



"This machine is for the aides": Tailoring Voice Assistant Design to Home Health Care Work

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ABSTRACT

This paper explores how the design of interactive voice assistants (IVAs) might be tailored to support home health aides' important work in complex home care contexts. We designed two custom IVAs: one that looks like an aide's medical kit and one that blends into the home environment. We also designed a voice-based application that provides aides with guidance for day-to-day tasks and for performing a medical assessment. Via a lab-based study with 25 aides and seven patients, we explore how tailoring the IVAs' design to home health care might impact its acceptability as a work device, enabling cooperative work among aides and clients, while potentially causing conflict that will require IVA designers to decide whose values to prioritize. We also highlight limits in aides' power to control IVAs in clients' homes. Finally, we discuss implications for designing privacy-preserving IVAs, including leveraging IVAs' physical design to enact privacy mechanisms and opportunities to build 'always on' IVAs for privacy-sensitive contexts like home health care.

CCS CONCEPTS

• **Human-centered computing** → *Empirical studies in HCI*.

KEYWORDS

Interactive Voice Assistant, Home Care Context, Digital Health, Internet of Things, Technology Probes

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1 INTRODUCTION

Interactive Voice Assistants (IVAs), like Amazon's Alexa or Apple's Siri, are AI-enabled software agents that use speech recognition and natural language processing to interpret and respond to voice commands. Already popular for use in people's homes, mostly

for information and entertainment [7, 11, 52], there is growing interest in how IVAs might be developed for work settings [6, 44]. For example, Cambre et al. examined how IVAs might function as lab equipment for biological scientists [19], while Reicherts et al. investigated the use of IVAs for data analysis work [66]. We build on this nascent literature by examining how the design of IVAs might be tailored to support the essential caregiving work done by home health aides (aides, hereafter).

Aides are paid, professional caregivers, mostly women of color, who work in clients' (the word for patients in this context) homes to provide care, often with the goal of enabling them to age in place [48, 58]. Aides' tasks range from personal care and activities of daily living (e.g., dressing, bathing, shopping) to medically-oriented care (e.g., vital signs, medication management) and helping with out-of-home logistics (e.g., doctor visits). The work is demanding and complex, requiring physical and emotional labor, and is an especially interesting work context in which to study the potential role of IVAs, since it bridges *home* settings, where IVAs are already common, with aides' *work* settings.

In prior work, Bartle et al. [10] used storyboards and video elicitations to understand how commercially-available IVAs might play a role in aides' work, but stopped short of asking aides to interact with the devices. Their findings suggest that the materiality or physical embodiment of IVAs may alter perceptions of who the intended user is and/or who is able to control the device [10]. In addition, their study, and others [79], suggested that technology might be more acceptable in home health care work if it is specifically designed as an aides' work tool, rather than a general purpose tool (e.g., for entertainment) that may be perceived as distracting aides from caring for clients [10, 79].

Our paper expands prior work by investigating *how the design of IVAs might be tailored to support aides' work*. Responding directly to Bartle et al. [10], we tailored the design of IVA devices in two ways. First, we designed two IVAs that, although roughly the same size and running identical software and hardware, differ in physical appearance. One device, the *Health Kit*, looks like an aide's medical kit (Figure 1). Built into a red, rigid-plastic case with a carrying handle, the design suggests the device 'belongs' to the aide and might be carried or controlled by the aide. The other device, the *Home Kit*, is a dark wood box designed to blend into the home (Figure 1), suggesting that it belongs in the home. Both devices are wireless, making them moveable from room-to-room. They are also both fashioned as storage boxes for aides' medical supplies, and can be physically opened, closed, and latched.

Second, we created a dedicated application, the *Home Health Agent* (Figure 2), that provides multimodal (i.e., visual and auditory) support for specific care tasks: managing a client's care preferences and performing a medical assessment. To enable exploration of

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Figure 1: The Health Kit (left) and Home Kit (right).

our high-level design goals and bypass rediscovery of well-known, basic usability problems (such as not pronouncing the IVA's wake word correctly [17, 86]) that are known to be especially prevalent among diverse user groups like aides and clients [25, 40], we used a Wizard of Oz approach [26] to control our application. A researcher acted as the 'natural language processor', listening to user utterances and updating the software state. After creating our IVAs, we conducted a qualitative study with 25 aides and seven older adult clients. Participants used our IVAs to perform care tasks in a lab-based setting before partaking in a semi-structured interview that explored their opinions and experiences with our devices.

We found that providing multiple interaction modalities enabled clients to be included in the interaction and reassured them about the IVA's purpose. We also saw how IVAs could provide information that is personalized to the client and thereby ease care coordination. Nevertheless, some aides and clients were resistant to the idea of using IVAs in home care work. We discovered interesting implications for aides' privacy and control of the IVAs, showing how aides saw themselves as controlling the devices, although their professional duty to report clients' health information may conflict with clients' privacy preferences for their data. In addition, our findings suggest that aides' power to control IVAs may be limited in clients' homes, even if the device is explicitly intended for use by aides. The IVAs' physical embodiment—particularly their ability to be opened, closed, and latched—also strongly impacted perceptions of when it was appropriate for the device to be on and listening. We then delved into some of the strengths and limitations participants perceived in our IVAs' different physical designs. At a high level, participants thought the red Health Kit was more professional, like a toolbox, while the wooden Home Kit did a good job of blending into the home, which might be an advantage for clients who wanted to be discreet about the fact that they were receiving home care, but may cause problems if clients think aides are going through their personal belongings. Although the Health Kit was seen as substantially smaller and lighter than the Home Kit, aides did not want to travel with either device outside of the client's home. Finally, we also unearthed discoveries that participants had clear concerns about durability and liability for the devices, and wanted clear policies regarding maintenance and repair procedures.

In summary, our paper makes the following contributions to knowledge:

As our first research contribution, we offer findings from our qualitative, empirical study that investigates if, and how, our

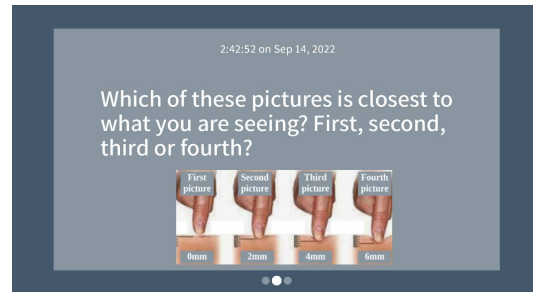


Figure 2: Screenshot from the medical assessment task.

custom-built IVAs might be perceived as acceptable work tools for aides. These contribute to identified areas of opportunity for IVAs to enable cooperative work (Section 6.1), such as how providing multiple interaction modalities may improve inclusion and transparency in aides' work and open up opportunities for multi-party interaction. At the same time, IVAs may introduce or exacerbate potentially unresolvable tensions between clients' wishes and aides' duties, and IVA designers and/or home care agencies may need to explicitly decide whose values to prioritize.

As our second research contribution, we present and discuss the implications of our study for IVA researchers, designers, and home care agencies interested in deploying IVAs in aides' work. These include creating IVAs that preserve privacy (Section 6.2), including how the physical design of IVAs might be leveraged to enact privacy mechanisms and also uncover opportunities to build 'always on' IVAs capable of preserving privacy in sensitive contexts like home health care.

2 BACKGROUND AND RELATED WORK

2.1 Understanding Home Health Aides' Work Contexts

Aides are an important group of frontline health workers and a fast-growing segment of the US workforce [18, 41, 75]. By 2060, the number of Americans over 65 years of age will reach roughly 95 million, almost a quarter of the US population [85]. Many older adults want to stay at home for as long as possible and remain in their community, rather than institutions (e.g., nursing homes) [87]. To do so, they need help from family caregivers and aides [48].

Aides deliver in-home care for clients who often have serious chronic conditions (e.g., heart failure, diabetes). They provide help with a wide range of activities, including tasks of daily living (e.g., bathing, dressing meal preparation, cleaning, shopping), providing emotional support, and delivering medically-oriented care (e.g. vital signs, medication reminders) [9, 27, 37, 70]. Aides usually follow a client's doctor-specified plan of care, which is often a paper document, signed by the client's doctor, that clients are supposed to provide to their aides [54, 70]. Prior work has suggested that aides may provide a key link between the client and the healthcare system, since they spend large amounts of time with clients and are able to observe fine-grained changes in their health conditions [72]. As such, they are well-positioned to communicate changes in the client's condition to other healthcare providers [37, 54, 73].

Although aides provide vital care for clients, research has illuminated how they are undervalued by the healthcare team [48]. Most aides are middle-aged women of color from racial/ethnic minorities [58]. They work long hours, endure erratic schedules, have limited opportunities for career advancement, and are paid low wages [18, 29, 41, 79]. Studies have also found that aides increasingly care for medically complex clients [70, 73]. Yet, despite their observations and insights into clients' health, aides are not considered part of the medical team and are undervalued by the healthcare system [9, 36, 42, 43] and society [74], and experience high levels of stress, burnout, [29, 38, 81] and job turnover [14, 32, 33]. Moreover, aides often do not receive sufficient training [46, 72, 73]. Many of their professional certification courses are general, not disease specific, and may not meet their needs in caring for medically-complex clients [46, 71]. In addition, studies have shown aides may perform numerous tasks that are not part of their formal training [65]. Finally, prior work has discussed how, from a technology perspective, aides current tools are outdated and do not provide adequate support for their work in clients' homes [54].

