

ASSISTIVE TECHNOLOGIES FOR INDIVIDUALS WITH ALZHEIMER AND  
INVESTIGATING MAIN CHALLENGES OF ADOPTING THE TECHNOLOGIES

by

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## ABSTRACT

YUN QU. Assistive Technologies for Individuals with Alzheimer And Investigating Main Challenges of Adopting the Technologies (Under the direction of DR. ALBERT PARK)

The number of individuals with Alzheimer's Disease (AD) is rising dramatically in the United States. Assistive technologies serve to assist with the care recipients' independence. However, while many technological systems for individuals with AD have entered the market, the adoption rate is low despite the potential benefits they intend to provide. Researchers demonstrated how existing and developing technologies can fit growing needs in Alzheimer's care, yet little work has explored how real-life AD care routine cope with technologies. To identify daily-life challenges in using assistive technologies, we conducted semi-structured interviews with 15 AD family caregivers. Our findings characterize the needs of transferring everyday technologies to AD assistive devices and further research directions that address family caregivers' aspirations. The goal of this project is to provide a base for a more comprehensive understanding of individuals with AD and their family caregivers as users and consumers of technology to help designers and developers to make the assistive system more effective, and therefore, improving their living qualities.

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## LIST OF ABBREVIATIONS

ACC	The Augmentative & Alternative Communication Device
AD	Alzheimer's Disease
AT EASE	Automated Technology for Elder Assessment Safety in the Environment
COACH	Cognitive Orthosis for Assisting activities at Home
ECG	Electrocardiogram
HATS	Hearing assistive technology systems
HRQoL	Health-Related Quality of Life
ICT	Information and Communications Technology
IMPACT.	The Improvement in Memory with Plasticity-based Adaptive Cognitive Training
IoT	Internet of Thing
REACH II	Resources for Enhancing Alzheimer's Caregiver Health II

## CHAPTER 1: INTRODUCTION

Alzheimer's disease (AD) is a progressive neurodegenerative disease and causes death by affecting an individual's cognitive function. It was estimated that in 2018, \$277 billion national costs are for Alzheimer's and other dementias, of which \$186 billion is the cost to Medicare and Medicaid (Lynch 2018). The Alzheimer's Association (2018) states that around 16 million Americans provided unpaid care for an estimated 18.4 billion hours in the forms of physical, emotional, and financial support of someone with Alzheimer's. This was valued as a \$232.1 billion contribution to the nation. In addition, there are \$11.4 billion in extra healthcare costs for Alzheimer's and other dementia caregivers for difficulties related to the care (Annual et al. 2016; Lynch 2018). By 2050, the number of older Americans affected by Alzheimer's disease (AD) and related dementias is projected to jump to as many as 13.8 million individuals compared to 5 million in 2007 (Alzheimer's Association 2007; Bharucha et al. 2009). Across the globe, the number of AD cases is expected to reach 115 million by 2050, which is triple the current number (World Health Organization (WHO) and Alzheimer's Disease International 2012).

The increasing prevalence of Alzheimer's has a subsequent impact on societies, those with Alzheimer's, their families and caregivers. According to Bharucha's study (Bharucha et al. 2009), a \$1.2 billion annual cost of healthcare expenditures could be saved by a 1-month delay in nursing home placement of all Americans older than 65 years. In light of socioeconomic forecasts and care quality challenges, there is an emerging interest in assistive technologies that have the potential to improve the living independence of individuals with AD (Lazar, Thompson, and Demiris 2018; Mokhtari et al. 2012).

Assistive technologies in this context refer to technical gadgets with virtual or Information and Communications Technology (ICT) components (Bharucha et al. 2009). The interventions cover both target individuals with AD and their family caregivers. These assistive technologies serve to increase the independence of the individuals receiving care. The development of cognitive aids, video and audio technologies, environmental sensors and advanced integrated sensor systems gradually address family caregiver's attention. These technologies aim to improve the health, safety, and quality of living of individuals with AD and their family caregivers (Bharucha et al. 2009). While many technological systems for individuals with AD have entered the market, the adoption rate is low despite the potential benefits they intend to provide (Astell et al. 2019; Lee and Coughlin 2015). According to Astell (2019), the reason behind is partially due to lack of awareness or challenges in accessibility. In addition, a study also noted that family caregivers' gender or family statuses also affect their attitude towards IT adoption in AD care. For example, female family caregivers appreciated more than male caregivers a tracking device. More studies have shown that individuals with AD and their family caregivers are often afraid of misusing technology, and sometimes they are even unable to use it given their limited technological experience (Carretero 2015; Lee and Coughlin 2015; Wangmo et al. 2019; Zhang et al. 2014). Moreover, the usability of assistive technologies has also been widely investigated by researchers. For example, a study selected devices and let participants (caregivers or individual with AD) provide feedback on those devices based on their user experience through the pilot study (Riikonen, Mäkelä, and Perälä 2010). Twenty-nine different technical devices were tested in the study. Result showed that the most accepted were passive devices that did not require activation or active control by the individual with

AD (Riikonen, Mäkelä, and Perälä 2010). While many studies are trying to find reasons behind the low adoption rate, people are not focused on what it is really like to live with Alzheimer's. Based on the fact of low adoption rate, we are not clear if there are alternative techniques been used instead, and what kind of challenges do AD patient encounter in using the alternative assistive technologies. Our research aims to get a full understanding of the real-life adopted AD assistive technologies, and investigate how adopted technologies fit into their care process and understand the everyday challenges of technology adoption. We investigated this by conducting a qualitative study that interviews with family caregivers.

## CHAPTER 2: RELATED WORK

To obtain an overview of the developed assistive technologies for AD care process, we researched existing technological systems in AD care using two databases, MEDLINE (1965-present) and Embase (1967-present), then used a Google Scholar search engine for other available literature. The database searching terms will include “assistive technologies”, “devices”, “sensors”, “wearable sensors”, “healthcare”, “caregiver”, “smart homes”, “Alzheimer’s” and “dementia”. Based on the literature review, we categorized existing assistive technologies into five types by their functionalities, and listed few research prototypes and commercial products as examples for a more comprehensive view and deeper understanding. Table 1 is a summarization of the five type of existing assistive technologies.

Table 1. Summarization of the five type of existing assistive technologies.

Type of Assistive Technologies of AD	Functional Deficit	Description and approach	Reference
Monitoring Assistive Technology for safety	Monitor	Safety and monitoring tools can innovatively monitor individuals with AD. They incorporate alternatives to set off cautions by monitoring (alert and pager units, fall detectors, flood finders, water temperature screens, lighting) and in this manner point to bolster the prosperity, autonomy, and security of the individual with dementia as well as to supply consolation to caregivers.	Review 2004; Knight et al. 2005; Di Rienzo et al. 2005; Lymberis and Paradiso 2008; Bharucha et al. 2009; Robinson et al. 2009; Dark 2014; Carretero 2015; Knapp et al. 2016; Lorenz et al. 2019; Weber et al. n.d.
Therapeutic Assistive Technology	Entertainment	Therapeutic techniques intend to help cognitive and physical fitness, entertainment, leisure, and wellbeing. Therapeutic technologies cover interventions for individuals with AD and caregivers the usage of therapeutic and assistive technology and ICT	Dark 2014; Lorenz et al. 2019; Leuty et al. 2013; Lewis et al. 2015; Tapus and Matarić 2008; Cevasco 2010; Wall and Duffy 2010
Cognitive Aids Assistive Technology	Cognitive Aid	Cognitive aids technologies aim to assist individuals with Alzheimer's disease to engage in basic daily activities	Levinson 1997; Beigl 2000; Gorman et al. 2002; Pollack et al. 2003 Bharucha et al. 2009; Dark 2014; Robert et al. 2014; Richard W. DeVaul n.d;
Communication Assistive Technology	Socialization	Communication assistive technologies include the use of technology that helps to enhance social interaction and networking	Hanley and Lusty 1984 Bourgeois 1990 Levinson 1997; Gorman et al. 2002; Pollack et al. 2003; Dark 2014 Burns et all. 2015; Carretero 2015 Lorenz et al. 2019
Remote Care Assistive Technology	Care Aid	The remote care assistant, control and support function can assist individuals with AD through telecare and telehealth interventions. We define telecare and telehealth as interventions facilitating healthcare through various means of technology from a distance, starting from sensors to assistive robots	Seelye et al. 2012; Davis 2013

## 2.1 Monitoring Assistive Technology for safety.

Safety and monitoring tools can innovatively monitor individuals with AD. They incorporate alternatives to set alarm by monitoring (e.g., alert and pager units, fall detectors, flood finders, water temperature screens) and in this manner to bolster the prosperity, autonomy, and security of the individual with AD as well as to supply consolation to caregivers (Knapp et al. 2016). Example include activity monitoring, wandering and strolling tools, telemonitoring and so on. Smart homes also belong to this category for its ability to monitor family's daily activities in home through remote-controlled domestic computerization frameworks, such as door sensors (Carretero 2015).

According to a systematic review of types of AD assistive technology, 70 monitoring assistive technologies for safety were described in research literatures before 2015 (Kurosu 2015). For example, the Automated Technology for Elder Assessment Safety in the Environment (AT EASE) uses the ZigBee wireless verbal exchange protocol as a sensor-monitoring program. This machine uses motion sensors and sensors on household hardware, which include taps and toilets. Depending on methods of alert triggered, records may be dispatched directly to family members, support personnel, or a building protection group of workers. This sort of wireless machine may be beneficial to families with a member within the early stages of AD (Dark 2014).

Vital signs and metabolic parameters are also monitored factors of the health status of individuals with AD. The monitoring of crucial signs and fundamental metabolic parameters has progressed substantially (e.g., Medical Mood Ring, Tadiran's MDkeeper) (Bharucha et al. 2009; Lorenz et al. 2019; Review 2004). There are existing assistance technologies that support textiles with inserted biosensors that allow persistent inaccessible

physiologic checking of numerous imperative capacities (Knight et al. 2005; Lymberis and Paradiso 2008; Di Rienzo et al. 2005; Weber et al. n.d.). These smart technologies can send alerts to family and proficient caregivers of variations from an earlier pattern and occurrence of therapeutic conditions that will sometimes escape discovery until complications are apparent and unavoidable.

Mobile Locater (Altus et al. 2000) is an electronic device designed to help caregivers locate a patient who has eloped quickly. Similarly, Care Media is also being developed to prevent instances of aggression by automatically recognizing and quantifying human behavior (Carrillo, Dishman, and Plowman 2009a) with 80% accuracy. Despite prototypes mentioned above, we can also find monitoring technological products in the marketplace, such as Moxee Signal, AngelSense, Project Lifesaver and Medical Alert Systems ([www.safety.com](http://www.safety.com)). Those are wearable devices, which functions by transmitting the location of people with AD in real-time. They are equipped with a mobile app for caregivers. If a user gets lost or needs additional help, they can send their location through the device and communicate through the two-way receiver. Caregivers can track a user's movement through the mobile app and set alerts if the user wander past the defined area. Moreover, some products are designed for assisting caregivers in daily care activities, for example, floor monitoring system: alarm mat, motion sensitive light and GSM camera (Riikonen, Mäkelä, and Perälä 2010). Table 2 summarizes available AD products for monitoring technologies for safety.

