Using Intelligent Voice Assistants to Enhance the Provision of Home Care for Older Adults

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Abstract
Recent demographic shifts in the U.S. population mean more older adults are seeking care in the home for conditions like heart disease, cancer, and dementia. Simultaneously, recent advancements in intelligent voice assistant (IVA) technology create a unique opportunity for design innovations to serve the needs of both these patients and their caregivers. In this position paper, we provide background on the social and technical challenges presented by the shift towards home care, and propose ways in which IVAs could be designed to address these problems. We conclude with a set of research questions for the HCI community that might draw us closer to realizing this potential.

Author Keywords
Intelligent voice assistants; conversational agents; conversational interfaces; older adults; caregivers; home care

Introduction
As the population ages, healthcare in the U.S. is in the midst of a tectonic shift, from a focus on treatment in hospitals and other tertiary care centers, to preventive and post-acute care in less centralized settings–most notably, the home. With this shift, there emerges a growing need for research into the technological needs of both the patients who receive care in their homes and the caregivers who are critical to patients' wellbeing.

Simultaneously, the recent mass commercialization of intelligent voice assistants (IVAs) presents a unique opportunity for addressing the problems faced in this care context. As a novel interface, IVAs offer a correspondingly novel design space, many dimensions of which may be uniquely suited to the needs of older adults in home care. For most people, speech is the most natural way to communicate, making IVAs a compelling interface for non-digital natives. Additionally, IVAs can be used in an eyes- and hands-free manner, allowing these devices to be utilized without the need to physically reach or see them. Finally, voice-enabled interfaces may be easier to use for people with visual and motor impairments, which become more prevalent as we age. The rapid adoption of IVAs into the product lines of nearly every consumer tech giant – Apple's Siri, Amazon's Alexa, the Google Assistant, and Microsoft's Cortana – make their exploration even more urgent today.

Already within HCI, recent work has begun to explore the issues that arise when this novel technology is deployed in related contexts. Bickmore [1] has studied how IVAs can be used safely in healthcare, given the often life-and-death nature of the work. Researchers have also studied the use of IVAs by older adults, through systematic analysis of Alexa reviews [7] and the deployment of Alexa skills providing audio prompts for assisting individuals with dementia with activities of daily living [3].

In this position paper, we propose a research agenda building on this work to investigate how IVAs might be designed and developed to further meet the specific needs of older adults and their care teams. We begin by providing background into the needs of the older population and their caregivers. We then articulate the ways in which IVAs may be designed to address these problems, and close with a set of research questions for the HCI community.

Challenges Older Adults Will Face

The U.S. Census Bureau's 2017 National Population Projections predicts that by 2030, the number of older adults will be greater than the number of children for the first time in U.S. history[2]. With this demographic shift comes an increase in the prevalence of specific needs associated with aging, as well as an increasing role for home care and the technological tools that might support home care delivery.

As described by Czaja and Sharit [4], while older adults are able to learn new technologies, they often face multiple challenges associated with its adoption and use. Many of these challenges hinder the adoption of technology, such as not knowing the benefits of specific tools, not having technological support available, monetary cost, and fear of failure.

A significant segment of challenges relate to the interfaces of the technologies themselves, which are often not designed adequately for older adults. As we age, we are more likely to experience difficulties with our vision, such as decreased ability to resolve detail, to adjust to different viewing distances, or higher susceptibility to problems with glare. We are also more likely to experience problems with hearing, such as an increased sensitivity to loudness, and motor skills, such as less flexibility and more disruptions in coordination. Other impairments such as memory loss and arthritis also increase in frequency with age. [4]

In addition to the impairments that naturally arise with aging, older adults are more susceptible to illnesses like heart disease, cancer, and dementia, which create needs for at-home care, often delivered by a formal, paid caregiver. We discuss the needs of these individuals in the next section.

Challenges Caregivers Will Face

Caregivers simultaneously face a slate of their own challenges, many of which emanate from the nature of the work – laborious, with long and unpredictable hours – and the way clinical care teams currently exclude or devalue caregivers' perspectives [11].

