Understanding the needs of older adults learning to use digital home assistants: A demonstration study

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Abstract

Background: Voice-activated digital home assistants (e.g., Amazon Echo) have potential to support older adults, especially those aging with disabilities who may require unique in-home assistance. However, our understanding of the learning and continued use needs for this population, as well as the impact of these devices on feelings of companionship, is still developing with more research needed to inform this space.

Objective: The objective was to improve our understanding of the training needs for older adults with limited or no experience using voice-activated digital home assistants. Moreover, we sought to learn how digital home assistants could support older adults with disabilities in their home environment by exploring facilitators and barriers to their adoption.

Methodology: We performed remote, longitudinal interviews with seven older adults with and without disabilities who had little to no experience using digital home assistants and were provided devices from a local community organization. In addition, we focused on three individual case studies to provide additional context for their specific uses and needs.

Results: Participants expressed mostly positive opinions toward the devices with nearly all participants finding the device useful and easy to use. Many viewed the device as a companion, highlighting the potential for reducing loneliness. Entertainment and time management features were most utilized. Although participants faced challenges in using the device (e.g., phrasing commands), they still expressed interest in future uses and features. Participants generally found the instructional materials (i.e., printed instructional manual and analogous support videos) both useful and easy to use.

Conclusions: These findings not only demonstrated the utility, instructional needs, facilitators and barriers, and the potential for social companionship of these devices among older adults, but also informed recommendations on how to better design these devices to support the diverse older adult population in accepting and integrating them into their lives.

Keywords: aging, technology learning, technology acceptance, instructional support

INTRODUCTION

Digital home assistant technologies & older adults

As the population in the United States and other developed countries continues to shift to a larger proportion consisting of older adults (Colby & Ortman, 2015), there is a complementary need to ensure that an adequate supportive infrastructure exists to help them maintain their personal independence as well as to reduce the societal burden imposed by this transition. As such, guaranteeing that this population can perform the daily activities important to their quality of life is imperative for not only maintaining their abilities with increased age, but also to reduce their needs for, and reliance on, external assistance that may not be sufficiently prepared to handle such a rapid increase in demand. Current and emerging in-home smart technologies offer capabilities that may bridge this support gap and provide assistance in helping older adults maintain their autonomy as they age (Binette, 2021; Rogers et al., 2020).

Voice-activated digital home assistants (DHAs) allow users to interact with a virtual assistant through a speaker, with some models including visual displays. These devices, such as the Amazon Echo, have the potential to assist older adults in a variety of ways (Blocker et al., 2020; Bonilla et al., 2020; Choi et al., 2020; Corbett et al., 2021; Garland, 2021; Jakob, 2022; Kim & Choudhury, 2021; Marston & Samuels, 2019). Users can perform voice commands to engage the device in both leisure and daily task activities, reducing the need to physically interact with the technology. Thus, the capabilities of these devices hold the potential to support individuals facing unique challenges with daily tasks such as those with ag-

Table 1. Participant demographics

	Factor	Baseline (n=7)	Case studies (n=3)
Gender	Female	4	2
	Male	3	1
Mobility Disability	Yes	3	0
	No	4	3
Hearing Disability	Yes	2	1
	No	5	2
Vision Disability	Yes	0	0
	No	7	3
Race	Black/African American	2	1
	White	5	2
Education	High school graduate/GED	3	2
	Some or in-progress college/Associate's degree	2	1
	Bachelor's Degree (BA, BS)	1	0
	Master's degree (or other post-graduate training)	1	0
Age (Years)	Mean, *SD*	70 (*6.0*)	71 (*4.9*)
	Range	61-79	65-77

ing with disabilities (e.g., mobility, the most common disability among older adults; Kadylak et al., 2020a,b; Koon et al., 2020; Okoro et al., 2018).

Although there is a clear opportunity for digital home assistants to improve quality of life for older adults in a variety of ways, this population may face obstacles when implementing digital home assistants into their everyday lives (Blocker et al., 2020). This is especially true for older adults aging with a chronic illness or physical disability who may require extra accommodation or instructional support to fully benefit from this technology. Although studies have identified a number of these specific barriers and facilitators to DHA use for older adults (Blocker et al., 2020; Koon et al., 2020), our understanding is still relatively limited. In addition, previous research has investigated the notion of Alexa for social companionship (Pradhan et al., 2019), but this idea had yet to be explored during the COVID-19 pandemic when this study was initiated.