To sum up, the monitoring assistive technology could help to solve family caregiver's concerns to individual with Alzheimer's Disease, such as getting lost and getting hurt. It thus helps to decrease the family caregivers' anxiety and improves the safety of

individual with Alzheimer's Disease in their daily life activities. However, the limitation of monitoring technology is also considerable. The monitoring function is not ethically acceptable to some individuals with Alzheimer's Disease, as people may feel the monitor would take their freedom away. Individual privacy could be violated because of the tracking function (Robinson et al. 2009).

Table 2. Available AD Products for Monitoring Assistive Technologies for Safety

Type of Assistive Technologies of AD	Product Name	Description and approach	Level of Maturity
Monitoring Assistive Technologies for Safety	SmartShirt	Monitors EKG, heart rate, respiration, temperature and a host of other important functions (MIRACLE and SIMS 1998).	Research prototype
Monitoring Assistive Technologies for Safety	Elder Assessment Safety in the Environment (AT EAST)	An automated technology that uses motion sensors and sensors on household hardware, which include taps and toilets. It sends a record to caregivers when alert is triggered (Dark 2014).	Research prototype
Monitoring Assistive Technologies for Safety	Mobile Locater	An electronic device designed to help caregivers locate a patient who has eloped quickly (Altus et al. 2000).	Research prototype
Monitoring Assistive Technologies for Safety	Care Media	A system that can prevent instances of aggression by automatically recognizing and quantifying human behavior with 80% accuracy (Carrillo, Dishman, and Plowman 2009b).	Research prototype
Monitoring Assistive Technologies for Safety	Moxee Signal	A device that can share location and get alert context instantly with audio recordings (www.safety.com).	Commercial product
Monitoring Assistive Technologies for Safety	AngelSense	A wearable device that can record and replay a single message of up to 10 seconds in length (www.safety.com).	Commercial product
Monitoring Assistive Technologies for Safety	Project Lifesaver	Aid communication through direct selection (www.safety.com).	Commercial product
Monitoring Assistive Technologies for Safety	Medical Alert Systems	A device enables 24/7 connection to emergency operators at the push of a button (www.safety.com).	Commercial product

## 2.2 Therapeutic Technology

Therapeutic technology intends to help cognitive and physical fitness, entertainment, leisure, and wellbeing. Therapeutic technology covers interventions for individuals with AD and family caregivers the usage of therapeutic and assistive technology and ICT (Dark 2014; Lorenz et al. 2019). These can encompass healing

approaches using robots (e.g., The robotic seal, Paro), art therapy delivered using technology, and distance psychotherapeutic support groups (Lorenz et al. 2019). Games introduced to contribute to cognitive schooling or reminiscence are also covered in this category (Leuty et al. 2013; Lewis et al. 2015; Lorenz et al. 2019).

Music has been embedded in assistive tools and devices and have been used in various methods with this population for memory retention or strain reduction (Lorenz et al. 2019) (Tapus and Matarić 2008). It has a calming impact on most individuals with AD and lessens their agitation, anxiety, and depression (Descartes et al. 2009). For example, some studies programmed active involvement of a therapist or professional musician in playing music directly to the participants (Cevasco 2010). The therapist used a guitar to lead the song and djembe to lead rhythms at some stage. Participants generally chose their preferred device for the rhythm activities, choosing a paddle drum, shaker, or maraca. Data for 38 individuals with AD suggested that 62% of the participants evinced a positive effect while the therapist utilized impact and proximity combined. Other studies have resorted to the simple presentation of prerecorded music (Wall and Duffy 2010). Apart from music embedded technologies, we listed more examples including prototypes and commercial products in table 3.

Overall, therapeutic technology could be useful to an individual with AD for emotional release, entertainment, leisure, and wellbeing. Also, it enables family caregivers with fewer interruptions and gives them more availabilities of time. Negative comments were mostly related to technical issues. Take music player as an example, individual with AD feel challenging to operate the MP3, or the player is not equipping the desired "settling" influence (Lewis et al. 2015).

Table 3. Available AD Products for Therapeutic Technology

Type of Assistive Technologies of AD	Product Name	Description and approach	Level of Maturity
Therapeutic Technologies	Music player such as mp3	Play the songs or rhythms to the patients for emotional release (Lewis et al. 2015).	Research prototypes
Therapeutic Technologies	Interactive computer-based cognitive training (ICT)	ICT use the computer based cognitive training to help delay the decline in cognitive function that in individuals with AD (Bharucha et al. 2009).	Research prototypes
Therapeutic Technologies	INHOME	INHOME embedded household devices, entertainment equipment, and home automation systems to provide improved quality of life for elderly people at home (Röcker and Ziefle 2012).	Research prototypes
Therapeutic Technologies	CogniFit Brain Training	CogniFit standardized data can help understand certain pathologies and work on those cognitive domains that have been altered or weakened ( <a href="https://www.cognifit.com/brain-games">https://www.cognifit.com/brain-games</a> ).	Commercial product
Therapeutic Technologies	Oxfordvr	Oxfordvr VR technology develops psychological interventions based on proven treatment protocols and deliver them using immersive technology ( <a href="https://ovrhealth.com/">https://ovrhealth.com/</a> ).	Commercial product
Therapeutic Technologies	Wall Decor 3D Illustrations	Wall Decor 3D Illustrations combine design with everyday objects in a 3D shadowbox ( <a href="https://store.best-alzheimers-products.com">https://store.best-alzheimers-products.com</a> ).	Commercial product
Therapeutic Technologies	Grandpad	Grandpad by Consumer Cellular is a tablet with entertainment content designed for older adult and can be used as a phone ( <a href="https://www.consumercellular.com">https://www.consumercellular.com</a> ).	Commercial product

### 2.3 Cognitive Aids Assistive Technology

Cognitive aids Assistive technology aims to assist individuals with Alzheimer's disease to engage in basic daily activities (Bharucha et al. 2009; Dark 2014). Given that Alzheimer's disorder brings about a sharp decline in reminiscence and cognitive functioning, a realistic effect is that humans with this situation face increasing difficulty in getting to their basic non-public needs (Dark 2014). Engaging in activities of each day generally becomes frustrating to them as their neurodegenerative circumstance slowly worsens due to the fact they simply cannot remember the collection of steps needed to initiate. AD even makes it hard for individuals to finish daily activities that they used to do (Bharucha et al. 2009; Dark 2014; Robert et al. 2014). Assistive technology in cognitive aids has been used to re-engage people with mild to moderate Alzheimer's disease (Dark

2014). The aids reviewed here are context-aware and use artificial intelligence to determine whether and when an appropriate reminder or procedural steering is essential for task execution. They are programmed to either enhance the performance of one or more different tasks in a routine day (e.g., Memory Glasses, MemoClip, Friedman) (Beigl 2000; Bharucha et al. 2009; Richard W. DeVaul n.d.) or to enhance a sequence of steps in both single or multiple tasks (e.g., Planning and execution assistant and education, ISAAC, AutoMinder, Friedman)(Gorman et al. 2002; Levinson 1997; Pollack et al. 2003).

Lancioni et al. (Dark 2014) reported three pilot studies wherein they assessed the effectiveness of verbal instructions, supplied mechanically through the natural techniques, to help folks with Alzheimer's disease to interact in basic daily activities. In all three researches, the assistive generation included a battery-powered, radio-frequency photocell, light-reflecting paper, and a changed Walkman (changed in later studies to an MP3 player) with a recording of the verbal instructions associated with the undertaking being taught. An example is a microprocessor-primarily based electronic manage unit with custom-designed software, a blanketed radio-frequency receiver that spoke back to the photocell inputs, and a programmable command function that regulated the presentation of the verbal instructions. Using recurrent trips to the bathroom as an example, the managing unit initiated a training sequence with the aid of activating the Walkman and the first instruction (e.g., take a seat on the toilet). Following a programmed c language, the control unit enabled the Walkman and the second instruction (e.g., take the soap). In taking the soap, the person broke the mild photocell beam and this started a programmed, short c language at the end of which the manipulated unit activated the Walkman and the subsequent instruction (e.g., use the bidet). This instruction began every other programmed c language

at the end of which the control unit activated the Walkman with brand-new guidance (e.g., take the towel) and so on until all the task steps had been presented for completion.

These three pilot studies provided preliminary evidence that the usage of taped verbal instructions paired with basic technology to manipulate the presentation of those verbal commands can be useful in helping individuals with Alzheimer's disease to recapture lost daily dwelling skills. The intervention produced fairly massive and rapid excellent consequences throughout all contributors and activities of each day residing. Furthermore, minimum support staff time became needed for the duration of the assistive technology intervention. The data were strong enough in these three pilot studies to support development studies similarly with this technology-based intervention. Table 4 shows more examples of current available products.

In general, cognitive aids assistive technology could help individuals with AD maintain or recapture their daily skills. Limitations of many available products under this category are the lack of sufficient prototype evaluations. Many related cognitive aids products have conducted prototype evaluations but only with healthy users (Dark 2014).

Table 4. Available AD Products for Cognitive Aids Assistive Technology

Type of Assistive Technologies of AD	Product Name	Description and approach	Level of Maturity
Cognitive Aids Assistive Technologies	Cognitive Orthosis for Assisting activities at Home (COACH) system	It is an intelligent environment prototype meant to assist people with dementia in completing daily tasks, such as hand washing (Dark 2014).	Research prototypes
Cognitive Aids Assistive Technologies	The Improvement in Memory with Plasticity-based Adaptive Cognitive Training (IMPACT)	It examines methods of assisting individuals with AD to discriminate better (Carrillo, Dishman, and Plowman 2009b).	Research prototypes
Cognitive Aids Assistive Technologies	Reminder Rosie	Reminder Rosie allows a caregiver to record reminders in his or her own voice and set them to be broadcast at certain times ( <a href="https://smpltec.com/remind-rosie">https://smpltec.com/remind-rosie</a> ).	Commercial product
Cognitive Aids Assistive Technologies	WatchMinder	The WatchMinder is a simple wristwatch that can be programmed to set up discreet vibrating reminders throughout one's day ( <a href="https://watchminder.com">https://watchminder.com</a> ).	Commercial product
Cognitive Aids Assistive Technologies	MedMinder Dispenser	MedMinder reminds user to take medications in the right amount and at the right time ( <a href="https://www.medminder.com">https://www.medminder.com</a> ).	Commercial product

## 2.4 Communication Assistive Technology

Communication assistive technologies include the use of technology that helps to enhance social interaction and networking (Carretero 2015). A common finding with individuals with AD is a gradual deterioration of communication—as their disease progresses, memory deficits increase and lead to repetitive questions and decreased verbalizations. During the later tiers of AD, the individuals continually engage in echolalia, perseverative speech, incoherent vocalization, and eventually mutism (Burns, A., Twomey, P., Barrett, E., Harwood, D., Cartmell, N., Cohen, D., Findlay, D., Gupta, S., Twomey 2015; Carretero 2015). Even with this deterioration in speech, the individuals may idiosyncratically maintain other skills that can be selectively accessed to help them maintain a reasonable quality of life. For example, some of them retain some forms of long-term memory (e.g., episodic, procedural) that can be utilized in a functional manner (Dark 2014).