Motivated to improve aides' work experiences, HCI research has begun to explore the design of technologies to support aides. Poon et al. [60] designed computer-mediated peer support programs for aides, providing aides with weekly sessions where they could discuss issues they faced with other aides. Looking more directly into tools that provide support for caregiving tasks, Tseng et al. [79] investigated aides' perceptions of a tablet-based tool designed specifically for them. Although this was a probe-based study in which aides responded to a hypothetical design, rather than interacting with a new design, the findings suggested that aides were eager to learn and use new technologies.

In another probe-based study, and closest to our work, Bartle et al. [10] used storyboards and video elicitation to explore aides' preliminary reactions to the idea of using IVAs in their work, showing how commercially-available IVAs might help to fill gaps in aides' access to information, assist with decision making, advocate on behalf of aides, and provide emotional support. A key implication in their study was that the materiality and physical embodiment of IVAs may impact the acceptability of these devices in home care work. In other words, they suggested that making an IVA look like it is specifically intended for home care work might improve its acceptability as a work tool for aides.

Our paper builds on their work in several key ways. First, we take a step forward by directly responding to Bartle et al.'s call for explorations into the materiality of IVAs. While their work focused on commercially-available IVAs, we designed and built custom IVAs, tailoring their physical appearance in ways that suggest they are intended for home health care work (Section 3.1 discusses the physical design of our IVAs in detail). In addition, Bartle et al.'s [10] study used elicitation and storyboarding methods, but stopped short of asking aides to actually interact with IVAs. By contrast, aides in our lab-based study interacted with our custom-built IVAs to perform care tasks, enabling our study to yield novel insights and implications surrounding the potential acceptability and use of IVAs in aides' work.

2.2 Exploring Device Materiality in Home Contexts

Our research expands prior HCI work that examines the materiality and form factor of digital devices in the home. One germane example is PhotoBox [53], which was designed as a wooden box that blends into the home (similar to our Home Kit). The device is intended to be used over a long period of time (i.e., years) and occasionally prints a randomly selected photo from the owner's Flickr collection, which can be stored inside the box and used for reflection.

Beyond research that focuses on individual users, a cluster of studies investigates devices that connect people in one home with those in another, often distant family members. For example, Degraen et al. created FamilyFlower [28], an artificial flower to foster connections between remote households by detecting human presence, movement, sound, and touch and creating awareness of everyday activities. Users in the study reported that the device increased feelings of connection with each other. Similarly, Brereton et al. [16] created the Messaging Kettle, which uses the routine act of boiling a kettle to promote communication and engagement with an older friend or relative who lives remotely. Finally, Tibau et al. [77] built FamilySong to connect internationally distributed family groups via synchronized music-listening.

Another cluster of studies focuses on encouraging social interaction between members of the same household, often family members. For example, Deuff et al. [30] built a custom robotic that aims to strengthen the relationships of newly retired couples. The device functions as a bowl for holding keys that wakes up when someone enters the room and uses movement and expression to emulate the atmosphere in the home. As another example, Li et al. [47] designed Slots-Story, a device inspired by slot machines that facilitates storytelling between older adults living in nursing homes and their children. Relatedly, Diks et al. [31] designed CoasterChat, which embeds asynchronous communication in a daily coffee routine to support social sharing between people with early stage dementia and their families.

Our work adds a novel dimension to this literature. To our knowledge, our study is the first to investigate the custom design and materiality of IVA devices. Moreover, we explore the materiality of IVAs in home health care, a novel context with multiple stakeholders and fraught power dynamics that bridges clients' *home* environments with aides' *work* environments. Our goal was to discover if and how tailoring the design of IVAs to home health care work might impact these devices' acceptability as work tools for aides. We now discuss relevant literature on IVAs.

2.3 Interactive Voice Assistants

Interactive Voice Assistants (IVAs) are an increasingly popular technology, with over 110 million users in the US [45]. As IVAs increase in ubiquity they are used in a variety of settings, occasionally in public [4, 25, 57] but most often in the home for entertainment, information, and IoT device control [7, 11, 52]. Prior research has studied how people use IVAs, for example, job interview preparation [8, 24], tutoring [88], booking appointments [89], and browsing the Internet [20, 34]. In health contexts specifically, research showed that people are willing to use IVAs for medically-related queries

[13, 91], although IVAs can struggle to recognize medication names [56].

Prior work has also examined IVA use by older adults specifically. Studies found IVAs to be feasible and usable for older adults [64, 67, 90], for example, to improve communication skills [5] or find online information [62]. IVAs have also shown potential for in-home health applications [55, 61, 80, 83], including self-managing health conditions [22], supporting independent living [21], and providing emotional support [24, 49, 52]. IVAs may also improve quality of life for older adults with mental illness [3], reduce stress for people receiving end-of-life care [82], and support reminiscence [50]. However, research also shows that expecting IVAs to be human-like can lead to breakdowns in older adult usage, [17, 25] possibly leading to abandonment of the IVA [78]. In home care, which is close to our context, Zubatiy et al. explored how family caregivers and care recipients might use IVAs [92] finding that, while IVAs can be empowering to both parties, utility for the care recipient relied on how much scaffolding the family caregiver provided [92].

Beyond personal use, a small number of studies have examined how IVAs may be useful in work settings. Cambre et al. [19] studied how IVAs might be used as lab equipment by biological scientists, finding that participants reported higher confidence in task completion after using the IVA and wanted IVAs to be embedded into the physical and social workspace. Reicherts et al. studied IVA use for data analysis work, comparing voice versus screen-based interactions for pairs of participants performing an exploratory data analysis task [66].

Our study builds on and expands this literature by being the first to explore how the physical and software design of IVAs might be tailored to support aides' caregiving work in clients' homes. To achieve this goal, we tailored the design of IVAs in two ways: (1) we customized the physical embodiment of the devices, creating one that looks like an aide's medical kit, and another that blends into the home environment, and (2) we created a voice-based application to provide on-the-job support and guidance for aides' work. The next section discusses our design rationale in detail.

3 DESIGNING VOICE ASSISTANTS TAILORED TO HOME HEALTH CARE WORK

3.1 Physical Design

As discussed in Section 2.1, Bartle et al. [10] put forth the notion that the physical embodiment of an IVA may alter perceptions of who the intended user of the device is. In particular, making an IVA look like it is explicitly intended for home care work might help to improve its acceptability as a work tool for aides. Our study aims to explore this idea. As a first step, we built two custom IVA devices with different physical embodiments (see Figures 1, 3 & 4).

Our design goal for the first device, which we call the *Health Kit*, was to embody the *health* aspects of home health care. To achieve this, we created a device that is fashioned as an aide's work kit, or first aid kit, with the goal of suggesting that it is intended for use in care work and might be controlled, operated, or carried by the aide. The device consists of a red, rigid-plastic, latching case with a carrying handle and storage space inside for medical supplies.

For the second device, we wanted a design that would provoke rich discussion by offering some contrast to the Health Kit. To

achieve this contrast, we chose to embrace the *home* aspects of home health care and create a device that looks like it belongs in the home. We wanted the outward appearance of the device to *not* explicitly signal that it was an aides' work tool, but still wanted the device to be fashioned for use in home care work. Although we considered several everyday objects as potential form factors, including a potted plant and a picture frame, we decided that these objects were too far from being relevant to home care. Thus, we ultimately settled on a relatively neutral wooden box (similar in appearance to the PhotoBox [53]) for storing medical supplies. We call this device the *Home Kit*; it consists of a brown, dark-wood, latching box with no handle that might belong on a table or shelf in the home.

Other than their differences in appearance, we deliberately kept other aspects of the two devices comparable to each other. Both used identical software and hardware and were of similar weight: roughly 6 pounds, and size, with Health Kit (12x9x4inches) marginally smaller than the Home Kit (12x10x6inches). The inside of both boxes were fashioned as medical supply storage, with bandages and medication placed on a false bottom that hid the hardware (Figure 4).

Unlike typical commercially-available IVA devices, which are usually plugged into an outlet at a static location, our IVAs are portable and battery powered, enabling them to be carried from room to room around the home. This is important since aide tasks are not static, for example, moving from the bedroom, to the bathroom to the kitchen. As mentioned above, the red Health Kit, which was housed in a carrying case with a handle, was somewhat more portable than the Home Kit, opening up the possibility that it might also travel with the aide to and from the client's home.

For both devices, being portable also enabled the IVA, when not in use, to be stowed for example in cupboards or under beds. In addition, the cases of both devices were hinged, enabling them to be opened, closed, and latched. This contrasts with the 'always on' nature of many commercially-available IVAs, and was a design choice we made to enable deeper exploration of perceptions around privacy and surveillance [10].

Finally, similar to many commercially-available IVAs, our devices were multimodal, providing auditory interaction, via speaker and microphone, and visual interaction, via a 7-inch screen embedded into the top half of the device (Figure 1). We did this to enable exploration of interaction modalities and learn when each may be most helpful.