A caregiver is defined as a person who is dedicated, either formally or informally, to assisting another person with recovery from illness, daily activities of living, or some combination thereof. Caregivers are often close friends or family members, for example spouses, children, or siblings, but in many cases, caregivers are unrelated professionals. In fact, recent work has shown that home health aides (HHAs), caregivers who work within agency structures under the supervision of a doctor and a nurse to provide home care, are the fastest growing segment of the American workforce [6].

The type and degree of difficulty of the assistance a caregiver provides varies depending on the needs of the recipient and the training of the caregiver. These tasks might range from tube feeding and administering injections [5] to filling out online questionnaires on the patient's behalf [10] and accompanying them to doctor's appointments [8]. Despite the vital nature of caregivers' work, and patients' increasing reliance on them, care work itself remains difficult and highly stressful [11, 12]. Caregivers are often expected to provide complex services with little training, and tend to be financially stressed [5, 8, 11]. A recent study found more than three-fourths of caregivers experience feelings of anxiety, fatigue, interference with normal activities and depressed mood [9].

Many of the on-the-ground symptoms of these systemic inequities are addressable through technology. In prior work understanding the needs of home health aides (HHAs) caring for adults with heart failure, we found these caregivers were especially interested in tools that would facilitate communication with their agency coordinators and nurses [8, 13]. These operational and clinical authorities were there to provide help in uncertain situations, such as when a patient's blood pressure fell below a certain level, but were often hard to reach–a problem the aides themselves readily acknowledged could be addressed through systems for real-time text and video communication.

Prior work also showed that aides envisioned roles for technology in helping them maintain and improve their skills [8]. Aides voiced a need for simple tools like an interface storing educational videos to help them retain information relayed in agency-mandated training courses, for example how to do CPR. But there was also potential for tools like crowdsourced databases of solutions to common problems to help them in their daily tasks.

Finally, aides saw a role for technology in helping them more efficiently and effectively document their work [13]. Such documentation is critical to how these formal caregivers' labors are recognized and paid; yet, current systems often fail to accurately reflect whether they have completed the tasks required of them, and prior work has also shown that disagreements over what the aide was supposed to do for a patient can adversely effect the aide-patient relationship [8]. Here, we also see potential for accessible systems for data recording and processing to address caregivers' needs.

IVAs as a potential solution

We consider IVAs to be a technological solution with the potential to address challenges on both sides of the patient-caregiver dynamic in the home care of older adults.

Currently, IVAs are sub-optimal for patients and caregivers alike. For example, the need for most IVAs to be setup and

managed via a mobile application is often not sufficiently simple for older adults.

If designed properly, IVAs could uniquely address the needs of this population: for example, an IVA for an older adult who experiences difficulty hearing fast and high-pitched voices could be calibrated to 'speak' more slowly, and with a lower pitch.

IVAs also have the potential to assist caregivers. For a home health aide who cannot easily and quickly access validated medical information while on-the-job, a voice assistant could be used as a more approachable way to ask care-related questions. Voice assistants could also serve as a hands-free way to document important caregiving information, such as pain levels, when medications were taken, or what a patient ate throughout the day, enabling the caregiver to focus on interacting with the patient.

We summarize potential IVA solutions to specific patient and caregiver problems in Table 1. In the following section, we propose a set of research questions for the HCI community that might investigate the benefits and drawbacks of IVAs for use in this context, with the goal of creating tools that ultimately facilitate better care delivery for patients and caregivers alike.

Stakeholder	Need	Potential IVA Solution
Older Adult	Short-term memory support	Multi-modal interactions (including visual displays), shorter utterances, room for more repetition
	Help hearing	More usable ways to make speed slower or change the pitch of the voice plus visual aides
	Increased security	More measures to prevent scams, privacy violations, etc, and to create awareness about risks
	Increased safety	Features that allow for quick identification and follow-up actions to situations such as falls
	To setup IVA independently	IVAs with easy setup instructions that do not need to be connected via a mobile application
	To know what's happening to their information	Basic explanation of how things work and who is involved
	Social interaction	More features that grant agency to connect with others
	Increased psychological safety	Ability to create filters for individuals with dementia to sort out potentially harmful content, such as disappointing news
	To be understood	Better models that understand older adult utterances and respond well to slower speech with more pauses
Caregiver	Access to medical information while on-the-job	Approachable and trustworthy conversational agent to answer care-related questions
	Hands-free ability to document information mid-task, e.g., pain levels or when medications were taken	Dictation-like conversational interaction with an agent that can also ask for corrections
	Knowledge of client's safety, e.g. in the event client falls while in another room	Feature that detects when a client falls and alerts the caregiver appropriately