Purpose of study
The purpose of this demonstration study was to improve understanding of the utility and support needs for older adults with limited or no experience using voice activated DHAs. We sought to demonstrate the potential of how DHAs could support older adults in their home environment by exploring how this population utilized the devices, investigating potential barriers to adoption, and addressing the following research questions:
1. How do older adults use their DHA device in the home over time?
2. What challenges do older adults face throughout the process of first-time DHA adoption and use?
3. What instructional materials do older adults perceive as useful for remotely supporting DHA device adoption and use?

METHOD
The study took place during the global COVID-19 pandemic in 2020 (i.e., July to December 2020); as such, our project had an increased focus on the potential social benefits of digital home assistant use by older adult residents who may have been isolated during COVID-19 lockdowns. This effort was a collaboration with CRIS Healthy Aging Center and sponsored in part by the Illinois Department on Aging and was approved by the University of Illinois Urbana-Champaign Institutional Review Board (IRB# 20642). Partnering with CRIS facilitated participant recruitment as well as increased our ability to provide effective assistance with the Echo Show device set up in the homes of the older adults. The participants received a free Amazon Echo Show 5 device, a digital home assistant with a 5″ display. This device was chosen because it provided complementary audio and visual interfaces that could facilitate older adults' use of the technology (i.e., reduce the impact of sensory-perceptual challenges many older adults experience with age; Correia et al., 2016), as well as because it was a relatively lightweight device that would be easier for older adults to manipulate themselves in comparison to older models. Moreover, this characteristic also facilitated shipping to participants due to the remote nature of the story. All participants received the same devices to ensure similar interaction experiences, and they were able to personally ask questions to research team personnel throughout the four-month period. Study personnel engaged with participants once per month.

We conducted individual phone-based interviews so we could successfully extract high-quality study data and so participants could effectively share their experiences with us. The circumstances allowed us to investigate different ways that DHAs could be used to enhance daily

living and social engagement during the pandemic lockdowns. As everyday activities move more towards the digital and virtual domains, DHAs such as the Echo Show, may offer older adults a chance to engage with their community and maintain independence. This demonstration project was a first step in exploring these possibilities during the COVID-19 pandemic. By taking a longitudinal case-study approach, we gathered rich data that could help tailor training and support to older adults' evolving needs and capabilities.

Participants

Participants were older adults (aged 60+) with limited to no experience using the Amazon Echo Show prior to the study. The baseline column in *Table 1* shows the demographics for the full sample at the beginning of the project. The case study column shows the demographic characteristics for the sample of participants who stayed in the study through its completion.

Our partnership with the CRIS Healthy Aging Center allowed us access to a list of 24 potential participants who had received an Amazon Echo Show 5. All 24 individuals were contacted via phone and at the very least left a voicemail message outlining the purpose of the study and offering enrollment. Following expressed interest by potential participants, we assessed cognitive status to ensure that participants would be fully able to learn the device and participate in the interviews. We used the Telephone Interview for Cognitive Status (TICS; Brandt et al, 1988) and required a minimum score of 24. We also assessed whether participants experienced any mobility challengers in their daily lives through self-report of difficulties walking or climbing stairs. This specific characteristic was not exclusionary, the purpose was to understand whether any participants were living with mobility disability so additional follow-up on the impact of digital home assistants on this population could be performed. All 10 of the potential participants screened were deemed eligible during recruitment. Participants were compensated with $70 in Amazon E-Codes.

Materials

The TechSAge Background Questionnaire was included in the baseline script to gather health and demographic data on each individual (Remillard et al., 2020). The UCLA Loneliness short-form measure assessed perceived loneliness and included eight items (Hays & DiMatteo, 1987). The Alexa Companionship measure (adapted from Cotten et al., 2013) was used to assess the perceived social role of Alexa in participants' lives. The Confirmed Social Benefits scale measured the perceived potential benefits from developing said social relationship with Alexa (Cotten et al., 2013). The System Usability Scale measured the practical design functions of the device for older adults (Brooke, 1996), and the Technology Acceptance measure assessed perceived usefulness, perceived, ease of use, and perceived enjoyment (Venkatesh et al., 2012). Due to space constraints, we provide a subset of the results from these assessments, specifically focused on the technology acceptance measures, which are most related to our research goals.