3.2 Designing a Voice-Based Application for on-the-Job Support

We now discuss how we tailored our IVA software to support aides' work. Prior work [10, 79] suggested that, in home health care, technology might be more accepted if it is a specific work tool, rather than a general purpose tool (e.g., for entertainment) that may be perceived as distracting aides' from providing care. Thus, we built dedicated software, the *Home Health Agent*, that only supported aides' work. When the IVA is first triggered, it welcomes users by saying, "Welcome back to your home health agent" and offers available tasks: "I can help with managing your care preferences or doing a leg swelling assessment." Simultaneously, the screen displays a



Figure 3: Closed Health Kit (left) and Home Kit (right)

home screen. We implemented support for two different care tasks: one that helps aides to manage and remember their client's care preferences, a common day-to-day task, and another that helps aides perform a medical assessment. We now describe these tasks in detail.

Managing day-to-day tasks. Aides' scope of work encompasses a broad array of tasks they help their clients with, including: personal hygiene, nutrition, medical care, monitoring vital signs, house-keeping, and managing medical appointments, to name a few. It is challenging for aides to keep track of all these tasks while also remembering client-specific needs or preferences associated with each task [73].

Thus, we explored how an IVA might help by enabling aides to record information regarding their client's preferences and set reminders for tasks. Specifically, we built a dialog around a scenario where an aide uses the IVA to record their client's preference for exercise: walking in the afternoon. The IVA solicits information about the task preference from the aide, records and stores this information, and offers to set a reminder for the aide or the next aide on shift. Appendix A.1 provides a typical dialog for the task.

Guidance for medical assessments. In addition to daily tasks, aides often need to assess and respond to changes in a client's medical condition. Although aides often care for clients with serious chronic diseases such as heart failure, they do not receive disease-specific training [72, 73]. As a result, aides find changes in a client's symptoms frightening and lack confidence in making decisions about what to do [73].

Thus, we explored how an IVA might provide support and guidance for carrying out a medical assessment in monitoring leg swelling associated with heart failure. Heart failure is a prevalent, life-threatening condition and research has shown that aides struggle to care for client's with heart failure [72, 73]. Leg swelling is a common heart failure symptom caused by fluid retention. Aides who care for clients with heart failure must routinely assess their levels of leg swelling and make decisions about if or when to alert the client's medical team.

Our IVA first asks the aide if the client's legs look more swollen than normal. Then, the aide is instructed to press their fingers on the client's leg and note how deeply the skin remains depressed,



Figure 4: Underlying device hardware

to observe what is called 'pitting'. In contrast to the client preferences task, in which the screen simply displayed in text the words being spoken, this task included photos and videos to help the aide visually compare different levels of pitting (Figure 2). To simulate performing an assessment for real, we provided a Pitting Edema Trainer tissue pad (Figure 6). When prompted by the IVA, aides pressed down on the pad and assessed the resulting level of pitting. This allowed us to explore how aides interacted with the IVA while their hands were busy with a real assessment. At the end of the task, aides were given the option of reporting the results to the client's nurse and/or family, and asked if they wanted to remind the next aide to monitor leg swelling. Appendix A.2 shows a typical dialog flow for the task.

Enabling smooth interactions for diverse users. As discussed in Section 2.1, currently, most aides are middle-aged women from diverse racial and ethnic backgrounds, who speak English as a second language [58], and who care for older adults [18, 41, 58]. In addition, we anticipated that many aides may not have prior experience interacting with IVAs [54, 79]. Existing research has documented many basic usability challenges that novice and/or diverse user groups face when interacting with commercially-available IVAs such as remembering to say and/or pronounce wake words correctly [17, 25, 40, 86]. Since our goal was to explore the high-level idea of tailoring IVAs to aides' work, rather than rediscovering current usability problems with commercially-available IVAs, we chose to manage participant interactions with our software using a Wizard of Oz approach [26].

To achieve the Wizard of Oz effect, a researcher acted as the "natural language processor", listening to participant commands and using a remote laptop to trigger spoken responses and control the application¹. We programmed the software so that, at any point, the wizard could trigger: 'reset', 'error', 'client preferences', 'medical assessment', 'tutorial', and 'home'. Arrow keys were used within each of these states, with left and right moving between stages of a task, and up and down incrementing options (such as choose one of: (1) repeat, (2) go back, or (3) skip).

Although our Wizard of Oz approach circumvented many basic usability problems (e.g., the need to say the wake word correctly),

¹A video demonstration of our IVA is provided as supplementary material.



Figure 5: An aide using the Home Kit

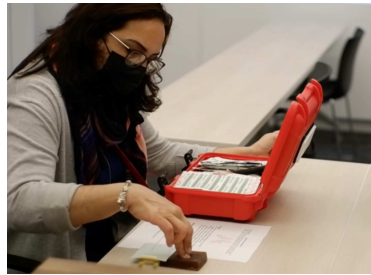


Figure 6: An aide using the Health Kit and edema training tissue pad

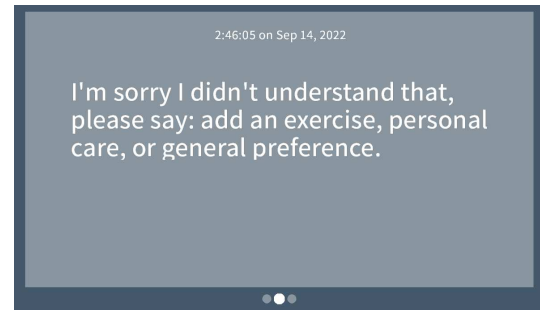


Figure 7: Example of error triggering

we anticipated that participants may still make errors, such as requesting unsupported functionality or asking questions that are not related to home care tasks. Thus, we included functionality in our software that enabled triggering an ‘error’, which would cause the IVA to say, for example, *“I’m sorry I didn’t understand that, please say: add an exercise, personal care, or general preference.”*

Since the wizard controlled the application remotely, participants were not aware that the IVA was not using speech recognition. While this facilitated smooth interactions and enabled exploration of our research questions, it also meant that our devices seemed to perform better than current commercially-available IVAs, simulating a world with more seamless natural language processing technology.

4 STUDY DESIGN

After building and testing our IVAs, we conducted an in-person qualitative study to explore aides’ and clients’ perceptions of and interactions with our devices. Between March and July 2022, we recruited 21 aides via an ongoing research partnership with the 1199SEIU United Healthcare Workers East in New York City. Then, we triangulated and complemented the data collected from aides by partnering with a local senior center to recruit seven older adult clients who receive home care, four of whom were accompanied by an aide. All study procedures were IRB-approved and followed local COVID-19 safety protocols (e.g., mask wearing). This section describes our study methods in detail.

Recruitment and Participants. Participants were recruited via the 1199SEIU United Healthcare Workers East, the largest health-care workers union in the US. Our team has been actively partnering with the union for five years on a range of collaborative projects. Since the study took place in person at the union offices, staff reached out by phone to aides who were already scheduled to come into the office, usually to receive training. Interested aides were invited to choose an available time slot. Recruitment continued until we reached data saturation.

As shown in Table 1, aide participants came from diverse backgrounds, with an average of 17.46 years experience providing home care. All but one were female. Additionally ten aides described their ethnicity as Hispanic or Latino. They possessed varying levels of prior experience with IVAs: five had no familiarity and had not used them before, eight had some familiarity, having used them

occasionally or seen other people use them, and ten were very familiar, having used IVAs regularly in their own lives.

After reaching data saturation with aides, we recruited a smaller number of clients to triangulate our data. We partnered with a local senior center that serves adults over the age of 60 and with whom our institution has a multi-year, ongoing partnership. Staff at the senior center helped us recruit clients who have received or currently receive home care from an aide, and who were willing and able to participate in person. We recruited seven clients: three of whom participated alone, and four who were accompanied by an aide and participated as an aide-client dyad.

As shown in Table 1, all clients were over the age of 60, and all but one were female. They had a wide range of experience receiving home care, as well as a range of prior experience with IVAs: three had no familiarity, one had some familiarity, and three were very familiar with these devices.

Procedure with aides. We began our study by conducting individual in-person sessions with 21 aide participants.

Setup. Sessions took place at partner organization offices in a room with a table and chairs. All sessions were in English. Two researchers were present in each session: one who guided aide participants through interacting with the IVA and interview, and a second who took notes and wizarded the IVA. Before the aide entered the room, we placed both IVAs on one side of the table away from the aide’s seat. We did this so, during the session, we could invite aides to pick up and carry each device to their seat, allowing them to get a feel for the size and weight of each device.

Warmup. Researchers began the session by introducing themselves, explaining the study purpose and agenda, and obtaining informed consent, including consent to record. Then, we collected aides’ demographic data and engaged them in a warm up discussion around their prior experience, if any, with IVAs.

