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SMART HOME TECHNOLOGY EFFECT ON BEHAVIOR, COGNITION, AND WELLBEING OF INDIVIDUALS AGING IN PLACE

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SMART HOME TECHNOLOGY EFFECT ON BEHAVIOR, COGNITION, AND WELLBEING OF INDIVIDUALS AGING IN PLACE

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Dedicated to all the creative minds, developers, and researchers who tirelessly work to elevate the quality of our lives. I am forever grateful for my husband's and friends' support.

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Terms and Definitions

Senior: according to Medicare, a senior is a person that is 65 years or older (Medicare.gov, n.d.).

Quality of Life: refers to an individual's perception of their position in life in terms of value, standards, and expectations (WHO, n.d.).

Aging in Place: refers to older adults being able to remain living in their community and home while sustaining independence, autonomy, and access to social support (Wiles, Leibing, Guberman, Reeve, & Allen, 2012).

Medicare: a federal health plan dedicated to providing healthcare insurance for people who are 65 or older, younger people with specific disabilities, and people who suffer from end-stage renal disease (Medicare.gov, n.d.).

Voice-Controlled Intelligent Personal Assistants (VIPA): refers to artificial intelligence-equipped devices that mimic human intelligence and can engage with users via conversations (Ermolina & Tiberius, 2021).

Data Scraping: refers to the process of gathering and organizing contents from a source using software that can imitate browsing behavior to extract data of interest according to preset extraction criteria (Glez-Peña, Lourenço, López-Fernández, Reboiro-Jato, & Fdez-Riverola, 2014).

Abstract

Overview

Background and Objectives

As many older adults prefer to age in place, there is a possibility of elevating the Quality of Life (QoL) via implementing smart home technologies, specifically Voice-Controlled Intelligent Personal Assistants (VIPA). This study explores the acceptance and user behavior of older adults who utilize such devices and how it affects caregivers in providing care and peace of mind for caregivers and older adults.

Research Method

The research method adopted for this study consisted of a qualitative thematic analysis of verified Amazon Echo Dot 3rd Generation reviews, posted on Amazon's website, that involved the keywords senior, elderly, grandparents, and caregiver. The reviews were extracted via a web scraping software, ParseHub, that helped organize and export the reviews into a Microsoft Excel workbook to prepare for coding that data. The reviews provided insight into how seniors and caregivers utilize the VIPA device to age in place, helping determine relevant themes.

Results

The dataset was obtained after filtering through 1,048,808 online reviews by keywords and set the search criteria concerning the reviews type set to verified only. The datasets included 414 verified online reviews that contained the keywords senior, elderly, grandparents, and caregiver. The process resulted in forming eight themes, which are entertainment, communication, companionship, learning and news, emergency and security, reminders and alarms, home automation, and shopping. The users, seniors, and

caregivers gave insight into how they utilize the VIPA device, which helped understand the most common uses of VIPA devices among older adults. Moreover, some of the reviews included additional information that indicated an elevated Quality of Life after acquiring and using the VIPA device, such as a senior with visual impairment using the smart speaker to control their home lights via voice commands.

Abbreviation List

The following table (Table 1) addresses all the abbreviations and acronyms used throughout this thesis.

Table 1

List of Abbreviations and Acronyms Used Throughout the Thesis

Abbreviation	Definition
VIPA	Voice-Controlled Intelligent Personal Assistants
QoL	Quality of Life
IoT	Internet of Things
CAPTCHA	Completely Automated Public Turing test
IP	Internet Protocol

Introduction

Background

According to the National Academies of Sciences and Medicine (2020), nearly one-quarter of older adults aged 65 and older who chose to age in place suffer from social isolation and loneliness. Loneliness and social isolation put older adults at risk of multiple health ailments that can further decrease their Quality of Life (QoL). Health risks associated with social isolation and loneliness include higher mortality rates, increased morbidity rates, decreased functional and cognitive decline, and a higher risk of developing mental health-related issues such as depression and anxiety. Moreover, when older adults report loneliness and isolation, it is also a byproduct of poor social relationships or lack of fulfilling human interaction (National Academies of Sciences & Medicine, 2020; Taylor, 2020).