Residual long-time period reminiscence may be enhanced with the assistive technologies and utilized to increase verbal exchange by people with Alzheimer's disease. For example, it is a not unusual practice for in-person daycare facilities and nursing homes to use memory wallets and customized brief books to increase communication in people who have middle-degree dementia (Hanley and Lusty 1984). An early study evaluated the effectiveness of teaching 3 people with middle-stage Alzheimer's disease to apply a reminiscence wallet as a reminiscence resource when conversing with familiar partners (Bourgeois 1990). The reminiscence pockets contained brief factual sentences (e.g., names of own family members, orientation facts, etc.) significant to the individuals and accompanying picture. They have been taught to apply these memory wallets in quick, twice a week, conversations with a partner, and the education results were assessed within a multiple baseline layout throughout topic areas. Results confirmed the individuals used the reminiscence aid to improve the first-class in their conversational content. However, they also engaged in conversation past what was taught.

Furthermore, assistive technology services enable distance communication via mobile phone or Internet applications. They play an important role for individuals with AD and their family caregivers as they can support the maintenance of social interaction despite limited ability to leave the house or potential distance to family and friends. Social interaction and networking can also be facilitated using online platforms where people concerned can exchange their experience and provide support to each other (Lorenz et al. 2019).

Researchers can capitalize on the intact long-term memory of individuals who are in the early stages of AD, to engage them in social, verbal exchange with support of

professional and family caregivers. Personalized wallets, personalized recollections, photographs, videos, and autobiographical memory statistics collected through a smartphone, or a computer-based multimedia system can be used to decorate the first-class of lives of persons with AD (Lorenz et al. 2019).

In general, distance can facilitate the maintenance of social interaction. However, communication devices such as mobile phone or Internet applications can sometimes interrupt current activities of individual with AD. For example, the ringing noise of mobile phone can lead individual with AD to the point where the person does not realize where he or she was. Table 5 shows more examples of current available products.

Table 5. Available AD Products for Communication Assistive Technologies

Type of Assistive Technologies of AD	Product Name	Description and approach	Level of Maturity
Communication Assistive Technologies	Memory Wallet	It contained pictures and sentences about familiar persons, places, and events that each subject had difficulty remembering. It helps to increase communication in people with AD (Hanley and Lusty 1984).	Research prototypes
Communication Assistive Technologies	CONTAIN	The CONTAIN project integrated communication, sensor and actuator techniques into a smart clothing to monitor environmental parameters (Röcker and Ziefle 2012).	Research prototypes
Communication Assistive Technologies	Smartphone	It can support the maintenance of social interaction despite limited ability to leave the house or potential distance to family and friends (Lorenz et al. 2019).	Commercial product
Communication Assistive Technologies	Partner Plus Communication Device	It is a single message communicator that can be used to record a reminder message. The device allows Caregivers to record a message for the end-user to playback that can be up to 30 seconds worth of total record time ( <a href="https://www.alzstore.com/default.asp">https://www.alzstore.com/default.asp</a> ).	Commercial product
Communication Assistive Technologies	Wrist Talker Assistive Technology Communicator	The Wrist Talker Assistive Technology Communicator is easy to use and wear. It can be used to record and replay a single message of up to 10 seconds in length ( <a href="https://www.rehabmart.com">https://www.rehabmart.com</a> ).	Commercial product
Communication Assistive Technologies	Tech Plus 8	Using "Real-Voice" technology, the Tech Plus 8 provides speech playback at a high audio quality ( <a href="https://www.amdi.net/products/aac-devices/tech-plus-8-aac-device/">https://www.amdi.net/products/aac-devices/tech-plus-8-aac-device/</a> ).	Commercial product

## 2.5 Remote Care Assistive Technology

The remote care assistant, control and support function can assist individuals with AD through telecare and telehealth interventions. We define telecare and telehealth as interventions facilitating healthcare through various means of technology from a distance, starting from sensors to assistive robots (Davis 2013). Interventions classified under this category aim to facilitate direct contact and exchange of relevant facts among professionals, individuals with AD, and their family caregivers. Also, each distance assessment and the provision of services and applications to improve coordination and management of the distinct actors involved inside the provision of care fall into this group. This category values care delivery and manipulation in context of assisting individuals with AD and the family caregivers (Seelye et al. 2012).

A research examined the feasibility of the use and attractiveness of a remotely controlled robot with video-conversation functionality in independently living, cognitively intact older adults. The researcher placed a cellular remotely controlled robot with video-conversation capability in the houses of eight seniors. The study assessed the attitudes and preferences of those volunteers and people of family or friends who communicated with them remotely via the device through survey instruments. Most participants placed the robot in their main living area during the study period. They provided positive feedback on the communication experience, saying that the sound from the robot device was easy to hear and answer calls. Some said the robot provided a sense of safety. They also reported that the picture and volume were clear enough to understand and assist. (Seelye et al. 2012). Overall, results indicate a positive feedback towards the robot. Participants preferred the ability of this technology to decorate their bodily health and well-being, social

connectedness, and the potential to live independently at home. We listed more available AD products for remote care assistive technology in table 6.

Based on research result of assistive technologies overview for AD care process, we conducted a semi-structured interview to understand how developed assistive technologies are adopted in AD care process, and whether the existed assistive technologies perform their functions as designed. We were interested in exploring the attitudes and rate of utilization of the assistive technologies in real-life AD care process.

Table 6. Available AD Products for Remote Care Assistive Technology

Type of Assistive Technologies of AD	Product Name	Description and approach	Level of Maturity
Remote Care Assistive Technology	Remote Controlled Robot	Remote Controlled Robot is a remotely controlled robot with video-conversation functionality in independently living, cognitively intact older adults (Seelye et al. 2012).	Research prototypes
Remote Care Assistive Technology	wearable electrocardiogram (ECG) wireless sensor	It has the availability of communication anywhere via a multi-layer hierarchical structure (Raad, Sheltami, and Shakshuki 2015).	Research prototypes
Remote Care Assistive Technology	Quantum	The Wander Alarm with Motion Detector can prevent AD patient from wandering away ( <a href="https://jnltech.net/products">https://jnltech.net/products</a> ).	Commercial product
Remote Care Assistive Technology	Signia TeleCare	Signia provides hearing-aid TeleCare services. It can track the patient's satisfaction for different real-world listening conditions to determine if programming changes or additional counseling is warranted ( <a href="https://telecare.signia-pro.com">https://telecare.signia-pro.com</a> ).	Commercial product
Remote Care Assistive Technology	Connected Health	Connected Health is a technology-driven home care intervention. It provides a caregiver with the support while caring for an individual with AD (Guisado-Fernandez et al. 2020).	Commercial product

## CHAPTER 3: METHODOLOGY

### 3.1 Semi-structured interview

A qualitative study is designed for looking at the real-life adopted technologies that support the daily care of Alzheimer's. Qualitative research attempts to realize the world from the subjects' point of view, to unhide the meaning of individuals' experiences, and to reveal the lived world of folks prior to scientific explanations (DeJonckheere and Vaughn 2019). We conducted a semi-structured interview questions related to the adoption of AD assistive technology. This method gives the interviewers and interviewees a chance to explore issues they feel important in a structured way (Asghar, Cang, and Yu 2017). The interview study result could help to discover barriers to assistive technologies adoption in AD care.

### 3.2 Interview Guide Development

Semi-structured interviews contain a list of "guiding" questions (see Appendix 1) and they are supplemented by follow-up questions according to each participant's responses (DeJonckheere and Vaughn 2019). In general, the interview study targeted 3 main topics: general individuals with AD care process, challenges, and attitudes and expectations towards related AD care assistive technologies. The interview study started by asking the relationship between the participant and AD individual he/she took care of. Then questions were focused on the experience of using assistive technologies during the care process of individual with AD. Based on previous study, we asked the experience of the participants about the adoption of five types assistive technologies mentioned above. Other questions will focus on investigating challenges faced in the process of AD care and how technologies support to overcome or decrease those challenges. The last few questions

will include fact-based questions, such as demographic information of both family caregivers and individuals with AD. There are open-ended questions to enable participants explore their thoughts. Interviewees will ask follow-up questions based on what the interviewee says when new ideas are brought up. Individuals with AD will not participate in the survey considering the neurodegenerative nature of AD. Table 7 listed interview questions with an analysis of expected information from participants.

### 3.3 Participants

The work was carried out with 15 family caregivers of people with AD via a semi-structured interview a semi-structured interview. We choose family caregivers (n=15) as participants because they are often the purchasers, end users and main beneficiaries of this type of technology. We chose to use User Interviews platform for participant hire assistance. This platform provides targeted access to diverse audience of over 350,000 vetted professionals and consumers. The researcher will first customize project in User Interview platform by providing essential project related information, including project overview, demographics, and screener questions. A requested participant number will be required and thus, researcher could get expected number of participants accordingly. Typically, the platform can find researcher at least one qualified candidate within 24 hours. The researcher needs to approve eligible candidates. Approved candidates will be emailed an invitation to participant in the study and then schedule with the researcher. The platform embeds with chat window to enable researcher to communicate with scheduled participants. In this research, we post a basic introduction of the study, and set conditions that applies to eligible participants: they need to be a family caregiver of individual with AD. There were no restrictions applied to gender, age, AD duration or AD severity. We set an

incentive as \$1.00 to each participant, which will be delivered through User Interview Platform. The interview is audio-recorded for backlog study.

### 3.4 Data Collection and Analysis

The interview audio recording was processed into descriptive statistics to characterize interview trends. We first generated transcriptions from audio recordings, and categorized each transcription by participant ID. Then, we went through each transcription, annotated with notes and grouped them into themes based on interview questions and responses. Using generated themes, we analyzed their patterns to support our findings. All themes and patterns are organized in a spreadsheet and classified by participant IDs for further content analysis. Table 7 presented a detailed explanation of content analysis direction to each question. In addition, given an overview of themes and patterns, we can group information by its similarities, showing if there is a common attitude towards a specific topic.

Table 7. Content Analysis of Interview Questions.