Tutorial. Aides then began interacting with the IVA by completing a voice-based tutorial that acquainted them with the device. They collected one of the IVAs and carried it to their seat, physically unlatched and opened the device, and began interacting with it. The IVA initiated a tutorial dialog, consisting of a simple get-to-know-you conversation between the aide and the IVA. The IVA asked the aide questions like *“how long have you been a care worker?”* before prompting the participant to ask it questions, such as *“what do you*

Table 1: Participant Demographics

Aide Participants (n=25)	
Gender	Female: 24 Male: 1
Age	35–40 years: 1, 41–45 years: 3, 46–50 years: 4, 51–55 years: 2, 56–60 years: 4, 61+ years: 7, Did not say: 4
Education	Some high school: 6, Completed high school: 8, Some college: 7, Undergraduate degree or higher: 4
Race/Ethnicity	Black/African American: 12, Asian: 4, White: 1, Unknown: 8
Familiarity with IVAs	No familiarity: 5, Some familiarity: 8, Very familiar: 10, Did not say: 2
Work Experience	1–5 years: 3, 6–10 years: 4, 11–15 years: 4, 16–20 years: 6, 21–25 years: 5, 26+ years: 3
Client Participants (n=7)	
Gender	Female: 6 Male: 1
Age	60+ years: 7
Education	Some high school: 3, Completed high school: 1, Some college: 2, Undergraduate degree or higher: 1
Race/Ethnicity	Black/African American: 2, Asian: 1, White: 3, Unknown: 1
Familiarity with IVAs	No familiarity: 3, Some familiarity: 1, Very familiar: 3
In home care	1–5 years: 3, 6–10 years: 3, 10+ years: 1

do?”, with the IVA then explaining available tasks. Appendix A.3 provides a typical dialog for the tutorial.

Interactive tasks. After the tutorial, aides used one IVA to complete the first care task and then the other IVA to complete the second. For the leg swelling assessment, aides performed the task using the Pitting Edema Trainer tissue pad (described in Section 3.2 and shown in Figure 6). We followed a 2x2 factorial design, counterbalancing the presentation order of IVAs (Health Kit and Home Kit) across participants, and the order of care tasks: client preferences and leg swelling, across devices to avoid ordering effects and/or biasing participants. Aides performed the first task with the IVA they used for the tutorial. Then, they closed that device, and picked up and opened the second device for the second task. For each task, we gave aides brief scenario scripts (see Appendices B & C) that described an imagined client, the task to perform, and key details needed for the task such as how to begin and what preference to set.

Interview. After using both devices and completing both tasks, we conducted a semi-structured interview with the aide. Both devices were placed on the table in front of the aide to enable discussion and comparison. Interview questions probed aides’ opinions of the IVAs, if or how they might be used in aides’ work, how aides anticipated clients might react to the devices, etc. Each session lasted roughly one hour, with the interactive portions roughly 30 minutes and the interview another 30 minutes. Aides were compensated with a \$25 giftcard.

Procedure with aide-client dyads. The four sessions with aide-client dyads followed a similar procedure to the aide-only procedure described above. The setup for the session was the same: a room with table and chairs in our partner organization’s office. In the warmup phase, the client sat beside the aide. Researchers obtained consent, collected demographic information, and asked warmup questions to both participants. Then, for the tutorial and interactive phases, the aide used the IVAs to perform the tasks (following the same procedure described above) while the client observed. Finally, the interview phase consisted of a joint interview, with both the

aide and client answering questions. At the end of the session both the aide and client received a \$25 giftcard.

Procedure with clients. The three sessions with solo clients again followed a similar procedure. The setup was the same; the warmup phase involved obtaining consent, collecting demographics, and discussing the client’s experience with IVAs and with home care. For the tutorial and interactive phases, a researcher acted as the aide, using the IVA to perform the tasks while the client observed. Finally, the client participated in the interview and received a \$25 giftcard.

Data analysis. Our data consisted of 32 hours of audio-recorded interactions and participant interviews which were professionally transcribed before being analyzed via thematic analysis [15], a constructivist approach inspired by grounded theory [35]. All data was double-coded by two authors. We began by reading through the data and generating initial codes. We then conducted multiple rounds of iterative coding, meeting regularly to discuss and resolve conflicts. Data from the aides was coded first, followed by data from clients and client-aide dyads. Our final codebook consisted of 42 codes that we clustered into high level themes that represent our main findings (our codebook is provided in Appendix D.). In reporting quotes, we use the notation A00 to denote aide participants, and C00 to denote clients.

5 FINDINGS

Our study yielded rich insights on the impact of tailoring the design of IVAs to aides’ work. We begin by discussing if and how our custom-built IVAs might be perceived as acceptable work tools for aides (Section 5.1). Then, we explore how tailoring the design of IVAs to home health care impacted participants’ perceptions of privacy and who was in control of the device (Section 5.2). Finally, we discuss some of the strengths and limitations of our two different IVA designs (Section 5.3). Table 2 provides a high level summary of our findings.

Table 2: Summary of our study findings.

Theme / Finding	Section
Understanding how IVAs might be acceptable as work tools	5.1
Devices tailored to home care may be more acceptable as work tools than personal devices	5.1.1
Providing multiple interaction modalities enables transparency and inclusion	5.1.2
IVAs can provide personalized care-related information to aides, across shifts, and ease care coordination	5.1.3
Some aides and clients may be resistant to IVA use in home health care	5.1.4
Exploring how tailoring the design of IVAs to home care work impacts control and privacy	5.2
Aides want to be the ones to control the IVA	5.2.1
The physical state of the IVA connotes when it is appropriate for the device to be listening	5.2.2
Clients' privacy preferences may conflict with aides' professional responsibilities	5.2.3
Wizard of Oz interactions facilitated nuanced exploration of aides' task workflows	5.2.4
Investigating the strengths and limitations of the Health Kit and Home Kit physical designs	5.3
Pros and cons of an IVA that looks like a medical kit vs. blending into the home	5.3.1
Aides perceived both IVAs to be portable inside, but not outside, the client's home	5.3.2
Participants were concerned about durability, liability, maintenance, and repair	5.3.3

5.1 Understanding how IVAs might be acceptable as work tools

We begin by describing how tailoring devices to home care may improve acceptability in contrast to the use of personal devices such as smart phones, we then highlight the significance, especially in home care, of provisioning multiple interaction modalities, and we detail how an IVA in particular might be well suited to improving care coordination across aides along multiple shifts. We also point to several points of resistance shared among our participants, such as concerns with the loss of a client's sense of agency.

5.1.1 Devices tailored to home care may be more acceptable as work tools than personal devices. Research has uncovered challenges around if, or when, it might be appropriate for aides to use technologies in their work [46, 54, 79]. Some issues stem from aides being expected to use clients' technology for tasks, such as aides being required to clock in and out of their shift via their client's landline phone [54]. Participants in our study described how some clients objected to this: "There are clients that won't allow aides to clock in using the phone. You say it's a 1-800 number, it means nothing to them" (A05). Aides also explained how clients often restricted access to in-home WiFi: "A lot of patients, for instance, will not give me their WiFi; they're like 'Why should I?'" (A07). Other issues stem from aides being expected to use their personal devices for work purposes, since clients often assume that aides are distracted and not working [79].

Our study explored if or how explicitly tailoring the design of technology to home health care work might improve its acceptability in these contexts. We found that aides did perceive the IVA as likely to be more acceptable than personal devices. As one aide put it: "My phone is personal ... this puts private medical problems in one place, the client sees the [IVA] and it's like part of the job" (A19). Aides also discussed how the specificity of the IVA for home care may make clients more accepting of the technology, because: "This

allows for personalized care, we [can] be specific about things [we] are doing [with the technology]" (A05). One client noted that technology might help to include clients in their aides' work, saying, "Is also nice because you're giving the patient an opportunity to work with [the IVA], with the aide" (C06). Below, we expand on how IVAs might improve inclusion and transparency in aides' work.

5.1.2 Providing multiple interaction modalities improves transparency and inclusion. The capacity for aides to involve clients in their care was important for aides, who explained that a large part of their work was in their relationship with their client. Aides felt that because the IVA spoke out loud, clients might be more accepting of it as an aides' work tool: "[The client] would hear it, and it would be in front of them" (A18). Aides added that while multi-lingual capacity was helpful for themselves, this might also improve the chances of clients accepting the IVA, by making sure it spoke the client's native language: "when you turn it on, they can hear what you're asking the [IVA] in their language so they don't feel offended" (A07). Participants also added that many clients have vision or hearing impairments, and the multi-modal nature of our IVAs might help these clients understand their aides' work. One aide told us: "I think about my clients, some can't read, but can listen, so if they can listen [to the IVA] they'll be happy" (A17).

Aides also emphasized the importance of providing *both* visual and voice-based guidance for their own work. Aides explained how, in some cases, they are not able to read instructions or look at a screen, since the task at hand requires their full visual attention. In such cases, voice-based support would be essential. In other cases, when aides could provide their full visual attention, they might use the visual information as a fail-safe or to check their understanding: "I can read it, but talking, sometimes I miss it" (A25). Aides further added that choosing an option from an image or following a looping video, as provided in the leg swelling assessment, was helpful for verifying and clarifying their understanding: "Because I want to not

only hear it, I want to see it. I want to see, okay, everything is correct that I'm seeing" (A24). In addition, aides felt that the ability to perform tasks, receive guidance, and report progress conversationally was better than having to record handwritten notes, which many aides currently do. One aide told us: "I would rather use this than writing notes ... especially since [my] main language is not English, you know" (A02).