Table 1: Examples of caregiver and older patient needs that might be addressed through IVAs

Research Questions

Compelled by the challenges patients and caregivers face, we propose research into the following:

RQ1. How might the introduction of IVAs change the patient-caregiver relationship?
We are intrigued by how the introduction of an intelligent agent might change the power dynamics of the patient-caregiver relationship. Prior work has shown caregivers often serve as an authoritative health record of sorts for patients who have difficulty keeping track of the many appointments, medications, and lifestyle adjustments that a complex medical condition can require [8]. With the introduction of an IVA, one might imagine a dynamic in which both patient and caregiver query the IVA–out loud–for this information. With such a scenario in mind, we ask:

- How does a caregiver's credibility to the patient change when an IVA is introduced?
- Do patients assign authority to an IVA in the same way they assign authority to a caregiver, or a doctor?
- How can an IVA handle disagreements between patients and caregivers?
- What other novel challenges arise when thus altering the patient-caregiver dynamic, and how might we balance mitigating those challenges with respect for both patient and caregiver autonomy?
- In a care context, what is the range of support an IVA can provide? What is the range it *should* provide? For example, an IVA may be equipped with a simple decision support algorithm that tells a caregiver when a patient's reported blood pressure level is considered elevated; but would providing this information in this format result in caregivers experiencing more or less stress over their patient's health?
- Who in the clinical hierarchy should decide what an IVA should be equipped to provide? Who should control the decision-making algorithms: the discharging doctor? The patient's home care agency? The patient themselves?

RQ2. What technical and design advances are needed for IVAs to be useful in these contexts?
We see significant work ahead in designing and developing IVAs such that they are ready for use in home healthcare settings. We consider:

- What sources of data should IVAs be equipped with to provide useful feedback in a care setting? Is voice input from patients and caregivers enough, or should an IVA have additional sensors, like a connection to the patient's blood pressure cuff?
- Modern approaches to dialog management use reinforcement learning to develop the policies used by the agent in test-time contexts. In health-related applications, however, clinical guidance is often critical to acceptable use of a system. What are semi-supervised approaches to conversational agent development that might retain the benefits of RL approaches while enabling the clinical supervision required?
- Privacy is particularly relevant in a medical context. How can IVAs be built to preserve patient and caregiver privacy, while maintaining usefulness in the room and enabling refinement of underlying algorithms from real-world data?

- What are older adults' and caregivers' privacy expectations regarding the information they share with their IVAs, and how can the technical and interaction design of IVAs respect those expectations?
- Can modifications increase the percentage of older adults and caregivers able to successfully use IVAs? If so, what guidelines should be followed for making these modifications? How can visual cues (such as text and an image) help adults and caregivers interact with IVAs?

Conclusion

In the next decade, the proportion of older adults is expected to be larger than ever before, and the segment of the workforce dedicated to providing them with care in the home is similarly expected to grow. Aging itself can introduce new challenges, such as hearing loss and arthritis, that hamper older adults' daily activities of living; in addition, older adults are more likely to develop illnesses requiring significant at-home medical care, such as heart failure. When impairments due to age and/or disease reach a certain threshold, these patients begin to need dedicated caregivers, often family members or externally hired home health aides. Caregivers in these roles also face challenges in their work, like a lack of ability to communicate in real-time with the patient's broader care team. We believe that intelligent voice assistants (IVAs) could be better designed to be usable by older adults experiencing different impairments, and to address caregiving needs that are currently under-considered. We call for the HCI community to engage in research and discussion around the role of IVAs in the patient-caregiver relationship, and the technical and design advances needed for IVAs to be useful in these contexts.

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