No.	Interview Question	Type of Question	Content Analysis
1	Please describe your relationship with AD individuals.	Fact-based question	To confirm the interviewee is a family caregiver of an individual with AD, and understand the relationship between the family caregiver and the individual with AD.
2	Alzheimer's stages of the individual with AD	Fact-based question	The Alzheimer's stage of the individual with AD reflects the independent living status of the individual with AD without assistive technology, which is a factor of adopting assistive technology.
3	How many caregivers does the individual with Alzheimer's disease have? Are they full time? What are their responsibilities?	Fact-based question	The number of caregivers, the working hours of caregivers and their responsibilities indicate the independent living status of the individual with AD, which is a factor of adopting assistive technology.
4	Do you and the AD individual have the experience of using assistance technology? Please describe how they facilitate the care process.	Fact-based question	To get a picture of the utilization of assistive technology and how the assistive technology assists the individual with AD in daily life.
5	Have you used Monitoring Technologies for safety? (Safety and monitoring tools can innovatively monitor individuals with AD. They incorporate alternatives to set off cautions by monitoring (alert and pager units, fall detectors, flood finders, water temperature screens, lighting) and in this manner point to bolster the prosperity, autonomy, and security of the individual with dementia as well as to supply consolation to caregivers)	Fact-based question	An expansion of question 4, to understand the utilization of Monitoring Technologies for safety in the daily care process of individual with AD. We further explained the definition of Monitoring Technologies for safety to help the participants understand the question.
6	Have you used Therapeutic Technologies (Therapeutic techniques intend to help cognitive and physical fitness, entertainment, leisure, and wellbeing)?	Fact-based question	An expansion of question 4, to understand the utilization of Therapeutic Technologies in the daily care process of individual with AD. We further explained the definition of Therapeutic Technologies to help the participants understand the question.
7	Have you used Cognitive Aids Technologies (Cognitive aids technologies aim to assist individuals with Alzheimer's disease to engage in basic daily activities)?	Fact-based question	An expansion of question 4, to understand the utilization of Cognitive Aids Technologies in the daily care process of individual with AD. We further explained the definition of Cognitive Aids Technologies for safety to help the participants understand the question.
8	Have you used Communication Assistive Technologies (Communication assistive technologies include the use of technology that helps to enhance social interaction and networking)?	Fact-based question	An expansion of question 4, to understand the utilization of Communication Assistive Technologies in the daily care process of individual with AD. We further explained the definition of Communication Assistive Technologies to help the participants understand the question.
9	Have you used Remote Care Assistant Technology (Interventions classified under this category aim to facilitate direct contact and exchange of relevant facts among professionals, individuals with AD, and their family caregivers)?	Fact-based question	An expansion of question 4, to understand the utilization of Remote Care Assistantive Technology in the daily care process. We further explained the definition of Communication Assistive Technologies to help the participants understand the question.
10	Please describe valuable functions you find in the assistance technology.	Open-ended question	To understand participants' attitude towards adopted assistance technology; To conclude valuable functions of assistance technology in real-life daily care process of individual with AD and to gain insights of the value of assistive technology for real-life AD family caregivers.

Table 7 (Continued). Content Analysis of Interview Questions.

No.	Interview Question	Type of Question	Content Analysis
11	What are barriers in adopting assistive technologies?	Open-ended question	To understand participants' attitude towards adopted assistance technology; To conclude challenges of adopting assistance technology in real-life daily care process of individual with AD and to gain insights of the barriers of adopting assistive technology for real-life AD family caregivers.
12	Please describe the most challenging issues in taking care of the individual with AD. Can those challenges be solved by AT?	Open-ended question	To understand the difficulties of taking care of the individual with AD. We will compare the most challenged issues with the services provided by assistive technologies that adopted by the participant, and conclude if assistive technologies helped to solve family caregivers' most concerned issues.
13	Please describe functions of assistance technology you wish to have in taking care of Alzheimer individuals. How those functions help in taking care of AD individuals?	Open-ended question	To discover functions of assistance technology preferred by family caregivers in taking care of Alzheimer individuals. We can compare and conclude whether existed assistance technology satisfied the needs of family caregivers.
14	What are top three possible dangers or problems can happen to Alzheimer individuals in current care process? In which way you which AT could help to decrease those dangers?	Open-ended question	To discover potential functions of assistance technology preferred by family caregivers in preventing Alzheimer individuals from dangers. We can compare and conclude whether existed assistance technology satisfied the potential needs of family caregivers.
15	What is your age?	Demographic question	N/A
16	What is your gender?	Demographic question	N/A
17	What is the age of the Alzheimer individuals you take care of?	Demographic question	N/A
18	What is the gender of the Alzheimer individual you took care of?	Demographic question	N/A

## CHAPTER 4: RESULTS

Fifteen family caregivers (9 females, 6 males) took part in the semi-structured interview for 26 minutes on average. Four participants took interview for over 30 minutes, eight participants used less than 30 minutes but over 20 minutes to complete the interview, and there are three participants took less than 20 minutes for interview. Among the individuals with AD who were mentioned in the interview, two of them are in early AD stages, eight of them are either in the early to middle, middle or middle to late AD stages, and four of them are in late AD stages. There is one participated family caregiver cannot describe the Alzheimer stage of the individual of AD.

The interview result shows that assistive technology designed for AD is not widely adopted by participants, however, technology is a common tool in taking care of individual of AD. The most frequently adopted technologies fall into monitoring technologies for safety category with 66.7% (10) respondents. In comparison, only 5 participants adopted therapeutic technologies for individual of AD. However, there are 9 out of 15 participants list emotional issue as one of their top three challenges in taking care of individual with AD. Among the participants who expressed concerns of their emotional health, only 2 of them value the AD assistive technology as an emotional release tool. Table 8 summarizes detailed demographic information for each participant.

Table 8. Participant Profiles.

ID	Interview Length	Participants	Description of Individual of AD	Gender of Individual of AD	AD Stage
1	0:33:53	Family Caregiver	Lives in home with her husband and a family caregiver	Female	Early to middle
2	0:39:32	Family Caregiver	Lives in home, has a care team led by a registered nurse who provides private home care.	Male	Middle
3	0:40:31	Family Caregiver	Lives in home alone, has some neighbors who visit for care.	Male	Early
4	0:23:15	Family Caregiver	Lived in a nursing home, needed a 24/7 care.	Female	Late
5	0:26:52	Family Caregiver	Lives in home with the caregiver	Female	Late
6	0:12:25	Family Caregiver	Lives in home with a family caregiver	Male	Middle
7	0:21:02	Family Caregiver	Lives in a care facility with a full-time caregiver 24 hours a day	Female	Middle
8	0:27:16	Family Caregiver	Lives in a care facility with a nurse 24 hours a day	Female	Late
9	0:27:47	Family Caregiver	Lives in home with her partner, has part-time caregiver engagement	Female	Middle to late
10	0:36:10	Family Caregiver	Lived in a nursing home, needed a 24/7 care.	Female	Late
11	0:20:24	Family Caregiver	Lives in an assisted living community with his wife.	Male	Middle
12	0:22:11	Family Caregiver	Lives in a care facility, has four day-time staff and two night-time staff.	Male	Don't know
13	0:11:54	Family Caregiver	Live in home, has two part-time family caregivers	Male	Middle
14	0:19:05	Family Caregiver	Live in home, has two part-time family caregivers	Female	Middle
15	0:26:44	Family Caregiver	Live in home, has two part-time caregivers	Female	Early

#### 4.1 Adoption of Different Types of Assistive Technologies for Individual with AD

Previous literatures have generated various types of Assistive Technologies for Individual with AD. We categorized them in five main types according to their functionality, including monitoring technology for safety, cognitive aids technology, therapeutic technology, communication assistive technology, and remote care assistive technology. We list and detail family caregivers' adoption on each types of technologies mentioned above to discover how those adopted technologies helped in taking care of

individual with AD. Figure 1 presents the adoption rate of different types of assistive technologies. We can discover the most popular and the least adopted assistive technologies among participants. Table 4 lists types and themes of adopted assistive technologies. There is one participant shared that his mother did not use any technologies for assistance, who was in the late stage of AD and passed away in her 89. The individual with AD went to a nursing home, and needed a 24/7 care by human caregivers.

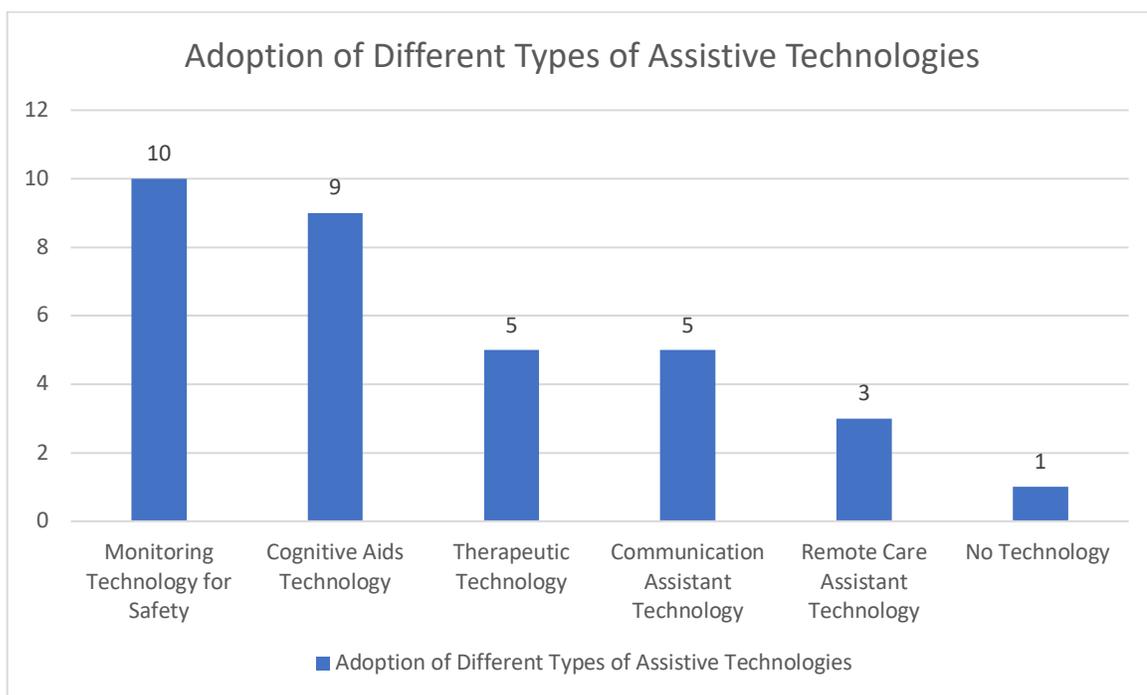


Figure 1. Adoption of Different Types of Assistive Technologies

#### 4.1.1 Monitoring Technology for Safety

##### 4.1.1.1 GPS System

The most frequently adopted technologies fall into monitoring technology for safety category with 66.7% (10) participants, 5 of whom mentioned a necklace-style tracker with GPS and alert function, which is the most common device used by individual with AD under this category. When individual with AD presses the button on the necklace,

professional people and family members will be alerted. This device is designed specifically for individual with AD to guarantee they can be tracked and protected when there is an emergency. However, 4 out of 5 family caregivers who used necklaces reported negative comments of the necklace-style GPS tracker for two reasons: first, the necklace-style GPS tracker is not user-friendly enough as the individual of AD does not understand how to utilize the device by pressing button. Second, the individual of AD does not really wear the device. P.1 described the reason why her mother was not willing to wear the necklace-style GPS tracker.

*I got her necklace that if she falls or something or, needs help when I'm not there, she can press a button and then the emergency people come. But I don't know. I feel like it scared her, so she doesn't want to use it anymore. And she wasn't really wearing it. (P.1)*

According to the description of P.1, assistance professionals' arrival scared the individual with AD and caused a negative experience in using the necklace-style GPS tracker. P.10 also shared the user-friendly issue caused by memory loss.

*In the early stages, she had kind of like a lifeline that went around her neck, so if she fell, she could call somebody. But the problem with that was she didn't know what it was for[...]she had to push the button and that was at a time when she didn't know that she had to push a button. (P.10)*

Apart from the necklace-style GPS tracker, P.9 used another wearable GPS tracker to locate her mother. As said by P.9, though the GPS tracker could enable more freedom of both family caregiver and individual with AD, but it also causes embarrassment to her mother.