The ability to interact with the IVA at a distance was also seen as advantageous, especially in emergencies. Aides pointed out that, if a client fell, they would be able to stay with the client, while still using the IVA to call for help: "If we have something like this, if a client falls, that would be better [than telling the client] 'I gotta go call 911'" (A24). However, aides pointed out that the 7-inch screen in our IVAs might be challenging to use at a distance, and preferred a larger screen. For their part, clients saw how the IVA might amplify their voice in the home, perhaps to reach the aide:

"Maybe the [IVA] could be set so that it could reach somebody in another room. Like if the aide was in the bathroom, and [you were in] the kitchen and you needed them, sometimes my voice doesn't carry." (C03)

Beyond visual and auditory interaction through microphone, speaker, and screen, participants imagined our IVA benefiting from an added camera. Aides discussed how they often have to describe what they are seeing for healthcare providers (e.g., in wound progression). They find it challenging to describe complex or nuanced situations, especially if English is their second language, and sometimes take photos instead to aid communication. Aides thought a camera embedded in an IVA may be more acceptable than taking photos with a personal phone: "The patient will feel more comfortable with something like this [for taking photos] than the phone" (A19). As another benefit, aides imagined a camera-enabled IVA might be directly connected to the care team who could reply with guidance on next steps:

"Aides cannot touch the bed sore ... I need to show [a] picture ... when I show the coordinator, then they have to tell the nurse, and it's [an extra] step, but [with] this one, I can show [the nurse], then they reply right away." (A25)

5.1.3 IVAs can provide personalized care-related information to aides, across shifts, and ease care coordination. In addition to providing multi-modal support for care tasks, aides found it compelling that an IVA could be a centralized store for personalized, care-related information relevant to the client. As prior work has pointed out [54, 79], clients sometimes do not share their plan of care with aides, making it challenging for aides to know what tasks to perform. In addition, aides may struggle to know details of the client's health condition needed to make decisions, especially if the aide is new to caring for the client. Aides perceived an IVA might provide needed information, as one described:

"If the patient's blood pressure is 200 something. That might be his normal ... for me, that's the first time I've taken it, it's 220. I'm freaking out because that's high. But it may not be surprising to him and the [IVA] because he's been having that for 10 years now. So [the IVA] should be telling me, okay this is something that's been occurring for this long, he needs two units of whatever.

There should be notes it's going to tell me, that my concerns are valid or not valid." (A18)

However, participants also saw it potentially becoming an issue if aides became too reliant on asking an IVA about the client's health or care preferences rather than asking the client themselves. One aide imagined a client asking "Why are you going straight to [the IVA] for MY condition?" (A07). This suggests a need to find the right balance between ensuring that an IVA augments, but does not replace, human communication between aide and client.

Beyond providing individual aides with care-related information, aides also liked the idea of an IVA being able to proactively communicate and track information across aides who care for the same client, helping to ensure that important details do not fall through the cracks. As one aide said:

"I come in from 8AM to 8PM, another aide is from 8PM to 8AM, so if we noticed in the morning, and [the other aide] recorded in the evening, [the IVA] would say they had the same issue, or this is the second notice of having this report ... [the IVA] recognized and already reported ... it's gotten worse." (A18)

More provocatively, aides suggested that an IVA might also be used to resolve disputes among aides who care for the same client by recording what happened in the client's home. One aide explained how, when a client gets injured for example, there may be a need to deduce who was at fault. They envisioned the IVA could record data that would provide "proof" that might be used to hold aides accountable:

"If the company puts this in the home .. they need to use the data that is there to know who's telling the truth and who's telling a lie. Because sometimes if the client has two workers, at different times, .. if the client falls .. and I don't see bruises until I physically, you know, see her, and then I report that, then the aide says, 'no it did not happen with me.' And you know, so I have proof right here, so that's good to record what is going on around the house." (A02)

Finally, participants also perceived an IVA may enhance coordination with the broader healthcare team. As one aide said, "Almost every day I have something I would like to say to the [care team] involved" (A05). Many clients receiving home care are also assigned a visiting nurse who comes to the home periodically (e.g., every few months). This is often a short, check-in visit and aides discussed how nurses may struggle to understand the complex situation in a short time. They thought the IVA might give the nurse important information, thereby also elevating aides' role in the care team:

"[The nurse] comes to the house ... they don't really assess [the situation] how this [IVA] does ... how bad it is. A nurse might not [be as specific] ... so this would help us a lot in giving information to the nurse." (A07)

In addition to providing information for visiting nurses, participants expected the IVA might improve communication with remote nurses as well. At the end of our IVA's leg swelling assessment task, the IVA asked if the aide wanted to report the results to the client's nurse (see Appendix A.2), although it did not specify how this report would be sent (e.g., email, text). Some aides perceived that the IVA may make it easy to quickly connect with a nurse or doctor to talk about the client's health, a notorious problem for aides [54, 70, 79]. Aides further imagined an IVA being able to, for

example, report a client's leg swelling history in real-time during an emergency call with a doctor, where they might be aided in navigating circumstances they would otherwise have little control over.

5.1.4 Some clients and aides may be resistant to using IVAs in home health care work. Beyond the potential benefits of tailoring IVAs to home health care work, we also encountered some aversion and/or resistance to the idea. For example, participants imagined clients saying: *"Turn that off, it's making too much noise"* (A07) or otherwise being confused by an IVA: *"This will freak them out ... they're gonna be like 'What the heck is this? Why is it talking back to me?'"* (A24). Some aides felt they would only use the IVA in specific circumstances, such as communicating with the client's care team in an emergency, but not for everyday tasks. As one aide said, *"I would just want to use [the IVA] for emergencies ... when I want to ask somebody [on the care team] ... but not always"* (A25). Clients also felt that some aides, especially experienced aides, would not need such a device. A client commented, *"My aide is not the kind that would need something like that"* (C02) and explained how, for their part, they would want to judge their own condition:

"I would look at my ankles and say, 'Yep, they're swelling up', [then] I would ask [my aide] to look at my ankles. I would judge my own problem ... I would not discuss it [with an IVA] ... because I feel like I'm in charge of my life." (C02)

One client added that whether they accepted the device or not would depend on if it was assigned by their doctor as a tool for home health care: *"[if] the doctor was saying to take this home and use it, whatever he gives me ... I'll take it home and I'll be careful with it"* (C06). Similarly, aides felt that it would be important to know the source of the information provided when deciding whether or not to trust and/or accept the device in their work:

"I would like to know who that is, where did [that information] come from? That voice. It's like if you are talking to somebody and you don't even know that person ... Who is behind [the IVA]? I think it's important." (A06)

5.2 Exploring how tailoring the design of IVAs to home care work impacts control and privacy

In addition to understanding how IVAs that are tailored to home health care might be acceptable as aides' work tools, our analysis uncovered important insights into who participants thought should control the device, when it is appropriate for it to be listening, and the privacy of data it might collect. We also found our Wizard of Oz approach facilitated nuanced exploration of aides' task workflows.

5.2.1 Aides want to be the ones to control the IVA. One goal of our custom IVA designs was to suggest that the devices were explicitly intended for use by aides. In line with this goal, aides generally saw themselves as being in control of the device and able to decide when to use it or not. As one participant said, *"this machine is for the aides"* (A06). One aide suggested that the IVA might only turn on in response to an aide: *"When we say we need it ... it will turn on"* (A19). Another pointed out that, if the aide was the only one

who could control the device, then when the aide left, clients might feel assured that the device was off and not listening to them: *"if [clients] know it only works when the aide is there to assist them ... I think they would be more open to have it"* (A18).

Participants also strongly associated control of the IVA software with control of the physical device. In particular, physically opening or closing the device equated to turning it on and off (discussed in detail in Section 5.2.2). Correspondingly, aides felt that *"the aide should choose if it's open or closed"* (A12). While some participants envisioned the IVA only being accessible when an aide opened its case, others imagined it needing to provide reminders to clients in the absence of an aide. This further led to concerns about clients being able to use the device to access or change their care information (e.g., adding extra tasks not on the approved care plan).

In contrast to aides' opinions, clients imagined using the device themselves to talk to their care team: *"I would call the nurse and doctor myself"* (C03). Further, even if the IVA was designed for aides, aides envisioned a client or their family having the right to demand access to it:

"Doesn't make a difference [who it belongs to], [as a family member] I would ask for the key. Or I would say what is this? Eventually you'd have to show it to them because it's in the family's house." (A16)

5.2.2 The physical state of the IVA connotes when it is appropriate for the device to be listening. Both our IVAs were designed as hinged boxes that could be physically opened, closed, and latched—properties that strongly influenced participants' perceptions of when the device would be on, listening or recording data, and when it would be off, and therefore shut down. Participants clearly felt that physically opening the device should turn it on. As a client suggested, *"that's only [on] if you lift it up, right?"* (C01). Similarly, participants felt that the device should not be listening when it was closed. Participants extended this perception of closed/off, open/on to other functionality, such as the hypothetical camera that might be added to the IVA, with one aide stating: *"if it's closed, the camera cannot see you"* (A22).