A semi-structured interview script was developed for four time points (i.e., once per month) and contained questions pertaining to participants' overall perceptions of Amazon Alexa and the Echo Show device, as well as how they had used the device and which features, they had engaged with since receiving it. Moreover, they were also asked to discuss any challenges and desired uses for the future. If the participant reported using additional instructional support, they were asked to evaluate their perceived ease of use and usefulness of these materials. Interviewers asked follow-up questions to elicit more information about device usage and user preferences.

We provided instructional support materials to assist participants with their initial learning and continued use. The instructional support user guides outlining device setup and basic device uses were mailed to participants' homes after their baseline interview. These user guides included detailed instructions for connecting a new Echo Show device to the internet and downloading new Alexa skills (which are analogous to smartphone applications), and were developed using a user-centered iterative process that included the use of task analysis, cognitive walkthrough, and participant testing to inform their content and older adults' needs (Ramadhani et al., 2019). The guides also provided introductions for new Alexa skills and contexts in which a participant may find useful in their daily life (guides at available on the TechSAge website: https://techsage.gatech.edu/resources/tools). Instructional videos were uploaded to the Collaborations in Health, Aging, Research, & Technology (CHART) YouTube Channel and shared with participants for their use and evaluation.

Data collection

Before data collection, participant consent was obtained via an informed consent form, which was mailed to them along with a response booklet to facilitate remote data collection. This response booklet contained possible answer choices corresponding to the multiple-choice questions asked in the baseline interview script. The interviewer then followed the script and asked the questions while inputting participant responses on their behalf into REDCap (https://www.project-redcap.org/), an online application
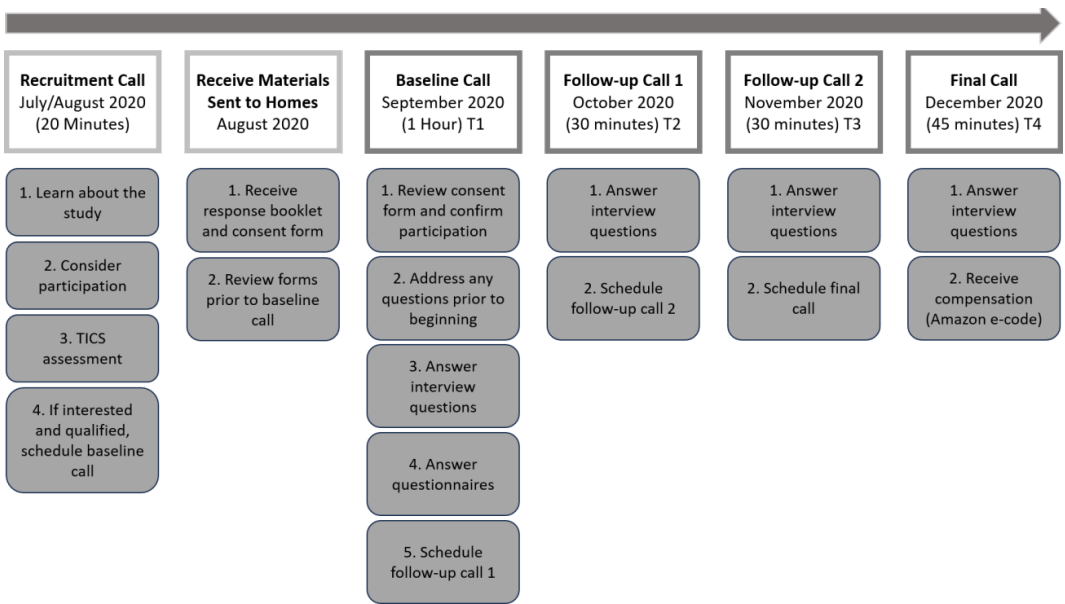
Figure 1. Overview of the procedural flow of data collection for the study

designed for secure data collection. During the semi-structured interview portion where the participants were asked more open-ended questions, the conversations were audio recorded and the interviewer took informal notes about high-level themes discussed during the conversation to aid in data analysis. At the end of the interview call, the interviewer scheduled the next research encounter for the participant.