*GPS is definitely something that she has pinned on her[...]it's wearable and it's often hung off of the back of her shirt or tucked in where her belt is. You have to put it on when you give her a hug[...]because she felt embarrassed[...]My mom and her partner have some what feels to be some freedoms and independence, because for them losing has been the biggest issue (P.9)*

#### 4.1.1.2 Environmental/Smart Home Devices

Environmental/smart home devices refer to a number of sensors are used to measure a single or multiple environmental contextual factor, such as appliance hazard sensors (Bharucha et al. 2009). Our result shows that 6 out of 15 participants have adopted door sensor, motion sensor and camera to monitor the individual with AD. Among those devices, camera is the most commonly used device, it is also the second top adopted monitor product with 4 participants. Many participants valued camera is an efficient tool in monitoring individual with AD. They will receive alert if a person under a monitor is appeared, that helps them to locate their loved one in time, to remotely realize the monitored living situations so that they can provide assistances when needed. It is normal that family caregiver would have multiple cameras in the living places of individual with AD, so that they can reduce blind angle. Exit of living place is important to place a camera to avoid the wandering issue. P.3 and P.7 expressed positive comments by saying that the camera could give them a piece of mind.

*We have, about seven cameras in the house now that, my sister and I can pretty much watch him all the time if we need to[...]that's good because it alerts me, for instance, if I get an alert that he's in the garage[...]It helps*

*me know that he's getting up in the morning[...]It helps me with hearing some of his conversations so that I can understand if he's having a problem with something[...]So, it helps with a variety of things. (P.3)*

From P.3's comments towards camera monitor, we can feel out that she is satisfied with the monitor, especially because of the alert function. It enables the caregiver to catch emergencies happen to individual with AD through a passive interaction. In contrast, P.7 expressed the positive comment for its great help to stress release.

*The doors and the cameras and stuff[...]It gives us a little bit of a peace of mind knowing that she's not able to get out and wander off and possibly get hurt and that there's people kind of watching her all day while we're not able to be there while we're working. (P.7)*

#### 4.1.1.3 Advanced Integrated Sensor

Advanced integrated sensor applies artificial intelligence and fuses data from a network of heterogeneous sensors. It advances the level of AD assistance, such as supervision and cognitive aids (Bharucha et al. 2009). Devices such as Fitbit and other health monitor appeared under this category during the interview. Instead of for AD assistance, the main purpose of using advanced integrated sensor are mostly because of other health related issues. P.5 shared her and her grandmother's experience of using Fitbit to monitor breathing and heart condition.

*Because she also had a heart condition, she had a couple of really bad health issues. It tells me how I slept. I'll go into the app on my phone. And it tells me if I was tossing and turning a lot, or if my back was losing my*

*breath at night[...]she was having trouble breathing a lot at night as she was getting older. But this is really awesome. (P.5)*

#### 4.1.1.4 Mobile Device

Mobile device is also used to track and navigate the individual with AD. Family caregiver could help to set up the mobile device to enable the accessibility feature, there is only one negative comment, which is when individuals with AD do not bring smartphone with them. Below is an example from P.3.

*I do have him tracked on my phone if that's what you mean. But the problem with that is that many times he just he'll go out and forget to turn his phone on. So, then that renders that useless. (P.3)*

#### 4.1.2 Cognitive Aids Technology

Cognitive aids technology is the second popular type of assistive technologies with 60% (9) participants. We found mobile device, reminder and environmental/smart home under this category.

##### 4.1.2.1 Intelligent Assistive Technologies

Intelligent assistive technologies are most commonly adopted by participants for the purpose of cognitive aid, with 6 out of 15 participants. Amazon *Echo Dot* is an outstanding product under Environmental/Smart Home category. There are 3 participants reported to use *Echo Dot* as a reminder. All of three participants shared positive comments towards *Echo Dot*.

*I've got an app on my phone. And I can be anywhere in the country. Say if, say I'm going grocery shopping and I'm getting ready to cook dinner and*

*I'm on the way I can say, grandma, go wash your hands. It's almost time for dinner (P.5)*

*There are the reminders that we put in the Alexa are helpful periodically because they'll go off and I think the program to say, Carol, take your whatever medication, but sometimes she just gets it. (P.14)*

It is worth to mention that some participants pointed out though *Echo Dot* is a success product, individual with AD still get confused when interact with *Echo Dot* as to why the *Alexa* is giving instructions.

*It's helpful probably 60, 70% of the time. But there are occasions she'll call us and say, my Alexis going off, can you tell me why? (P.14)*

#### 4.1.2.2 Mobile Device

Mobile device is mostly used for setting reminder to help family caregivers in management during the care process. For example, family caregivers would use electronic calendar and set alarm for an appointment. When the reminder is set for individual with AD, there is a case that it causes confusion because she or he does not understand the alert of the reminder.

*We have a visual reminder to take her medicines. And then we have every kind of alarming system beeping, all those kinds of things, which she forgets what the sounds are. So, she's not sure what it's about. It doesn't really remind her. It just reminds her that she doesn't know what she's doing and it's that. (P.9)*

Another functionality of mobile device is to display photo show in order to enhance the memory of individual with AD. P.7 said picture show is functionable because it helps individual with AD to recognize people.

*We have the pictures which helps with family members, like facial recognition and stuff[...]pictures have been really helpful. (P.7)*

#### 4.1.2.3 Reminder Device

To overcome difficulties associated with taking medication on time, there is one participant mentioned that her mother has a medication reminder to overcome this difficulty.

*Yeah, she did have a purely reminder thing, a medication, because, she'd forget to take her medication. (P.13)*

#### 4.1.3 Therapeutic Technology

##### 4.1.3.1 Mobile Device

Apart from monitoring and cognitive aids technology, there are 5 out of 15 participants have adopted therapeutic technology. Tablet is the most common devices under this type (3 out of 5). Participants said they use tablet to play music, videos or games. For example:

*She does have a tablet that my mom set it up[...]It plays her some music, and then she can see pictures and stuff. She does like a little tablet. (P.7)*

However, P.7 also mentioned that using tablet for therapeutic also create extra difficulties.

*She only has a few things loaded onto it so that she's not like, you know, it gets stuck in a wormhole and gets super confused. (P.7)*

P.14 provide a positive comment on using iPad for therapeutic and described how the individual with AD play games and watch videos on an iPad.

*She does have an iPad. She likes to play Sudoku on that and some other games, not active shooter games, but games to just help mentally stimulate her that she enjoys. And she can also watch Netflix on it. (P.14)*

#### 4.1.3.2 Video/Audio Player

Radio, DVD player also appeared under this category for the purpose of entertainment. P.1 shared his mother's experience in listening and talk to the radio. She feels the radio can give her mother a more pleasant feeling in memory compared to new information.

*She loves, talk to radio and I think it helps her mentally, like her memory from those things is it's better than like new information. So that's why she enjoys it. Cause she feels comfortable. Like she can remember it. (P.1)*

#### Intelligent Assistive Technologies

Intelligent assistive technologies enable a smart way to display videos for entertainment. In order to display videos in the right place, the right time for individuals with AD, P.5 used *Echo Dot* and smart TV to program the video show to play on certain times automatically or under voice instruction.

*I guess with the fact that on the show on the Amazon Alexa show, and the kitchen with the video, she could say, Alexa, let me watch[...]I could record*

*all of her favorite shows for her on the smart TV, And I could program the TV to come to play certain shows at certain times for her. (P.5)*

#### 4.1.4 Communication Assistive Technology

##### 4.1.4.1 Mobile and Computer Device

There are 33.3% (5) participants have adopted communication assistive technology. An interesting finding among participants under this category is that all of them consider mobile and computer device as a communication assistive technology during the care process. Except for text and call, software like Zoom and Facebook are also been mentioned while describing the detailed functionality of mobile device. Although it helps in communication, participants shared many negative comments of the mobile device. Three example quotes below illustrate this finding.

*Sometimes she does it and forget that she did it, and then she does it again, like, she'll say the same message over and over[...]She even likes to search social media sites, but then she forgets. She must have at least three Facebook accounts right now. but then she forgets. (P.1)*

*He'll speak on the phone with people that he remembers, but nothing enhances. (P.11)*

*We have video chat available to us. But, typically my wife just goes and sees him in person. He is hard of hearing and his hearing is going downhill. (P.12)*

##### 4.1.4.2 Augmentative & Alternative Communication Device

The Augmentative & Alternative Communication Device (ACC) is used to assist people who have difficulty talking. Touching letters or pictures on a computer screen that

speak for an individual is an example of devices under this category (Light et al. 1998). There is one participant mentioned that her mother has played communication board a lot because she was a speech therapist.

*What's interesting is she used to be a speech therapist. So, she used all those technologies, like, those boards for communication stuff. (P.1)*

#### 4.1.4.3 Hearing Assistive Technology System

Hearing assistive technology systems (HATS) is mentioned by one participant, which aims to assist individual with AD to hear others. In this way, it could improve his or her ability in communication.

*Well, she has hearing aids, but I mean, that's part of communication, but in terms of speaking or any of that kind of stuff, that's not an issue for her at all. (P.9)*

#### 4.1.5 Remote Care Assistive Technology

##### 4.1.5.1 Mobile and Computer Device

The least adopted type of assistive technology is remote care assistive technology, with only 20% (3) participants. Two of them adopt mobile device as the remote communication tool. They either make a phone call or use communication application for contact. One adopts computer device and use zoom for psychological assistance.

*It's a tablet that goes through, different kinds of things for him, for his doctor's appointments. (P.6)*

*She is now having some virtual health meetings via zoom. (P.15)*

The appointment with doctors and other health professionals could be conducted online through remote care assistive technology, which is the primary reason for individual with AD to adopt this technology.

Table 9. Types and Themes of Assistive Technology Adopted by Participants.

Types of Assistive Technology	Theme	Sub-theme
Monitoring Technology for safety	GPS System	Necklace-style GPS tracker
		Other GPS Trackers
	Mobile Device	Smartphone with GPS tracker
	Environmental/ Smart Home	Door Sensor
		Motion Sensor
		Camera
	Advanced Integrated Sensor	Fitbit
		Other Health Monitor
Cognitive Aids Technology	Mobile Device	Smartphone with Reminder
		Smartphone with Photo show
	Reminder	Medicine Reminder
	Environmental / Smart Home	Lighted Toilet Bowls
		Amazon Echo Dot
		Stove Sensor
		Google Home
Therapeutic Technology	Video/Audio Player	Radio
		Video Related
	Mobile Device	Tablet
	Intelligent Assistive Technologies	Amazon Echo Dot
Communication Assistive Technology	Augmentative & Alternative Communication Devices	Communication Boards
	Mobile Device	Telephone Call
	Computer Device	Zoom
		Social Media
	HATS (Hearing assistive technology systems)	Hear Aids
Remote Care Assistive Technology	Mobile Device	Telephone Call
		System Application on Tablet
	Computer Device	Zoom

## 4.2 Challenges in Adopting Assistive Technologies

We found out in the interview that family caregivers/patients are facing challenges while using adopting assistive technologies. We categorized those challenges in four main categories, including acceptability, learnability, usability, and functionality. Table 10 listed the challenges into different themes showing obstacles of adoption from various perspectives.

Table 10. Challenges in Adopting Assistive Technologies.