Aging in place refers to seniors continuing to live in a familiar environment while sustaining a degree of independence as long as possible. There are multiple aspects of aging in place that contribute to becoming a favorable option for many seniors as they grow old. These aspects include sustaining their autonomy and reducing reliance, controlling their environment, and having access to a community, which allows them to socialize and interact with others (Vanleerberghe, De Witte, Claes, Schalock, & Verté, 2017). The studies involving aging in place developed to reform how we design homes and communities for people who choose to age in place. The primary aspects that relate to aging in place homes mainly focus on physical safety, where most guidelines recommend practices that are rooted in providing an alternative for nursing homes (Becker, Dickinson, Sullivan, & Cline, 2020; Lawlor & Thomas, 2008). Furthermore,

there are studies regarding technology integration in aging in place homes to provide a safety layer via monitoring the occupants' movement (Chen et al., 2015). However, other types of technology are available for integration in aging in place homes that may help in automating tasks and help with aspects related to the psychological concerns that arise with aging in place (Chen et al., 2015; Choi, Demiris, & Thompson, 2018).

Smart home technologies have developed over the years to cater to different lifestyles and allow users to automate daily tasks to elevate homeowners' QoL. There are multiple devices available that are easy to acquire and configure and are aimed to assist users with various daily tasks (Alam, Salem, Alsharif, & Alhujaili, 2020). With more seniors preferring to age in place, integrating smart home devices and smart home automation systems helps them live independently and maintain or improve their QoL (Wang et al., 2019). Moreover, smart home technologies support caregivers in managing different care arrangements for seniors or aging family members remotely, easing the emotional and financial burden (Lindeman, Kim, Gladstone, & Apesoa-Varano, 2020; O'Brien, Liggett, Ramirez-Zohfeld, Sunkara, & Lindquist, 2020). Caregivers can use these smart devices, such as Amazon Alexa, to connect with senior family members via initiating phone calls or video calls, set reminders for them, and contact services such as health or emergency services via simple commands (Berridge & Wetle, 2019; Choi et al., 2018; O'Brien et al., 2020). With complex home automation systems, users can control the thermostat, lighting, home appliances, lock and unlock doors, and even set up security settings via their phones or tablets (Mtshali & Khubisa, 2019).

Integrating smart home devices and home automation systems adds a layer of complexity to the environment of aging in place homes. It shifts the methods by which

occupants' function and complete their daily tasks (Carnemolla, 2018; Rahman et al., 2019). The majority of Voice-controlled Intelligent Personal Assistants (VIPA) depend on verbal information input, allowing users to utilize VIPA devices without learning additional control methods. With simple voice commands, the user can initiate questions and complete tasks that may have required them to perform physically. Utilizing verbal commands to automate daily tasks allows the users to control their environment and feel a sense of independence in their own homes (Lau, Zimmerman, & Schaub, 2018; O'Brien et al., 2020). Another aspect of VIPA or home automation technology is the development of a sense of attachment between the machine and the user. Seniors often experience a degree of loneliness that affects their mental wellbeing and often leads to developing depression. With VIPA devices' ability to respond to questions, tell stories or jokes, and provide sources of entertainment, seniors develop a sense of connection with VIPA devices and often view them as companions that assist when needed (O'Brien et al., 2020; Perissinotto, Stijacic Cenzer, & Covinsky, 2012).

Home automation and smart home technologies affect how occupants behave and operate within a space, as it reduces the effort required to complete tasks. An example would be changing daily movement or commute habits if a senior opts for smart locks and can lock or unlock their doors from anywhere. Further, some devices allow for continuous monitoring, such as installing indoor security cameras or motion sensors to track the occupants' movement on a day-to-day basis. However, to run some of the home automation services, the users must type in personal information to operate the smart devices optimally, which might deter some seniors from acquiring them out of fear that such devices interfere with their privacy (Abdolrahmani, Kuber, & Branham, 2018;

Berridge & Wetle, 2019). That said, do smart home devices or automating an aging in place home help improve the home environment? And do the benefits of aging in a smart home outweigh the disadvantages?