Follow-up interviews performed at the second and third month of use were shorter in length than the baseline, and only used the semi-structured interview questions to assess participants' experiences learning and using their device. The final interview phone call performed at fourth month of device use closely mirrored the protocol for the baseline interview which included both the quantitative and qualitative data collection measures. This allowed for assessing longitudinal change in participants' experiences and opinions. For an overview of the data collection procedure, see *Figure 1*.

Analysis
We conducted a thematic review of the qualitative data (Braun & Clarke, 2006). After concluding data collection for the study, the research team iteratively met and used open-coding procedures to identify emergent themes within the qualitative data. We used a series of descriptive statistical procedures and data visualizations to analyze the questionnaires used during the baseline and final interview sessions. We provide further demographic information for three participants in the case study analysis to explore their experiences in depth. When reporting re-

sults from the case studies, we used a mix of qualitative and quantitative analysis. These participants were the only ones to remain in the study throughout the four months of the project. These case studies provided a more detailed assessment of participants' device usage over time, potential barriers to use, and a fuller understanding of their individual circumstances.

RESULTS
To address the first research question (i.e., how older adults use their DHA device in the home over time), we summarize participants' experiences relevant to their attitudes, described device use, relevance to companionship and loneliness, and their desired future uses for the device. To address the second research question (i.e., what challenges older adults face during their participation), we summarize the difficulties our participants faced in learning and using the device in their daily lives over the four months. To address the third research question (i.e., what instructional materials older adults perceive as useful for remotely supporting DHA device adoption and use), we present participants' opinions regarding the utility of their tools they used to gain competency with the device. Finally, we present in-depth three older adults' experiences with, and perspectives of, the device to exemplify their actualized utility and relevance for DHA use.

Baseline attitudes
We used a series of descriptive analyses and figures to assess participants' baseline perceptions towards the device and psychosocial indicators (e.g., loneliness). Specifically, *Figure 2* shows baseline levels of loneliness, perceived need for technical
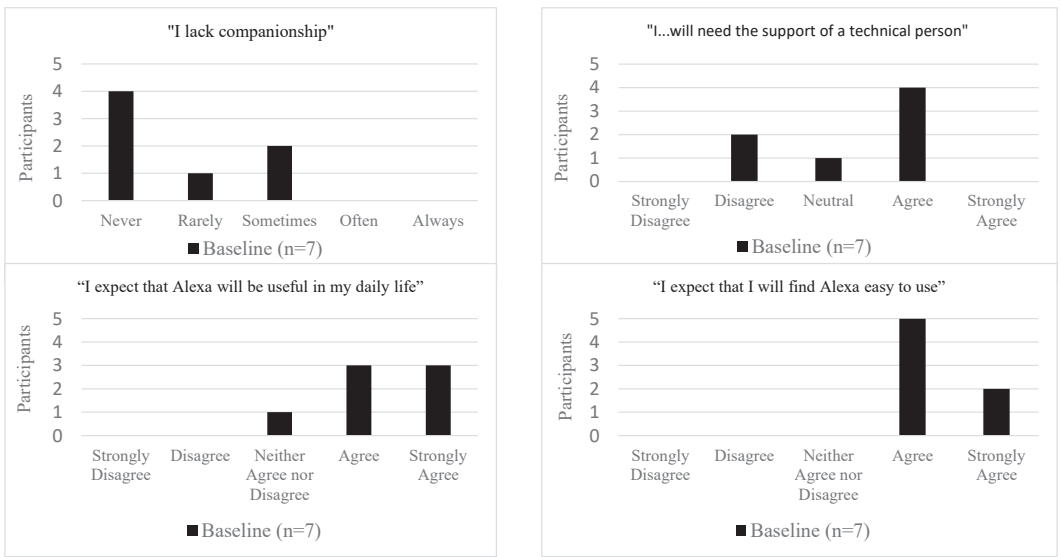
Figure 2. Baseline Initial Impressions: Perceived Loneliness (upper left); Perceived Need for Technical Support (upper right); Perceived Usefulness (lower left); Perceived Ease of Use (lower right)

support, perceptions of usefulness, and ease of use.