Challenges in Adopting Assistive Technologies	Theme
Acceptability	Acceptability of individual with AD
Learnability	Learnability of individual with AD
	Learnability of family caregiver
Usability	Hard to use
	Family caregiver assistance is needed in using tech
Functionality	Non-technology Activity Assistance

### 4.2.1 Acceptability

A research showed that the use of technologies greatly declines at the age of 75 years, which is especially common to happen for older people who are affected by cognitive and physical impairments (Klimova and Poulova 2018). This finding is also confirmed in our finding that some elder people can be skeptical to the new technology. For example, both P.5 and P.12 mentioned that elder people has concern with accepting assistive technology.

*The very beginning, she was a little bit skeptical. I had to prove to her that Alexa wasn't listening all the time. (P.5)*

From P.5's interview, the AD patient was not familiar with *Alexa* and worried about privacy issue when talking in front of it. It is uncertain and lack of security for P.5's AD

patient to accepting *Alexa*. Similarly, P.12 mentioned that the AD patient who is 94 years old also refused to use assistive technologies. Unlike p5, p12 was not willing to wear the technological device (hearing ADIS) because he has no interest in the technology.

*He has no interest. He doesn't, he doesn't even want to wear hearing AIDS. he is 94. He's had probably four or five sets of hearing AIDS that have been bought for him over the years. Doesn't want to wear them. (P.12)*

#### 4.2.2 Learnability

And even if individual with AD are willing to use assistive technologies, it is really hard for them to learn. There are 7 out of 15 participants deem learnability issue as one of top three challenges in adopting assistive technologies. Many of them never use such technologies in their entire life. And due to AD, they have bad memory. It makes learning how to use assistive technology even harder. P.7 described how hard it could be for individual with AD to learn it.

*She just doesn't totally understand like how to use them. the hardest thing is like, we can't really employ a lot of new things just because she won't use it or she doesn't understand, or, she forgets how to use it. So, it's been, I think that's the biggest challenge is just like, fighting with her memory to try and like include new things, even though they might be really helpful. (P.7)*

P.7 think learning is not applicable for people with cognitive impairment because remembering new skills and losing memory are contradictory. P.11 also expressed same idea, saying:

*That is not really helpful. Well, I'm not sure my dad wouldn't be able to implement it himself, for sure. For example, they got cable in their new house and no texts were allowed to come in their home and set things up and she had trouble even doing that. It's kind of an oxymoron assistive technology for a person who's cognitively impaired seems difficult to even get it set up. Very hard for an Alzheimer's patient to learn anything new. (P.11)*

There is also another thing worth to mention. Some family caregiver themselves find out that it is challenging for them to learn assistive technology. Take quotation form P.9 as an example, the participant said:

*The hard part is that there's so many things to manage, and then having a team of people managing the communication. It's just, it's a lot of work. Yeah. It's helpful. But it's also burdensome because it allows them to get the freedoms that they want. (P.9)*

#### 4.2.3 Usability

Usability is the second frequently mentioned challenges with 26% (4) participants. 75% (3) of these participants think it is hard to use assistive technology. They have met various scenario that assistive technologies were not working well. For example, P.13 shared that there is nothing for AD patient to adopt easily:

*Nothing very easy to adopt. He doesn't have anything he's beyond that point and he sits and he watches TV and I have the TV set, so it's on for a certain period of time and it goes off. If he gets up to go to the bathroom, the TV*

*did a lot of magically turn off and then I have to turn it back on when he comes back, that kind of thing. (P.13)*

P.13 described that the TV is not user-friendly enough for her father because it will automatically be turned off for a certain period of time even though her father is not . P.3 also mentioned that family caregivers have to put a lot time and effort helping individual with AD to use the technology such as reading email.

*[...]help with a lot of different things, specifically technology, because that is a huge challenge. So, like, just for him to like read his email or something, you know, sometimes we have to walk them through it. Or many times we do. (P.3)*

P.15 take learning *Alexa* as an example, saying that she has to write additional reminder to assist her grandmother in using the *Alexa*, because *Alexa* only recognize speech command in certain patterns.

*It's you know, even with Alexa, you have to get the voice. You have to say things in a correct way in order to get the response that you're looking for. I've written down some of the ways that you have to ask her things and she can't remember [...]. With any of the assisted technology. Geez. It's, it's almost more work for the caregivers or me and the benefit is for her. (P.15)*

#### 4.2.4 Functionality

During our interview, 40% participants (6 out of 15) questioned whether AD assistance in form of technology could solve main challenges met by family caregivers. They provided negative answers to our question that “Do you think any of those challenges

you mentioned before can be solved by assistive technologies?” For example, participant P.2 brought up this topic that was thought-provoking.

*The part that isn't easy is things like, or the non-technology, how do you help somebody get dressed? (P.2)*

P.2 pointed out that many daily physical assistances such as getting dressed is not supported by technologies. Coincidentally, other four participants also shared their own care experience to illustrate obstacles that cannot be solved by technologies. Physical activities are a primary reason that technology cannot function well in an assistive perspective. For example, a caregiver needs to clean an AD patient up when he or she goes to the bathroom. An interesting option mentioned by one participant is that instead of setting an individual with AD as the user of assistive technologies, he preferred to have a device to help the caregiver and help them to cope with the situation by providing training of AD patient care.

*Not technology, I don't think there's a way that the technology, Oh, well, a better, geriatric panel on a microwave might be okay, but she can't see the buttons. That's why things happen. She adds zeros to the time, but other than that, no technology that I know of is going to keep her from falling. She shuffles her feet. She uses a Walker in the house she's very slow. So that's why that's not happening. And her pills are managed and I'm sure that there's technology related pill stuff that she could get if she needed it, but she doesn't. (P.15)*

The above quotations presented several aspects to illustrate the deficiencies of technology in its functionality perspective. P.12 and P.13 addressed the same question with

P.2, saying it is the physical problems challenges their care process. P.11 paid more attention on caregivers and suggested that technology should focus more on assisting family caregivers in the AD care routine, because the family caregiver does a great job as a caregiver as well as a spouse. Considering adopted technologies still have usability issues, a family caregiver could make the care activities smoother. Another possible reason for P.11 to not putting assistance technology in a significant role of carness is because the AD patient is still in the early stage of AD, during which the patient does not come across severe safety and cognitive problems that could be eased by current technologies. P.14 see AD conditions as a main challenge to family caregivers. He does not see current technology could help to prevent the disease progressing, which means technologies could not solve the key challenge issue that caused by AD, such as preventing neurodegenerative disorder and decreased cognitive function.

#### 4.3 Challenges in taking care of individual with AD.

In response to the question related to challenges in taking care of individual with AD. Top three challenges are related to safety, emotional issue and cognitive aid. Other comments mentioned difficulties in coordinating with hired caregivers and living style changes due to external care assistance needs. Table 5 listed challenges in taking care of individual with AD and the percentage of participants with the same concern.

Table 11. Challenges in taking care of individual with AD.

Themes (Percentage of participants with the same concern)	Challenges in taking care of individual with AD
Safety (60%)	Get lost
	Get hurt
	Burn down the house
	Fall
	Driving
Emotion (60%)	Emotional issue of family caregiver
	Emotional issue of Individual with AD
Cognitive-Aids (60%)	Financial Issue
	Forget daily behaviors
	Toileting
	Keep ask same question
Caregiver Related (13%)	The coordination between caregiver and ADIs
	Short of caregiver
Living Style (6.7%)	Change Family Dynamic

#### 4.3.1 Safety

There are 60% participants mentioned that they worried about the safety issue in daily care process, including get lost, get hurt, burn down the house, fall and driving problems. Among those possible safety challenges, get lost and get hurt is the top two challenges worried by most of the participants. If the AD patient gets lost without ID alongside, caregiver would face huge challenge in finding participants. Another safety related concern is getting injured, such as getting hit by a car if the AD patient ends up out on the road. More example comments from P.7 and P.9 can be found below. They all showed concern related to safety of the individuals of AD due to various occasions.

*I think obviously like her safety is, is definitely like the number one thing, just because the last facility that she was in while it was like a*

*lockdown[...]she was able to escape and they found her in the parking lot.  
(P.7)*

*She would cook and forget to turn the stove off and she'd have things burned to the bottom of the pan. And we were afraid she was goanna burn the house down or burn her apartment building down. We were really worried about that. (P.9)*

#### 4.3.2 Emotion

Emotional challenges are also raised by most of participants. Family caregiver would get frustrated during daily care routine. From the interview, participants expressed that unlike taking care of a child, the difficulty of caring individuals with AD is because they don't learn new things or get better, instead, they need constant assistance from family caregivers. Moreover, individual with AD would keep repeating themselves and not understanding simple tasks. Example comments from P.10 reflected caregiver's negative emotional effect in dealing with individuals with AD can be found below.

*She's intentionally trying to drive me crazy[...]She doesn't understand anything. She forgets. (P.10)*

P.10 addressed the cognitive impairment issue is the reason affect her emotion. P.14 also discussed her problematic emotion caused by the same reason, saying:

*It's a daily thing about him repeating himself and not understanding simple tasks and it's kind of get frustrated. (P.14)*

Another underlying reason that affect family caregivers' emotional health is watching their loved one disappear. This emotional issue is commonly found in family

caregiver because the individual of AD they deal with are mostly their close relatives. In our research, 14 out of 15 individuals with AD are either parents, spouse or grandparents of the participants. When describing challenges in assisting individuals with AD, P.2 instantly bring out this emotional issue when she takes care of her husband.

*The first is watching a loved one disappear. there's no question that he knows who I am. And occasionally we joke. We say we hate flashes of who he was, but he's not there. You know, he's really reverted. he almost shows autistic[...]but to watch a loved one disappear like that is just heart wrenching because you miss who they were as well as you're thrust into the role of caregiver. (P.2)*

P.11 is a daughter of the individual of AD, her emotional feeling about her father has also changed. Compare to husband and wife, P.11 expressed the loss of authority when a father becomes an AD patient.

*He's not really my dad anymore. And I don't talk to him in the same ways. In some ways I look at him not as the authority figure as he used to be, but someone in decline, it's hard to see that change.*

P.5 has a close relationship with her grandmother, thus she expressed deep concern on losing the connection between her and her grandmother. She also tried various method to keep her grandmother's memory stay with her.

*One of my biggest fears is forgetting who everybody is. I take pictures constantly. I have thousands of pictures of my kids, my husband, my mom, her, my dogs. I figured that a good idea was put captions on every picture. That way they would the date and usually the date who's in the picture and*

*what they were doing. And until I started doing the pictures all the time, she actually forgot who I was a couple of times.*

#### 4.3.3 Cognitive-Aid

Cognitive-aid related challenges are brought up by 60% (9) participants. The need of cognitive aid is throughout everyday lives. including financial management, daily behaviors activities, and interaction with others. Among the cognitive-aid issues, there are 26.7% cases reported that financial issue is a big challenge, as individuals of AD are not able to manage their own budgets or pay their bills on time. It thus needs assistance from family caregivers. Below comments from P.3 showed concerns related to financial control ability of individual with AD.

*The financial stuff was becoming an issue because we were seeing problems and mistakes. (P.3)*

P.3 expressed her deep concern over the financial mistakes happened to her father. P.9 also showed that the financial management is problematic, and it create further difficulties to caregivers.