Although participants generally perceived the device as shut down when closed and active when open, they also wanted mechanisms to be able to override this general rule in certain situations, like emergencies. As one aide said:

"I would like to be able to speak to it when it's closed just in case, for example the client falls ... it would be nice to know [the IVA] listens and I can say 'I'm holding the patient' ... and you can say what you need to while it's closed." (A05)

Alternatively, aides suggested that the device might include an emergency alert button, similar to medical alert systems installed in client's homes, that would activate the IVA even if it was closed, imagining: *"I just touch [the] button and somebody can help me right away"* (A25).

5.2.3 Clients' privacy preferences may conflict with aides' professional responsibilities. Although aides generally agreed that they should be the ones to control the IVA, concerns about privacy generally centered on clients. When we asked how clients might feel about the IVA listening to their conversations, some aides felt that *"most [clients] won't even know"* (A05). For clients who were aware

that an IVA could record their conversations, aides felt that they might not be happy. One aide put herself in the client's shoes, stating: *"I would get a little annoyed ... I would be looking at the [IVA] all the time, wondering if it's recording"* (A07). Similarly, aides imagined clients' family members having privacy concerns, saying: *"If a family member finds out that it's recording them it's going out the window"* (A16). They also emphasized that ultimately they would need to respect clients' preferences regarding privacy: *"If they don't like that the machine listens, it's a privacy [concern], so I have to respect that"* (A17). When we asked aides about their own privacy preferences, they were often hesitant to divulge how they felt, and often qualified their responses based on what the client would want:

"The patient has the choice, and as an aide, I have to respect the patient's choice. Even if she doesn't want it, I cannot fault her. Even if she has it, I will do whatever she is comfortable with. So it's not a big deal for me, it's for the choice of the patient." (A12)

Despite wanting to respect client's privacy preferences, aides discussed how doing so was often a fundamental tension in their work, when the client's desire to keep information about their health care private clashed with the aide's duty to report changes in a client's health to the care team. As one aide said:

"I noticed that his foot was swelling. I told him about it. And he said no, that's okay. And then, I felt it. So, the next week I went back and I noticed it had gotten bigger. I called the agency and I told them about it. He was mad. He was mad because they called him, and he went to the hospital." (A21)

This aide further suggested need for mechanisms to circumvent the out-loud nature of IVA interactions, such as by including features for discreetly reporting information without the client being aware of it:

"Is there going to be a button to lower [the volume] down so the patient doesn't hear it? If the patient doesn't want you to say anything? Is there going to be a button that you can lower it down and still talk to [the IVA]?" (A21)

5.2.4 Wizard of Oz interactions facilitated nuanced exploration of aides' task workflows. In addition to balancing clients' personal privacy preferences with their professional duties, aides also need to navigate complex rules governing who they may share the client's personal health information with. In our study, we found that the choice to use a Wizard of Oz approach to control our IVAs' responses enabled nuanced exploration of privacy and data sharing since it enabled us to adapt the interaction to aides' actual needs and workflows.

For example, at the end of our leg swelling assessment task, the scenario we provided to participants suggested that they share the results of the assessment with both the client's nurse and their family. However, we saw that 10 of our 25 aide participants deviated from these instructions, opting instead to send the results only to the nurse. The flexibility afforded by our Wizard of Oz approach allowed us to support aides' choice, enabling them to complete the interaction and only send data to the nurse. Aides went on to discuss how they are not allowed to share the client's private data with their family, explaining *"We're supposed to report to the nurse, even if the family wants to know, they have to contact the nurse"* (A02). Another aide elaborated:

"The voice assistant wouldn't know there was [family] tension, sometimes family will want to take away power, they will say 'he is too sick, I need power of this', but if a [client] wants to keep their dignity, or power, or control ... they'll say, 'listen, I know what [the family] tells you, I don't want you telling [the family], you can tell the nurse or the doctor but that's it.' And that's their right ... so maybe I could ... set [the IVA] so that from now on, [it goes to the nurse]." (A18)

As demonstrated by this example, we found our Wizard of Oz approach to be an effective way to provide participants with the ability to deviate somewhat from the provided instructions, which in turn opened up interesting spaces for further discussion with participants about the potential role of IVAs in their workflows. This exploration may not have been achievable had we instead used current commercial IVAs.

More broadly, participants with prior experience using IVAs found their interactions with our wizarded IVAs to be somewhat smoother than commercially-available IVAs: *"[This IVA] kept going, I like [that] it moves along ... it seems like it [understands] me better"* (A05). In the leg swelling assessment, an aide noted that as they performed the assessment *"even when I was slightly distracted, it waited and repeated"* (A18), and if the aide misunderstood a step *"I'm able to get feedback just in case I need more instructions"* (A15). In some cases, aides went as far as to potentially trust the IVA to decide what information to report to the healthcare team automatically, *"maybe the [IVA knows] something, like the doctor is supposed to know about this."* (A03).

5.3 Investigating the strengths and limitations of the Health Kit and Home Kit physical designs

Building on our analysis around the general impact of tailoring IVA design to home health care on control and privacy, we also found nuanced differences in participants' perceptions of our different IVA designs that we now unpack.

5.3.1 Pros and cons of an IVA that looks like a medical kit vs. blending into the home. In line with our design goals, participants saw the red Health Kit (Figure 3) as explicitly looking like it was intended for health care work. One aide told us, *"It looks more professional ... it could be considered like a medical device"* (A11). Seven participants described the Health Kit as looking like a toolbox, with one saying: *"It looks like a toolbox ... as soon as you open it you have all the tools that you need"* (A07). However, participants pointed out that clients may not like such a medical-looking device. One aide described, *"that [Health Kit] looks too technical, and [clients] are not going to like that"* (A01). In particular, aides perceived that the appearance of the Health Kit might be a drawback for clients who wanted to maintain their sense of independence. As one aide said: *"You want them to feel like they are still home and not in a facility or hospital"* (A24).

By contrast, and also in line with our design goals, aides found the wooden Home Kit to look like it belonged in the home. Seven aide participants independently said it looked like a *"jewelry box"* and another six called it *"part of the furniture."* One participant elaborated: *"It looks like a chest, something you can keep stuff in"*

... you wouldn't know it's a voice assistant ... people have these things in the home, it's familiarizing" (A11). Having the IVA blend into the home was perceived to be better for clients who prefer to be discreet about needing professional home care, a theme that also extended to other aspects of aides' work. For example, aides recalled clients who asked them to wear casual clothing, rather than agency uniforms or scrubs:

"We are supposed to use uniforms, and when we go out with [clients], they suggest, 'You know what, I would prefer you to wear regular clothes, so nobody knows our business that I'm sick.' ... [Clients] want to keep appearances." (A02)

However, aides also raised concerns around a device that blended in too well, since clients may forget or not understand that the IVA was for aides' work. Several aides pointed out that clients with cognitive challenges might wonder *"why is my aide in my jewelry box"* (A18), which could get aides in trouble. Aides also emphasized that, although they liked that the device could hold supplies, there was only so much space they would want to take up in the client's home. One aide said, *"It's not my house, I don't have space"* (A19). Other participants said that it did not matter if the IVA blended into the home or resembled a medical kit. Instead, the functionality of the device is what mattered:

"Even if it has EMS written all over, it just depends on what mindset they're in ... If [you] have a bag with butterflies on it ... if it's needles in there, then you're gonna stick them." (A01)

5.3.2 Aides perceived both IVAs to be portable inside, but not outside, the client's home. At a high level, participants found the red Health Kit to be smaller and lighter than the wooden Home Kit. Aides pointed out how the Health Kit could stand vertically on its side, with its handle raised (Figure 3), *"with these handles, it can be closed and carried"* (A19). We chose this carrying case in part to suggest the option that aides might carry the device with them to and from their client's home. However, aides were clear that, due to their size and weight, both IVAs would be best left in the home. One aide described: *"I have to travel around mostly on trains, so instead of carrying it around, I would leave [the IVA] with my client"* (A08). One potential exception was for client's visits to the doctor, with some aides envisioning bringing the IVA to doctor visits, perhaps enabling the aide to be better integrated into the care team:

"You could take [the IVA] to the doctor and be like, 'Check the [IVA]' and they could review it and see the notes and everything, all she has to do is 'alright let me look at it, let me look at everything.'" (A24)

To make the IVA more suitable for transportation to and from the client's home, several aides suggested making it into a backpack or messenger bag, describing: *"It would have to have straps so we can sling it around like a messenger bag. As a messenger bag it's perfect for us to carry"* (A01).

By contrast, for use within the client's home, aides perceived that the Health Kit could be easily moved from room to room. They discussed using the IVA in the living room, but bringing it into the bedroom to help initiate a bed transfer or tasks where a client might be bed-bound. Some aides also wanted to use the IVA in the bathroom, with one describing: *"[the IVA] can be entertaining, maybe play pop music, to help the client be more happy, [so] they*

accept baths" (A19). Although the wooden Home Kit was generally perceived as less portable than the Health Kit, participants thought it could still be moved around the home, with one client suggesting augmenting its design to include carrying handles: *"I have a makeup box and it has handles I could carry it with from one room to another"* (C06).