Although four participants did not perceive that they lacked companionship at the time of starting the study, the remaining three perceived feeling this way rarely or sometimes. When asked to rate whether they agreed that they would need the support of a technical person to learn and use the device, the majority did in fact feel this way. Nearly all participants perceived that the device would be useful for them in their daily lives, and agreed that they expected it to be easy to use prior to learning how to use it.

Device use
Participants reported integrating the DHA, the Amazon Echo Show 5 with Alexa, into their daily lives in a variety of ways. The most common use was listening to music. All participants mentioned this feature at least once. Checking the weather and news, using the device as an alarm clock, and playing games were also frequently reported. One participant shared the following: *"Every morning, Monday through Friday we're up at 5 o'clock, so Alexa gets us up. She answers questions. Obviously, she's great for telling jokes. She plays music. We do that quite frequently. We use her every day for the alarm and except of course, on the weekends. We play a lot of music, things like that, so we probably interact with her just get about every day."*

In addition, all the participants used their Echo Show device to seek general information and health information. For example, one participant used the device to manage her diabetes condition, whereas another used it to ask about health symptoms her relative was experiencing.

Alexa social companionship & loneliness
Throughout the interview process, participants anthropomorphized their Echo Show device when referring to Alexa. For instance, participants routinely referred to their device as "her" and "she." Similarly, participants often described interactions with their device as providing a sense of companionship. One participant who lived alone described how she felt with Alexa nearby: *"I'm rarely feeling alone, but if I got a little lonesome, I can ask her some stuff and she's here. It's as if she knows me."*

Two of the participants even developed a more personal relationship with their DHA and perceived Alexa as a friend. For example, another participant stated the following about interacting with Alexa for information searching: *"I don't want everybody to know that I don't know something, but I don't mind Alexa. She seems like my friend."*

Desired future uses
Participants expressed several desired uses for their Echo Show device that they could not perform at the time of interview. This included both existing features that the participant wanted to learn about, as well as features that did not yet exist but that the participant imagined would be useful in their daily life.

One commonly reported desired use of the device was to contact family with voice commands, especially relatives residing out-of-state and otherwise separated due to the COVID-19 pandemic. Participants desired to make phone

calls and video-conference calls with Alexa. This desired future use highlights the need for an Alexa phone call/video-conference call instructional guide for older adults to effectively onboard older adults to similar existing features currently capable with these devices.

In addition, participants expressed interest in using Alexa to access other types of knowledge and information. For example, at least two of the participants desired the ability to use Alexa to find physicians and other types of healthcare professionals in their local area. One participant reported wanting to utilize the Echo Show device for nutritional tracking related to her dietary restrictions: *"I was maintaining my diet with the salt, that's been a problem. Do you think Alexa could help with that?"*

When asked what type of personalized content or information participants wished Alexa could recommend them, the majority of participants reported wanting suggestions for usable Alexa skills related to their personal interests. Participants also desired personalized media recommendations such as for books, games, and movies to enjoy on the device.

Challenges
While attempting to navigate the Alexa interface as a novice older adult user, participants reported a number of challenges related to their use of the device. The most frequently reported challenge was Alexa command phrasing and knowing the correct keywords to use. When formulating a verbal command to use Alexa, it is important that users phrase the statement in a concise, clear manner. At least three participants expressed difficulty with phrasing commands and found themselves learning to reword their desired command. This was a challenge that continued to be reported through the final interview time point. One participant shared how she and her husband manage this challenge: *"We have to be careful of how we ask things or say things, we have to stop and think about it so that she receives it the right way."* Another participant shared the following response when asked about her greatest challenge using Alexa: *"Learning to ask the question appropriately…I have a real difficulty in using it."*

Initially, two of the participants reported fearing that they would somehow damage the technology if they phrased an Alexa command in an incomprehensible way. However, after being reassured by the interviewer that it would be difficult to damage the device by using incorrect phrasing, participants expressed feeling more open to experimenting with new commands.

