experience of interacting with another person face-to-face. Some described feeling even more isolated after a video call with their friends or acquaintances, especially a call with multiple people. In other words, the virtual connection sometimes made what was missing more salient, and participants experienced a sense of loss. Such experiences align with previous work that has shown that increased use of digital communication during the pandemic was associated with an increase in depressive symptoms despite a decrease in loneliness [11]. CSCW has long argued for imagining technology mediated interactions that differ from in-person encounters and that are uniquely suited for the medium [29], and our study results continue to support this. In contrast to using video calls to replace a

family gathering, participants did not describe feeling the same sense of loss when they engaged in virtual experiences that were not trying to replace in-person interactions with virtual facsimiles. For example, a well-structured online course that delivered unique virtual experiences could be satisfying for older adults, but gathering on zoom for coffee with friends one would have otherwise met at a local café was not as satisfying. Asynchronous communication that augmented and enhanced previously established social connections excelled in helping create opportunities to interact with each other that did not exist previously.

When designing technology-based interventions to connect older adults with their support networks in meaningful ways, researchers should consider older adults' evolving social networks and the social contexts in which these networks exist. Prior work argue that technology design aimed at older adults can also often embody ageist stereotypes of what technology should look like when designed for older adults, which can in turn lead to user aversion (because of not wanting to be associated with aging); this work suggests that co-designing technology with older adults could help avoid ageist stereotyping in the design process [50,87]. However, even in co-design workshops, older adults can at times stereotype themselves and others in their age groups, which can lead to technologies that are less likely to target real needs of older adults [56]. The sharing of life experiences in co-design sessions in prior work showed that including individual perspectives could challenge homogenization in how older adults are viewed in the design process [72]. Researchers in CSCW and HCI have also argued for the necessity of designing with older adults' life stage transition in mind [19,47]. Considering the much higher heterogeneity of older adults compared to other age demographics, Vines et al. argues that researchers must take into account the "diverse and dynamic qualities of ageing" [84]. The life course perspective argues that a person's own social and historical context should be emphasized over a more chronological view to life stages that is associated with age [18]. The convoy perspective could provide creators of social support technologies for older users with an additional perspective by helping designers and co-designers understand the evolving personal and situational context as older adults experience changes in their social convoy composition.

For the most part, participants who cut back on face-to-face interactions during the pandemic also did their best to return to in-person interactions as soon as regulations or their own personal risk tolerance allowed them to do so. Many of these participants adopted technologies that did not provide more than what was needed at the moment to create an emulation of real-life experiences online; these changes to participants' social convoys were likely short term. However, we also saw many cases where, either due to the use of new technologies or new services that extended social connectedness, technology filled a gap in older adults' communication needs effectively. Most participants indicated that they would continue to use these types of technology even after the pandemic. This was especially true for technologies that enabled different ways to connect that took full advantage of their digital nature, such as messaging, accessing online classes, and telehealth for mental health services. Our findings indicate that when a new use of a technology creates a way to connect with or expand older adults' social convoy in a way they perceive to be useful or meaningful, these changes in older adults' social support networks can become long-term.

For older adults' social convoys, the pandemic was an event that served as a catalyst for new technology uses and new digital connections. In this study we were able to see the effects on older adults' social support networks and accompanying technology use due to forced remoteness and its effects. Our findings could help designers imagine technologies built for other situations where older adults are introduced to environments that require building and maintaining different social ties, such as moving to a different city or transitioning to assisted living.

6 CONCLUSION

Technology can play a crucial role in connecting older adults with their social networks. Through interviews conducted with older adults about their experiences using technology during the COVID-19 pandemic, we explore how older adults experienced technology use with those around them. We discuss barriers, changes in social support networks, and the evolving dynamics of providing and accessing support both online and offline. In this study, we use the convoy model of social relations to contextualize social connections and technology use. Furthermore, we present design implications and argue that designers and researchers should 1) create technology for older adults that, in addition to addressing accessibility needs, help emphasize to their social networks these adults' roles as both providers and receivers of support; 2) create social technologies that are meant to provide meaningful digital experiences rather than attempting merely to replicate in-person experiences; and, 3) utilize the convoy model of thinking to evaluate new social technologies so they are better situated in the social context in which they are meant to be used. We urge CSCW and HCI researchers and designers to explore a broader design space that more closely examines the role technology plays as a tool for providing and receiving support in a social context.

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