5.3.3 Participants were concerned about durability, liability, maintenance, and repair. Finally, aides perceived the Health Kit to be more rugged and durable than the Home Kit, both necessary qualities in aides' work contexts. The Health Kit's hard plastic casing was seen as more cleanable than wood, able to be wiped down for the next aide to use (especially during COVID-19). In addition, participants discussed how the device should withstand getting wet if used in the bathroom, *"when it's wet ... or something happens with water ... when it falls on the floor ... it should not be damaged"* (A23). Along these lines, participants discussed how the device would need to withstand client interactions: *"If [clients] start talking to it, they will probably panic and drop it and break it, or they will throw it away"* (A16).

More generally, participants were concerned about possible breakages and discussed the importance of clear protocols for repair and maintenance. One client asked, *"What happens if it breaks? Then what can we do? Have a number to call someone to come and fix it?"* (C06). Liability for the device or its possible effects were also a concern. For example, one participant wanted to know if they would be held responsible should the device cause a fire:

"Another thing about it too: fires. This [Health Kit] is plastic and this [Home Kit] is wood. What happens after the patient's house catches on fire? What do we do now? How do we explain it? Do we get blamed for that?" (A07)

Finally, aides said the device would need to also work in scenarios of unstable power, *"like when the power is down, you should have a backup plan"* (A06) and envisioned it might handle these situations *"with a long-lasting battery"* (A22).

6 DISCUSSION

Our findings illuminate the impact of tailoring IVA design to home health care work, a complex, multi-stakeholder setting that bridges aides' work contexts with clients' home contexts. We now synthesize key takeaways from our study for IVA researchers, designers, and home care agencies. First, we discuss implications for designing IVAs that enable cooperative work (Section 6.1), including how providing multiple interaction modalities may improve inclusion and transparency, the need to carefully decide whose values to to prioritize when deploying IVAs, and the limits of aides' power to control IVAs in clients' homes. Second, we highlight implications for designing IVAs that enable privacy (Section 6.2), including how designers might leverage IVAs' physical design to communicate privacy mechanisms and opportunities to build 'always on' IVAs that might still preserve privacy.

6.1 Implications for Designing IVAs that Enable Cooperative Home Care Work

Home health care is a complex and sensitive work context. To do their jobs, aides must maintain strong relationships, and perform cooperative work, with clients, their families, other aides, and healthcare providers. HCI research has long examined technology-supported cooperative work in healthcare (e.g., [12, 39, 59, 68, 84]). We add to this literature by discussing implications from our study for how IVAs might impact cooperative work in home health care.

6.1.1 Designers could leverage multi-modal interaction to improve cooperative work. We found early signs that our IVAs might promote cooperative work between aides and clients. In particular, the out-loud nature of IVA interactions may improve transparency, making them more acceptable as work devices for aides since clients are reassured about the purpose and function of the technology. Aides and clients pointed out how, since clients can also hear the information being spoken by an IVA, they may be included in aides' work, potentially enabling aides and clients to work together to accomplish care tasks. This finding opens up opportunities for IVA designers to consider how to design voice-enabled care tasks that might explicitly include roles for both aides and clients, such as by prompting clients to respond to certain questions. This idea connects to recent work that explores how to design intelligent agents to facilitate group conversation among older adults [69]. We are excited for future research to explore the design of effective mechanisms for enabling multi-party conversations between IVAs, aides, and clients.

At the same time, our findings suggest that voice-only interaction was not sufficient. Our participants also wanted image and text-based information displayed on a screen, since some clients may have hearing problems. They further suggested adding camera-based interaction, to enable capture of photos that might communicate a client's symptoms and condition to their care team. Taken together, these findings suggest that IVA designers should move beyond one-modality-fits-all approaches when building IVA applications. Instead, allowing users to choose from a selection of interaction modalities, switch between different modalities, and combine different modes of interaction may amplify these devices' utility in complex work environments like home health care.

6.1.2 Care will be needed when making decisions about whose values to prioritize. In contrast to many other workers, like biological scientists [19] or data analysts [66], aides' work in complex, multi-stakeholder environments, where work tools and technologies require buy-in from clients, families, home care agencies, and healthcare providers, many of whom are in a position of power with respect to aides [54, 79]. Our findings highlight numerous tensions and challenges that suggest how, if IVAs are deployed as work tools in home health care contexts, designers and home care agencies will need to take care when deciding whose values are prioritized.

For example, our findings highlight that, in addition to potentially promoting cooperative work (discussed above), the out-loud nature of IVA interactions could lead to conflict between aides and clients, such as clients not wanting aides to report changes in their health to the care team, even though doing so is a required part of aides' job. On one hand, the additional transparency afforded by interactions with the IVA may provide an important site at which to engage with this conflict by spurring more conversation between

the aide and client about how each party feels, why reporting is required, or how aides might act in clients' best interests. On the other hand, such conflict may not be resolvable: aides may still be required to report data against their client's wishes.

We see two possible paths forward. In one, home care agencies (and IVA designers working with them) could decide to prioritize clients' values, by making any data reporting by the aide optional. This would enable an aide to respect their client's wishes and not report data to the agency. In the other, home care agencies could override clients' values, deciding that the agency's or healthcare system's need for data is more important than the client's wish to keep their data private. In this case, we would suggest that designers build mechanisms that might allow aides to report data discreetly (i.e., via an app or tablet rather than an IVA), so as not to upset the client and cause conflict. Of course, these decisions should be made carefully, since building workflows that encourage or require aides to go behind their clients' backs is ethically fraught and may harm the aide–client relationship, potentially worsening care.

Along these lines, our findings suggest a need for IVA designers to explicitly prioritize the aide–client relationship when building IVAs for aides' work. For example, we saw how IVAs might harm the client–aide bond, and potentially worsen cooperative work, by encouraging aides to look to the IVA for learning their client's preferences, rather than talking with the client. This as an interesting tension that again will require care and attention from designers. On one hand, clients who have multiple aides may become annoyed or fatigued at having to repeat over and over how they like things done, and an IVA may save them the trouble. They may also want reminders for important tasks that might be forgotten (e.g., taking medication on time). On the other hand, clients may relish the human communication with their aide and not want it to be usurped by an IVA.

To deal with this tension, we see opportunities for designers to build IVAs that can be highly personalized to clients' and aides' needs and preferences, and that also might adapt over time as clients and aides get to know each other. In addition to configuring an IVA with clients' and aides' general preferences, IVAs might be designed to allow users to vary their interactions day by day (or hour by hour), since some days clients may feel like talking, while other days they may want to rest. Capturing or inferring interaction preferences of multiple users and figuring out how to balance them appropriately is an exciting area for future work to explore.

6.1.3 Aides' power to control IVAs may be limited in clients' homes.

A major goal of our study was to explore the impact of tailoring the physical appearance of an IVA to explicitly suggest it was an aide's work device, to be controlled or operated by the aide. Although at a high level participants clearly saw the IVA as a machine for aides, and even said "*this machine is for the aides*," questions of who ultimately controlled the device remained nuanced and complex. For example, aides felt that, regardless of who the IVA was designed for, since it is in the client's home, clients have the authority to decide about its usage, with aides having to respect clients' decisions. Alternatively, clients looked to doctors for authority on whether to accept the IVA. In addition, although aides were clearly the intended users of our IVAs, both aides and clients discussed how clients might decide, and have the authority, to use the device,

raising concerns that they might bypass the aide, change their care plan, or break the IVA. These findings suggest that there may be fundamental limits on how much control aides might have over any technology tool if the context of use is in the client's home and related to the client's care. Ultimately, acceptance of any device as a work tool for aides will require buy-in from clients, who will in all likelihood retain the power to use, alter, or reject the technology.

At the same time, some of our findings suggest that aides may not *want* to be in control, and therefore responsible or liable for, the IVA. Aides were concerned that they might be held responsible for breakages and/or maintenance of the device. They also worried that they may be unable to prevent clients from using the device, possibly leading to privacy violations or changes to clients' information that they could not prevent. These findings highlight a clear need for home care agencies who might deploy technology in aides' work to develop and communicate clear policies around liability, repair, and maintenance. Moreover, IVA designers should be aware that, in attempting to empower aides by assigning them control of the IVA, they might inadvertently exacerbate systemic inequities and disempower aides by also assigning fault or liability, especially if they do not have the power to prevent inevitable problems (e.g., a client demanding to use and breaking the IVA). Designers of future IVAs for work settings will need to play close attention to complex power dynamics like those uncovered in our study and take care when making decisions about assigning control of, or responsibility for, the operation and safety of these devices in complex, multi-stakeholder work settings.