Another issue that arose during the study was the appearance of restricted content or the need for a subscription service to access additional material. Amazon Alexa offers users the opportunity to connect several paid subscription services to their device so that they may access additional media such as music or movies. Unfortunately, this also interfered with the ability for some participants to enjoy their desired media content, as they were unsure of what features would require additional setup or fees. For example, one participant described being unable to access songs by particular music artists: *"I think challenges we run into really have to do with music, and I have to do with rights, and that's not her, that's just how things are set up."*

Instructional support feedback
During the interview process, participants were asked to evaluate the instructional support materials that were shared as both mailed written manuals and YouTube videos. Although participants were not required to use these instructional support materials as part of the study, most did use them at least once and offered feedback. For instance, one participant shared their thoughts on the instructional materials: *"It's very useful, especially when I sit down and I go through [the written instructional guide] and I say, Wow."*

All the participants reported finding both forms of instructional manuals easy to use and provided helpful information. The instructional materials were perceived as useful by the participants, and helped some participants feel more independent about their device usage.

Case study results
A detailed look into these cases provides insight into practical adoptions of the Amazon Echo Show device in the everyday lives of older adults and how their usage habits may develop over time.

Case study #1
Case study #1 was a 77-year-old female who lived alone in an independent living community specifically designed for older adults. Regarding her health status, she would sometimes use a lift chair to assist with mobility needs, was diagnosed with cataracts, hypertension, and was managing a heart condition. Although initially hesitant to adopt any new form of technology into her life, she found that she used the device extensively to ask questions about medical conditions because she and multiple family members were experiencing health problems during the study. This is especially interesting considering that the COVID-19 pandemic made seeing physicians and her family members more difficult, so she found herself needing to search things on her own more frequently. One concern she consistently had was phrasing commands correctly and the fear of somehow breaking the

device if she asked Alexa something she did not know. As time went on and she was reassured nothing would be damaged, it appeared she became more confident and eager to ask new commands. Regarding the feedback she provided for the provided instructional materials in which ratings were provided for usefulness (scale of 1-5, with 5 being the most useful and 1 being the least useful) and ease of use (scale of 1-5, with 5 being the easiest to use and 1 being the least easy to use), she rated the written instructional guides as both useful (5/5) and easy to use (5/5). Additionally, she thought the video instructional materials were very "straightforward" and rated them as somewhat useful and easy to use (4/5 and 5/5 ratings, respectively).

Case study #2
Case study #2 was a 65-year-old male who lived with one older adult roommate in an independent living community not specifically designed for older adults. Regarding his health status, he reported being hard of hearing in one ear as well as having a generally poor memory. He was a relatively young older adult currently working a demanding temporary factory job that left him with little time for much else. This participant mostly used the device to listen to music and for general information seeking, and he found that he started using it more often and for expanded uses to alarms and specific information seeking once he moved the device from the communal living room to his bedroom. He was interested in customization options and was able to upload his contacts and photos. This participant had an overall positive impression of the device but perceived Alexa as less of a friend than any other participant. He experienced consistent difficulties with command phrasing and watching videos and movies. This participant was still interested in making video calls to his mother in the nursing home, as well as accessing Amazon Prime content by the end of the study. He always stated that he wished for a bigger screen. This participant did not yet use the provided instructional resources so was unable to rate them but mentioned that he planned to review them in the future.

Case study #3
Case study #3 was a 72-year-old female who lived alone in an independent living community specifically designed for older adults. Regarding her health status, she was diagnosed with arthritis, cataracts, diabetes, and was managing a heart condition. Out of all the participants, she seemed to develop the most personal relationship with Alexa. She often expressed finding comfort in Alexa's presence and found Alexa's readiness to answer questions in her nonjudgmental nature to be her favorite feature. As a person with diabetes, she was interested in using the

device to help her manage the disease, search for healthier recipes, learn about and track the nutritional contents of her diet. By the end of the study, she planned meals and grocery trips using the device and incorporated it regularly into her daily life. She rated the written instructional guides as both useful (5/5) and easy to use (5/5). However, she did not engage with the instructional videos despite specifically requesting video content during the study.

Summary of case studies
The long-term users of the Amazon Echo, as portrayed by these three case studies, represent both generalized uses of the device as well as variability among attitudes and utility within these older adult participants. For example, all three participants utilized the device for information search, with two specifically using it to learn more about their current health situations. The case studies illustrate the potential varying initial and longitudinal perspectives among older users toward the device. Two participants showed strong appreciation and utility for the provided instructional material, with one using both forms and another only using the printed version, whereas another participant did not try to use them. Notably, the participant who did not use these materials did express use-related barriers that these tools may have helped with overcoming. One participant reflected on substantial feelings of companionship developed with Alexa, another did not mention such feelings, whereas the remaining participant explicitly mentioned they did not view it as such.