*[...]trying to manage your own budget. And then you're trying to manage the budget of adult parents. (P.9)*

Forget daily behaviors such as dressing, shower and toileting is another big topic for caregivers during the assistance. Family caregivers need to help to monitor the daily activities schedules and manage minor tasks. For family caregivers, those assistance is needed in everyday lives. P2 described in details to explain how AD affect an individual in taking shower and dressing.

*I discovered that he couldn't take a shower without cuing because he was missing spots[...] He can get stuck. You can sit there and just wash himself for hours. I mean, it just gets stuck[...]He needs assistance with dressing. he's gone from choosing your own clothes to putting on the clothes...what order do you put clothes in and making sure that his shirt isn't doesn't go on backwards. (P.2)*

P8 also mentioned that his grandmother does not remember the daily activities, and also forget common hygiene.

*I would say the third problem would just be, unfortunately they forget common hygiene and they forget how to do certain things, fix things, get dressed, simple things[...]She doesn't remember when she last ate when she took her medicine. (P.8)*

Some participants also mentioned that it is challenging to coordinate with individual with AD when they keep repeating themselves, because it's a daily behavior for individual with AD and hard to stop them. Apart from the top challenges mentioned above, some participants also meet obstacles in coordinating with hired caregivers. Some worried about caregiver arrangement in the further. And the need of caregiver would change the original family dynamic, which is also something need to overcome.

#### 4.4 Technologies in Addressing the Most Concerned AD Challenges

We have 60% (9 out of 15) participant think that AD care challenges can be solved by assistive technology. Tools such as remote camera GPS tracker help a lot to address most concerned AD care challenges for them. For example, P6 had mentioned GSP could actually help and similarly p7 also like the idea that using camera to monitor for safety.

*It will say that the GPS around is that helps. (P.6)*

*I would say, as far as like the safety thing...with the camera. Definitely. I liked that idea (P.7)*

However, we also found that 6 out of 15 participants think that assistive technologies cannot solve all AD care challenges. For example, as we have mentioned in 4.2.3 section, P.2 bring up a topic - “non-tech challenges”, which cannot be solved by assistive technology we have today.

*[...]but the, the part that isn't easy is things like, or the non-technology, how do you help somebody get dressed? (P.2)*

To these participant’s view, assistive technologies are helpful, but they can’t solve all the issue, especially for the physical issue. For example, no technology they know of can keep individuals with AD from falling. Caregivers are playing the most important role in AD care challenges. Assistive technologies are only there to help caregiver. P.11 also pointed out that it is caregivers who need technologies during the care process so they can better manage the care activities:

*[...]No, not really. I think what needs to help is help the caregiver and help them to cope with the situation and maybe give them tools and train them as to how to deal with an Alzheimer's patient. It's hard because it's your spouse in my mom's case, in her life partner. And it's a very different dynamic between the two of them now. So, I don't feel like they're technologically challenged or things that like, she does everything for him that needs doing. So, he might come to a point. So, he becomes a wander that he'll need some sort of GPS monitoring device. (P.11)*

#### 4.5 Technologies Wish to Have

Our participants shared their opinions on how technology could help them ideally in taking care of individual with AD. For most of the participants, monitoring technology for safety is still the most preferred types of assistive technology to keep their loved one safe (10 out of 15). The second top preferred category is assistive tech for caregiver (4 out of 15). Others expressed a need to have a more intelligent cognitive-aids technology (3 out of 5), to adopt exoskeleton legs for more social interaction (1 out of 5) and to have a less expensive and more user-friendly assistive technology products for individual with AD (1 out of 5). Below we generated three top categories of technologies that participants wish to have.

##### 4.5.1 Monitoring Technology for Safety

As many family caregivers are not with their family member with AD, the monitoring technology served as a tool to give family caregivers a piece of mind. The most common mentioned technologies they wish to have under the category of monitoring technology is an intelligent robot with camera. P.3 noted a little robot to follow the individual with AD in or out of the house is great to have for the purpose of monitoring.

*I would like a little robot to follow him around the house that would have the screen there. (P.3)*

Despite the needs of having a screen on a robot, P.7 also wishes the robot could enable family caregivers to control the camera screen so that the family caregivers can know the real situation around individual with AD.

*Robot, this is just like such a foreign idea that probably doesn't exist, but like having some way that like they're on like a screen or something, that's*

*in the room that we could just tune in a FaceTime and control it and chat with and see what she's doing. (P.7)*

P.10 also would like to have the alert function when there is a need for family caregivers to be with individual with AD.

*That would be nice if they had a robot, a program that could turn off the stove. If she went out... it would be nice to have something that would have alerted the caregiver that you needed to go get her right away. (P.10)*

Despite the top-rated intelligent robot as a means of monitor individual with AD for safety, two participants mentioned that having a system-controlled door locker instead of the keylock would be helpful, because it limits unlock authority to family caregivers only, and the operation process to unlock a door, such as simply press a button, which is much easier than keeping a keylock.

*So, a better system for locking the doors that he couldn't open up that are safer. Again, the Keylock is unsafe because if you had a fire in the middle of the night, could you find the keys to get out of the house[...]something I could just press a button and have the cabinet online as opposed to using a little plastic thing. That would be terrific (P.2)*

Few participants also mentioned a portable camera and a smartwatch with GPS is good to have so that they could track the location of individual with AD when family caregivers are not along with them.

#### 4.5.2 Assistive Technology for Family Caregiver

Another prominent theme was the need of assistive technology for family caregiver. There are 4 out of 15 participants expressed that they wish to have a tech-related tool to support themselves both physically and mentally. There are two participants expressed wishes to have monitor sensors during the care routine when dealing with individual with AD. For example, P.2 described her difficulties in assisting her husband to toileting.

*What do we want to stick a sensor down his pants[...]You would be some way of giving me a heads up that he's got a Pee[...]it sounds silly, but those are the kinds of things that if you get really down to true base level executive function? (P.2)*

Similarly, P.9 described challenges for her mother to take a shower individually. A sensor to track the water usage or automatically turn off the water would help a lot when her mother forgot to the turn off the water when she is not in shower.

*she wants to go in and take a shower on her own. Right. And she knows how to do it and she could turn the water on and an often, if it's too hot, she knows how to attend to that, which is a sign that she's still marginally lucid, making sure we can track the water[...]she goes in, makes a cup of tea and it goes out to the garden and the water is still running and the water bill is extremely high and it's only because she forgot to turn it off[...]I've never seen any technology around turning the water off. (P.9)*

Emotional health assistive technologies that seek to encourage family caregivers is also mentioned by few participants. P.4 described needs of support group to help family

caregivers go through the process when their loved one gradually disappeared because of AD. However, he thought it is beyond the scope of technology.

*But I do believe that outside of technology, if you're going to do in home care for a, for a loved one with Alzheimer's, you have to have something, some level of, of a support group to help you through that process. Because like I say, I think it's easier to do with someone who's not a loved one than it is to do with your own loved one. (P.4)*

#### 4.5.3 Cognitive Aids Technology

While our participants expressed wishes to have more intelligent monitoring technologies for safety, and tech support for family caregivers, some participants brings the topic of cognitive aids technology on the table (2 out of 15). An interesting finding is that robot is also mentioned as a preferred technology pattern to achieve the purpose of cognitive aids.

*If you had somebody, a little robot to walk along with her[...]Just ask her the same questions[...]I try not to ask too many closed questions. I asked some closed questions, some open questions, some of them are, have you talked to your friends recently? How's the weather today compared to yesterday? Have you talked to the girls recently? Those are her granddaughters. Sorry. Have you talked to the girls recently? That's her granddaughters. Have you talked to the girls? (P.9)*

As shown above, P.9 wish to have a robot that walk with her family member with AD, and ask similar questions to strengthen the memory. According to P.9's description,

questions could be programmed through which individual with AD can interact and communicate with robot for the purpose of cognitive-aids.

## CHAPTER 5: DISCUSSION

### 5.1 Generalize the Adoption of Professional Assistive Technologies

Our research shows that assistive technology is a supportive care method embedded in the family caregivers' care. It can enhance the level of independence for individuals with AD. Therefore, assistive technology is assumed to reduce the care quality deficits provided by caregivers (Bharucha et al. 2009). However, impediments to technology adoption affect how this technology could help. One of the most important findings of our study is that the most of the technologies adopted in the regular everyday care of an individual with AD are not designed for AD care.

#### 5.1.1 Everyday Assistive Technologies Create Usability and Learnability

##### Challenges in AD Care Activities

Amongst 27 technological devices adopted by our participants, only one (i.e., necklace-style GPS tracker) is intended for AD assistance specifically. Many participants indicated that their motivation for purchasing technological devices was not related to AD care initially; they already had the devices before starting to care for individuals with AD. For example, one participant explained that she purchased a door sensor for house safety because thefts occurred in her living community. Later on, the door sensor was found to be useful in preventing individuals with AD from wandering. Another participant bought *Echo Dot*, but not to take care of her grandmother. Later on, she found that *Alexa* helps strengthen the memory of her grandmother and can act as an intelligent reminder during the care routine.

Those technologies could benefit individuals with AD in certain degrees while they served as assistive devices in people's everyday lives. However, the adoption of everyday

technologies can pose challenges for the people with cognitive impairment or of an older age as they are not specifically designed for these individuals. However, even though when the devices are designed for older individuals, prior work (Stowell et al. 2019) has revealed that older people often abandon the usage of health technologies. Similarly, our research results imply that older people can be skeptical about new technology. They tend to drop the use of technologies quickly because they are hard to use.

Moreover, many participants (7 out of 15) pointed out that it is tough for people with AD to learn new knowledge. Due to the nature of AD, a study revealed that individuals with AD and their caregivers are often afraid of misusing technology or they cannot use it given their limited technological experience (Zhang et al. 2014). Researchers have explored numerous ways to increase interaction with health systems and suggested a different design orientation, one that minimizes the required engagement time with the technology (Stowell et al. 2019).

#### 5.1.2 Transferring Everyday Technologies into a Professional AD Care Tool

One path forward is exploring how everyday technologies could better serve AD care-related users since we cannot ask every tech device producer to consider AD group people as one of their target users. Exploring an integrated platform connected with various types of standard technologies could be an option. We suggest developing an IoT (Internet of Thing) mobile application with AD care functionalities for caregivers. The system could integrate most adopted devices in AD care, such as cameras and GPS trackers. Product designers could make AD-related users the IoT system's target user and make it more user-friendly and more comfortable to adopt by family caregivers. For example, family caregivers could get alerts when their loved one is in an unfamiliar or dangerous location.

In this way, we transfer existing technological devices into professional AD assistive technologies through the integrated platform.

We suggest the IoT application should present as a mobile application because of the high adoption rate of mobile devices in AD care. In our findings, other mobile devices appeared in all types of AD assistive technologies adopted by family caregivers. Research reveals that smartphone's significant benefit is wireless communications and several software applications (Armstrong et al. 2010). Our findings also show that many participants mentioned communication and social software such as Facebook, Twitter, Facetime, and Zoom. The researchers further illustrated that mobile phone handsets are beneficial because of their small size, portable, and user-friendly design with various practical functions. Those functions could also cover the need for AD care, such as motion sensing, video chat, voice recognition, and interaction with the surrounding environment (Armstrong et al. 2010).