6.2 Implications for Designing IVAs that Enable Privacy

Our findings also yield implications for how IVA designers might build devices that provide users with privacy choices. At a high level, we discovered that the general appearance of an IVA may preserve or compromise privacy. We designed our red Health Kit device to look like an aide's medical kit and, while participants did think it looked like a professional tool intended for healthcare, they also pointed out that its appearance and bright red color may compromise the privacy of some clients who might prefer to keep private that they receive professional home care. On the other hand, our findings suggest the wooden Home Kit sometimes did too good of a job blending in, leading to concerns that, when aides use the IVA, clients might think they're rifling through the client's personal belongings. At the same time, commercial IVAs currently do not provide users with any choice over the appearance of the device. Once again, we see opportunities for IVA design to move away from once-design-fits-all approaches. Future work might explore how providing people with more choice over the color, form factor, and general appearance of IVAs might better support users with diverse needs or preferences at home and/or at work.

6.2.1 Designers could leverage IVAs' physical design to communicate privacy mechanisms. In addition to the privacy implications associated with the IVAs' general appearance, the physical embodiment of our IVAs as hinged cases that could be opened and closed further impacted participants' perceptions of privacy: when open, the IVA would be listening and recording data; when closed, it would be

turned off. We see these findings as being in line with Nissenbaum's theory of privacy as contextual integrity [51]. According to Nissenbaum, contextual integrity demands that information gathering and dissemination be appropriate to the specific context and obey the governing norms within that context. In our work, the norm associated with the IVA being closed is that it is turned off, and therefore should not gather or disseminate information. By contrast, the norm associated with it being open is that it is on, and information participants say may be recorded by the device. These findings have implications for IVA designers; we see rich opportunities for future work to explore how IVAs' physical design might be leveraged to enact privacy mechanisms in ways that match users' existing norms and mental models, helping to build trust in these devices.

6.2.2 Opportunities to design 'always on' IVAs that preserve privacy.

Although participants in our study generally wanted to be able to trust that the device was turned off when it was closed, this policy did have some drawbacks. Aides may forget to open the device when they arrive or be unable to interact with it from a distance when needed in an emergency. It was also unclear how reminders would work if the IVA was closed at the time the reminder would be activated. Participants' proposed solutions included having a physical button on the outside of the device that could be pressed to turn it on while closed, which would still not work for interaction at a distance, or having a specific phrase that might activate the device in an emergency, even when it was closed. Participants seemed unaware that this second solution may reintroduce 'always on' listening for the special phrase, which was what they wanted to avoid.

Our participants' concerns regarding 'always on' IVAs corroborates recent work that points out the privacy and security risks of these devices [23, 76]. Prior work explored if providing the ability to customize privacy preferences might improve user experience and trust [23], an approach that may also be relevant in our context by giving users choice and control over what data is shared. We further see opportunities to explore 'always on' IVAs that enable the computation required to listen and recognize speech to be done locally, avoiding the need for a users' speech to be uploaded to the cloud. Then, users might explicitly decide what data should be communicated and to whom. Currently, several IVAs exist that enable local and/or offline speech recognition [1, 2, 63]. Future work is needed to explore how these devices might perform and if they might prove useful in privacy-sensitive contexts like home health care work.

7 CONCLUSION

This paper explored the impact of tailoring IVAs to home health care work. We designed two IVAs with different physical embodiments: one to look like an aide's medical kit and another to blend into the home. We also created a voice-based application that provides support for home care tasks. Via a qualitative study with 25 aides and seven clients, we showed how our IVAs may support cooperative work by improving inclusion and transparency, while potentially causing conflict that requires IVA designers to decide whose values to prioritize when deploying IVAs. We also discussed

how aides' power to control IVAs in clients' homes may be inherently limited. Finally, we provide implications for designing IVAs that preserve privacy, both by leveraging the physical design of IVAs to communicate privacy mechanisms, and by building 'always on' IVAs that use local computation to enable privacy. Our study expands the HCI community's knowledge of how to design IVAs for complex work settings like home health care.

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A TYPICAL DIALOG FLOWS WITH OUR VOICE-BASED APPLICATION

A.1 Managing Day-to-Day Tasks: Client Preferences

IVA: Welcome to your home health agent. I can help with managing care preferences or doing a leg swelling assessment.

Aide: I would like to adjust my client's preferences.

IVA: What kind of preference would you like to add? Examples are food, exercise, or personal care?

Aide: I would like to add an exercise preference.

IVA: Alright. I'm going to need a bit more information. What is the exercise the client wants to do?

Aide: Take afternoon walks.

IVA: Please tell me when the client likes to take afternoon walks?

Aide: Around 3:00 pm

IVA: Is that 3pm?

Aide: Yes

IVA: Does the client need assistance with this exercise?

Aide: No the client doesn't need assistance

IVA: Okay we have set a client preference for afternoon walks at 3pm. Now that you have added to the client preferences would you like to set a reminder for this or exit?

Aide: Set reminder

IVA: Ok! Reminder set for preference of taking afternoon walks at 3pm. Now that you have set a reminder, would you like to hear the client's preferences for your shift, or exit?

Aide: Exit

A.2 Guidance for Medical Tasks: Leg Swelling Assessment

IVA: Welcome to your home health agent. I can help with managing care preferences or doing a leg swelling assessment.

Aide: Leg swelling assessment.

IVA: Starting the leg swelling assessment. Looking at the client's legs do you notice them to be more swollen or tight compared to last time?

Aide: More swollen.

IVA: Okay, let's run a leg swelling test. Firmly press on the middle of the shin for at least two seconds, and then note how deeply the skin remains depressed. Let me know when to continue, or if you want me to repeat the instructions.

Aide: Continue.

IVA: Does the skin indentation look like one of these? (image displaying on the screen)

Aide: It looks kind of like the second image.

IVA: The second image has roughly two millimeters of skin indentation, which is a moderate reading, is this what you see?

Aide: Yes.

IVA: This is the third day of moderate readings. Given the client's heart failure history, this is concerning. Would you like to report this?

Aide: Yes.

IVA: Who would you like to send the report to? You can say: Client's nurse or family, or both.

Aide: The client's nurse.

IVA: Ok, I sent the report to the client's nurse. Would you like to leave a note for the next aide to monitor leg swelling?

Aide: Yes.

IVA: Great, I've recorded a note. You have successfully completed all steps! Goodbye.

A.3 Initial Tutorial Task for Familiarization with the IVA

IVA: To get started, how old are you?

Aide: 40.

IVA: What is your gender? (Male, Female, Non-binary offered as text suggestions on-screen)

Aide: Female.

IVA: What is your highest level of education? (Options provided on screen)

Aide: Completed some college.

IVA: How many years have you been a home care worker?

Aide: 20 years.

IVA: Thank you for helping me get to know you, to proceed with the study, can you ask me: what do you do?

Aide: What do you do?

IVA: In today's study, we will walk through two tasks. Adding a preference, and recording leg swelling. You can ask me to add a preference or start a leg swelling assessment. Then we will walk through either task. Do you want to know more? Or return to the home page?

Aide: I don't know.

IVA: I didn't understand, do you want to know more or finish the tutorial?

Aide: Yes tell me more.

IVA: I will also ask guiding questions like: Would you like to create a report for this reading. At any time you can ask me to restart by saying: return to home page. Can you ask me to return to the home page?

Aide: Return to the home page.

IVA: Welcome back to your home health agent. (The IVA transitions back to the main page)

B PROMPT GIVEN TO PARTICIPANTS FOR THE CLIENT PREFERENCES TASK

Prompt. You have been working with Emerson since his diagnosis of heart failure six months ago. Emerson's doctor has told him to add unassisted exercise into his daily care plan. He wants to start going for afternoon walks. You are now going to add and save this information in the voice assistant.

Key Details.

- Start the voice assistant by saying, "Start client preferences"
- Client wants to add an exercise preference
- Prefers to take afternoon walks at 3:00 pm
- Prefers unassisted exercise

C PROMPT GIVEN TO PARTICIPANTS FOR THE LEG SWELLING TASK

General Information. The patient has a history of heart failure and cardiovascular issues. Leg swelling is a common symptom of heart failure. Part of the patient's daily care routine is checking for leg swelling, which is caused by excess fluid trapped in the body's tissues.

Prompt. You have been working with Emerson since their diagnosis of heart failure 6 months ago. Emerson is sitting in a chair and has been remarking about their legs being more fatigued than usual. You notice their legs are more swollen than yesterday. You decide to start a leg swelling assessment.

Key Details.

- Start the voice assistant by saying, "Start leg swelling assessment."
- Legs are more swollen
- There is 2 mm of skin indentation

D CODEBOOK

Table 3 summarizes the codebook produced by our analysis.

Table 3: Summary of themes and codes from qualitative data analysis.

Theme / Code
Understanding how IVAs might be acceptable as work tools (5.1) Real life feasibility Multilingual So when is this coming out Time saving Device reliability Acceptability Explaining device Functionality perception Multimodality Ease of use Interaction Cross communication Scope of work Telehealth Cooperative Work Trend detection Ownership Accountability Loss of Agency
Exploring how IVAs tailored to home care work might impact privacy, surveillance, and control (5.2) Authority Ultimate choice Mediating conflict Power imbalance Agency restrictions Access to information Client use Hands off Key Privacy IVA Experience WoZing
Understanding the strengths and limitations of the Health Kit and Home Kit physical designs (5.3) Responsibility Medically Explicit Emergencies and dispatch Life alert Specificity Throwing Multiroom Blending into the client Durability Form factor Client appropriateness