A common theme among these participants was represented by the subjective feeling of improved competency with the device over time. All three mentioned some form of concern, ignorance, or even fear of using the device that was alleviated by experience and exposure to the features they found personally useful. Overall, these case studies portrayed that older adult users, as well as all users of these technologies, may benefit from finding their personal place and utility within the device's capabilities. Allowing them to experience the benefits possible from consistent and facilitated use. General access or training to use certain features (e.g., entertainment, health, information search) is useful for engaging older users, but ensuring they can find those that best reflect their personal abilities, needs, and lifestyle may lead to more effective and longer-term use.

DISCUSSION
This demonstration study provided a useful basis for understanding Amazon Echo Show and Alexa conversational assistant usage within older adults' homes, as well as related learning and support needs for this population (60+) living with and without disability.

Older adults' attitudes toward, and use of, digital home assistants

The older adults who participated in this study nearly all believed the device would be useful and easy to use. These findings represented the perceived overall potential for DHAs for older adults even though they may not be generally viewed as the target demographic for these devices. Thus, marketing their utility for older adults in supporting them with a variety of daily activities may be not only beneficial for this potential customer base in expanding their adoption, but also for the producers of DHAs. It is yet another example of a finding that challenges the common misconception that older adults do not desire to use current and emerging technologies, especially if they are aware of the potential benefits of such devices (e.g., Mitzner et al., 2010). Specifically with respect to voice-activated devices, the Jakob (2022) review also indicated generally positive views of older adults.

We learned how older adults integrated their Echo Show device into their lives across a range of activities of daily living, as well as to address their evolving needs during the COVID-19 pandemic. Entertainment features were endorsed broadly (e.g., music, games), and daily utility of information search and organization was reported. Moreover, we discovered the specific need for health applications in the everyday lives of older adults with chronic health conditions and/or disabilities. Participants who were unable to gain access to healthcare professionals due to COVID restrictions were able to use their device to search for health information to better understand a condition they were recently diagnosed with as well as to find health information for their family members. Although all participants endorsed using the DHA for information search, and health information search specifically, this was especially evident by use for medical reasons evident in long-term use within case study examples. The older adults did not just perceive the DHA to be useful; this utility was actualized in specific and personally relevant ways. Additionally, multiple participants expressed a desire for more personalized content related to entertainment skills they would find useful. Perhaps personalized medical applications could be strongly endorsed by this population in learning more about the important health-related questions for which they are curious.

Tinker (2016) described the dangers of generalizing with respect to housing needs; the same holds true with respect to designing DHAs and instructional support materials. We must understand the unique experiences, capabilities, and preferences of older adults to support their autonomy and use of DHAs.

Facilitators and barriers

We identified potential facilitators and barriers to digital home assistant device adoption by this population. Regarding facilitators, older adults reported learning the specific features and skills that they found personally useful across a variety of categories (e.g., entertainment, information search). Thus, a potential facilitator that could be emphasized to reinforce learning and continued use of DHAs to allow for more personalized instruction that best fits their preferred use case. This could not only facilitate delivering the desired benefits of use, but also ensure that older adults are initially gaining competency with their preferred features, so they may then use this newfound understanding of the device to explore additional capabilities as they see fit. Relevant to this facilitator is the need for proper support to ensure that effective resources are delivered to older adults to best teach them to use these devices.

Regarding barriers to adoption, we learned that difficulties with interacting with the device (e.g., command phrasing) and a lack of awareness about device capabilities introduced notable challenges for the participants to use the devices as they desired. Multiple participants expressed having problems with the lack of clear presentation of locked or application-restricted content. Improving this presentation and more effectively supporting those that may not have previous experience with similar technologies (e.g., smartphone app stores) could help older participants form a more complete mental model of how these devices and their ecosystems are navigated and fully used. This understanding could reduce the shared perspective by multiple participants that they were concerned they might break or damage the device through improper interactions. These findings are consistent with the recent review by Jakob (2022) and highlight the importance of recognizing the utility of these devices for all ages and ensuring that facilitators and maximized and barriers are minimized to accommodate all potential populations that may adopt them.