Our study participants prefer a system with less need for learnability and higher user-friendly design. A way to make the technology into a no-need-to-learn device for an individual with AD is to make family caregivers the technology controllers. We call for further research that examines the feasibility of such IoT platforms mentioned above and how to maximize the usefulness of everyday technologies in caring for an individual with AD.

## 5.2 The Future of Robotic Assistance in AD Care

Research has shown that robotic assistance devices are designed to enhance users' quality of life and give them an independent living experience (Feuilherade 2017). Japanese government data revealed that the robotic assistance devices' market is expected

to increase 25-fold to USD 3,7 billion by 2035. Similarly, the demand for automated intelligent assistance devices and other devices assisting elderly individuals is estimated to reach EUR 13 billion by 2016 (Feuilherade 2017).

#### 5.2.1 Robotic Assistance is a Solution for Functionality Challenges in Adopting AD Assistive Technologies

40% of the participants in our study explained that current adopted assistive technologies cannot fully address the most concerning challenges in AD. For example, participants believe there is not much assistive technology can do when it comes to “non-tech” physical challenges, such as getting dressed. In addition, physical issues cannot be prevented through assistive technology; such as falling, getting hurt, driving accidents, etc.

However, researchers from Georgia Tech published a paper, “Deep Haptic Model Predictive Control for Robot-Assisted Dressing,” at a Robotics & Automation conference, presenting a robot they created for the purpose of daily physical assistance in getting dressed (Giges 2018). The mechanism adopts haptics rather than vision to finish the dressing steps. This robot has successfully guided a hospital gown onto a user’s hand, elbow and shoulder. The development team expressed that they feel optimistic about robotic ability in helping people manage their daily activities (Giges 2018).

It is notable that the development of care robots for daily physical assistance is still in an early stage. Further research is needed to solve challenging technical problems. Taking dressing assistive robots as an example, researchers need to find a way to monitor whether the dressing outcome is appropriate and detect if there are more dressing items required.

### 5.2.2 Capabilities and Limitations of Robotic Assistance

Although robotic devices are not commonly seen in our participants' care process, their voices about robotic assistance. Our findings indicate that the most demanded assistive technology types are monitoring technology for safety, assistive tech for caregivers, and cognitive-aids technology. Robotic assistance, as an ideal solution, was mentioned by participants for safety monitoring and cognitive-aids. Participants expect robotic service to be more intelligent than current technology-assistive devices and assume the robotic devices with the energy of AI technology can facilitate family caregivers more efficiently. For example, one participant remotely monitors her mother, who is in the early stages of AD. She had a problem seeing a paper bill through video call, even though her mother tried to face the camera towards the bill. The participant wishes to have a robotic camera in her mother's house that she could operate to make the remote care assistance easier. Another participant wishes to have an accompanying robot that could walk with patients with AD. Additionally, the participants would like to have a robot that can have conversations with elder AD patient to strengthen their cognitive ability.

In addition, we also discovered that caregivers are often worried about leaving the individual with AD alone, either because of potential safety risks or the distress it may cause them. They may be tied in the house for the most time and only spend short periods outside. When possible, caregivers might ask friends and other families to stay with the individual with AD (Wherton and Monk 2008). To reduce caregivers' workload, today's assistive robots can automatically navigate locations and complete various tasks, such as aiding with mobility, handling, lifting, and bathing (Feuilherade 2017). Their capabilities could extend to human-robot interaction skills like speech, gestures and face recognition.

Typically, these robots are multiple intelligent devices. They are equipped with digital cameras to achieve smart camera functions, such as recognizing facial expressions and recording the surrounding environment (Feuilherade 2017). Besides, to fulfill monitoring and communicating with target users, many robotic assistive devices carry with stereo microphones and speakers. Moreover, some robot types also serve as entertainment tools by having databases of photo galleries, brain exercise, and music for individuals with AD (Feuilherade 2017).

Although the design of robotic assistance could ease the reliance on human caregivers, the accessibility of matured care robot is limited. We noticed that none of our participants have purchased a care robot. There is a participant (P.7) did not even know if a robotic assistance existed. Based on the Executive Summary World Robotics 2016 Service Robots report, the current service robot in use is 5,400,000 globally, among which only 4,713 are described as devices for disabled persons. The prediction for 2016–2019 showed that this number would be increased by 42,000,000 new robot devices, out of which 8,100 are expected to serve as assisting everyday tasks at home (Gerłowska et al. 2018). The above data shows the robot industry is still in an evolving stage. Family caregivers do not have enough choices in current robotic assistance marketing. Future work is needed to make robotic assistance more potent by equipping various assistance services in one.

Regarding the user acceptance of robotic assistance in AD care activities, other studies validated that older adults provided positive feedback towards care robots after realizing a robot's capabilities through video demonstrations. Functions of a care robot include delivering objects and playing a memory card game (Wang et al. 2017). It is worth mentioning that robotic care companies is siloed with each other. Their functionalities are

focused on particular components of care robots (Jason Walker 2017). Future work is needed to make robotic assistance more potent by equipping various assistance services in one.

### 5.3 Assistive Technology for Family Caregiver's Emotional Health

Our finding highlights the significant emotional health challenge met by family caregivers. 9 out of 15 participants indicated that they get frustrated when taking care of the individual with AD because AD patients will not learn new things or get better. Other studies also reveal that AD caregivers disproportionately have various mental health burdens, such as feelings of guilt for taking time for self-care (Stowell et al. 2019). This caused numerous mental health problems, including mood disorders, insomnia, and care-related stress (Stowell et al. 2019).

The risk of decreased emotional health has been discussed in the literature in the context of health-related quality of life for individuals with AD (Barbe et al. 2018). One major factor affecting HRQoL for individuals with AD is the care quality provided by caregivers. However, heavy caring responsibilities lead to a massive decline in caregivers' emotional and physical health, which negatively affect care quality as well as caregivers' emotional and physical health. (Barbe et al. 2018). According to Stowell (2019), a caregiver with a strong management ability of his or her health and well-being needs can translate directly into more effective care for an individual with AD. Researchers have been investigating various methods to prevent psychological health concerns amongst AD caregivers. For example, one study shows that an active lifestyle greatly benefits AD family caregivers' physical health. The authors described that designed exergames would support

family caregivers physically (Stowell et al. 2019). Thus, this will eventually benefit the individual with AD.

The above research indicates that a caregiver's emotional health would positively correlate to the individual with AD (Stowell et al. 2019). Our findings similarly suggest that few family caregivers adopt therapeutic technologies for themselves or individuals with AD. Few participants wish to have the technology developed to support the caregiver. In contrast, safety-related technologies caused the most attention of family caregivers. The neglect of adjusting the emotional issue could increase personal challenges and make mental health a more severe issue amongst family caregivers and individuals with AD. In our study, participants revealed that a support group is a standard option for caregivers to reduce stress and share the experience. Nevertheless, one participant shared that the family caregiver may be reluctant to join the support group activity. Thus, we consider therapeutic-orientated technology an option for caregivers, considering it provides more privacy than a support group. Therefore, we suggest that assistive technology should focus not only on the physical challenges in AD for the caregiver but also on their emotional health. The Resources for Enhancing Alzheimer's Caregiver Health II (REACH II) program indicated that interventions should be developed to reduce family caregivers' negative emotional impact and strengthen the positive experience in improving family caregivers' healthy status (Stowell et al. 2019). Future work is needed to investigate how assistive technology could help decrease negative emotional impact and strengthen family caregivers' mental health.

#### 5.4 Limitation and Future work.

As evident, this study was conducted with a small number of participants (n=15) within the United States. The interviewed participants are family caregivers so that they may represent a group of individuals with AD. In addition, our participant recruiting channel is the User Interview platform. People who are members of this online platform may be more familiar with technologies than people who do not interact much with laptops. A diverse recruiting source may lead to a different research result.

Moreover, researchers only interviewed family caregivers, considering they have more opportunities to decide whether to purchase assistive technologies for individuals with AD. As a result, we did not understand the perspectives of individuals with AD and professional AD caregivers. They may have a different opinion regarding assistive technology adoption. For example, AD nurses may adopt professional assistive technologies more frequently than family caregivers. In future research, we could include more groups of people involved in AD care to gain a broader picture on this topic, such as people who run a nursing home and care facility, professional caregivers, AD doctors and individuals with AD.

## CHAPTER 6: CONCLUSION

The result of our semi-structured interview highlights a multifaceted spectrum of challenges of assistive technologies adoption associated with low usability (complicated operation steps, high reliance on caregiver's assistance), high demand for learnability, and functionality deficient. The low adoption rate of professional assistive technologies on the consumer market might aggravate those challenges, however we revealed that caregivers are repurposing existing technologies, such as using to Smartphone with GPS tracker to enhance their ability to take care of individuals with AD. Connecting different types of adopted assistive devices with an IoT platform that serves AD care users could be a key to a more user-friendly orientated deployment. In addition, our research underlines the significant role of the care robotic in AD care. Future work is needed to popularize care robotic and release the family caregiver's burden. A major concern of family caregivers' negative emotion requires further research to understand ways to relieve psychological stress and how assistive technology could help decrease family caregivers' negative emotional impact and strengthen their mental health. The goal of this project is to provide a base for a more comprehensive understanding of individuals with AD and their caregivers as users and consumers of technology, to help designers and developers to make the assistive system more applicable for caregivers, and therefore, improving the quality of life for individuals with AD and their caregivers.

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## APPENDIX: INTERVIEW QUESTIONS

1. Please describe your relationship with AD individuals.
2. Alzheimer's stages of the individual with AD
3. How many caregivers does the individual with Alzheimer's disease have? Are they full time? What are their responsibilities?
4. Do you and the AD individual have the experience of using assistance technology? Please describe how they facilitate the care process.
5. Have you used Monitoring Technologies for safety? (Safety and monitoring tools can innovatively monitor individuals with AD. They incorporate alternatives to set off cautions by monitoring (alert and pager units, fall detectors, flood finders, water temperature screens, lighting) and in this manner point to bolster the prosperity, autonomy, and security of the individual with dementia as well as to supply consolation to caregivers)
6. Have you used Therapeutic Technologies (Therapeutic techniques intend to help cognitive and physical fitness, entertainment, leisure, and wellbeing)?
7. Have you used Cognitive Aids Technologies (Cognitive aids technologies aim to assist individuals with Alzheimer's disease to engage in basic daily activities)?
8. Have you used Communication Assistive Technologies (Communication assistive technologies include the use of technology that helps to enhance social interaction and networking)?

9. Have you used Remote Care Assistive Technology (Interventions classified under this category aim to facilitate direct contact and exchange of relevant facts among professionals, individuals with AD, and their family caregivers)?
10. Please describe valuable functions you find in the assistance technology.
11. What are barriers in adopting assistive technologies?
12. Please describe the most challenging issues in taking care of the Alzheimer individual. Can those challenges be solved by AT?
13. Please describe functions of assistance technology you wish to have in taking care of Alzheimer individuals. How those functions help in taking care of AD individuals?
14. What are top three possible dangers or problems can happen to Alzheimer individuals in current care process? In which way you wish AT could help to decrease those dangers?
15. What is your age?
16. What is your gender?
17. What is the age of the Alzheimer individuals you take care of?
18. What is the gender of the Alzheimer individual you took care of?