Social companionship

This study, and the unique data collection period during a global pandemic, allowed us to learn about the potential that Amazon Alexa-featured products have to combat loneliness and social isolation in older adults. Overall, multiple participants appeared to accept Alexa as a social companion that assisted them with their daily activities. This could be utilized during introductions of these devices to older users by effectively representing this potential early in the process as well as in training them to use the device through a more companion-focused approach. However, we found variability with this perspective as some participants did not report viewing Alexa

in this manner, representing a variability among this smaller sample. Thus, focusing on such utility may be effective for some, but not all, older adults who are learning to use these devices and how they may be relevant to their daily lives. Less than half of the participants reported perceiving that they lacked companionship in their lives. Thus, future research that specifically focuses on those who perceive themselves as deficient of companionship within their lives may lead to a more contextually relevant understanding of this specific potential for conversational agents in playing the role of a social companion.

Initial learning and continued use support
Most participants thought they would need the support of a technical person to assist them with the initial learning of their device. This represented a potential barrier that could be alleviated by the production of effective instructional support materials specifically designed for and with older adults in mind such as those provided to our sample. As we received positive feedback for the materials we provided to assist with learning and using the devices, we demonstrated the feasibility and utility of providing multiple formats of instruction support remotely to older adults, which worked as a facilitating agent for some participants. Conversely, some participants who mentioned having difficulties learning to use their device reported not using the materials we provided, highlighting their potential import in ensuring a solid foundation is provided to get older adults to a level of competency that then becomes reinforced through continued use of the features they find personally relevant.

Limitations and future research
Due to the impact of the COVID-19 global pandemic during the study, limitations of the study were the small sample and the need for fully remote data collection. The isolation during the pandemic due to need for quarantine created a challenging environment for some older adults to learn to use the devices as social and technical support was difficult to access during this time, leading to complications with recruiting as well as increased attrition. For example, when internet or other technical issues occurred for participants, they usually required either a family member or neighbor to come help resolve the problem and this was not an option for some during this time. It was often difficult to diagnose the exact problem over the phone and to assist the participant with troubleshooting and getting their device to work as intended. In one instance, a participant had not been able to use her device since the last monthly interview due to a reported internet connectivity issue. Despite several attempts to help

the older adult connect her device to her home Wi-Fi network over the phone, we were unsuccessful and relied on a younger family member of hers to eventually resolve the issue in-person for the participant. There is a continued need to identify common DHA difficulties and develop related instructional support materials to promote self-troubleshooting of technical issues.

Due to the small sample size of participants, there is a need to replicate the study with more participants, such as those both with and without disabilities as well as a broader representation of education, to better understand potential beneficial uses for a range of older adults and improve the generalizability of such work. Moreover, analyzing the device command histories of older adult participants to gather more quantitative data on the types of features engaged and use cases for digital home assistants in their daily lives would elucidate even more information about the utility of, and interactions with, these devices by older adults. Given that multiple participants expressed interest in using their Amazon Echo Show device to connect with others, especially when also facing physical isolation from family and friends, specific instructional support materials should be developed and shared with older adults for these social purposes. Other types of instructional materials to promote continued DHA learning for older adults should be explored. All of these tools could prove to be beneficial for users of digital home assistant devices of all ages.

CONCLUSIONS
Digital home assistants such as the Amazon Echo with Alexa have shown strong potential for supporting successful aging-in-place and independence for older adult users. This demonstration study and participants' use of these technologies illustrated their utility with older adults' homes, outside of the research environment, as well as the ability of older adults to learn and use these devices when provided with effective onboarding and initial instructions. Thus, instructional support materials specifically designed for older adults, especially those with limited technology experience, should be provided to users to maximize potential benefits of DHAs, especially health applications. Both our quantitative and qualitative data collection, thematic analysis of use trends, desired device applications, and other measures related to the use of DHAs in older adults can serve as a basis for continued research and understanding of this subject area so these devices can be further designed to support aging adults as they desire so they may age successfully and best maintain or improve their quality of life.

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