Problem Statement

The American Society of Interior Designers (ASID) published a book in 2008 that discussed designing homes that allow older adults to live independently (Lawlor & Thomas, 2008). The solutions provided for creating an environment supportive of aging in place focus on the occupants' physical safety within the physical environment. While physical safety is essential, most of the standards, recommendations, and measures often overlook the solutions concerning social connectivity and solutions to tackle loneliness and social isolation in older adults.

Purpose of Study

The purpose of the study is to provide insight into the influences of smart home technologies' integration, focusing on VIPAs, on seniors' behavior in aging in place homes. The study explores how human-to-machine relationship aid seniors' in accessibility, usability, mental and physical support, and its level of assistance in providing a sense of further independence (C. Lee & Coughlin, 2015). Moreover, to explore how employing VIPA devices can provide companionship, meaning, and enhance connectivity and relationships. Further, this study can help determine if there are any recommendations for placement of the VIPA devices around the home, depending on the room type. Lastly, this study investigates if there are any suggestions to improve the current VIPAs available on the market to cater to seniors to aid them in aging in place.

Research Questions

The proposed questions will contribute to the research and help find any links between including VIPA devices in aging in place homes and improved cognition, improved emotional status, and streamline occupants' daily tasks. Further, it will note any additional behavioral changes or adaptations caused by employing or using VIPA devices, if any.

- Would VIPA devices help generate positive emotions, engagement, positive relationships, meaning, and a sense of accomplishment?
- How does the daily routine of both elderly and the caregivers differ in the presence of VIPA devices?
- Do people who choose to age in place need VIPA devices designed and programmed to cater to their needs? Or are the current options available on the market sufficient to substantially improve cognitive, emotional, and safety aspects?
- What is missing from the current aging in place homes, and how can integrating VIPA devices or similar devices change how we design aging in place homes?

Moreover, the study will look at the cons and pros of using the current VIP devices available on the market and how the models could improve to assist those who choose to age in place. These suggestions will also consider placement options and recommendations for the VIPA devices in a home environment, which might amplify the users' experience. These recommendations will be part of the discussion as ideas for further studies or when testing and comparing other devices that fit the purpose of supporting aging in place. The study will follow three interpretations to evaluate the

findings in order to answer the research questions. These interpretations include the meaning of home and objects for seniors who choose to age in place, meaning of connectivity in terms of sustaining or developing relationships with family and loved ones, and lastly, understanding the behavioral and psychological changes that occur with employing VIPA devices at home.

Method

The study followed qualitative thematic analysis of verified online product reviews to develop themes to help define user usage patterns of the VIPA device. The themes helped categorize the usage patterns and provide insight into how seniors and caregivers utilize VIPA devices to help with aging in place. The reviews were filtered depending on keywords related to seniors, caregivers, and aging before extracting them into a Microsoft Excel workbook. The product reviews extraction procedure was conducted via employing a web scraping software, ParseHub, to streamline the process. It also helped export the data in an organized manner into a Microsoft Excel workbook for coding and analysis**.**

Limitations

While the study provided insight into how older adults and caregivers utilize VIPA devices to help age in place, some limitations should be considered for future studies. The first limitation concerns how the dataset was collected, specifically utilizing a web scraping software to obtain data. Amazon's website frequently detected and blocked the web scraping tools as they consider the speed of how the software navigates multiple pages to be an abnormal activity. When Amazon's website detects scraping software activity, it either initiated an Internet Protocol (IP) ban or employed a

Completely Automated Public Turing test to tell Computers and Humans Apart (CAPTCHA) to block the software. The IP block and the CAPTCHA issues were solved by waiting for a few hours before initiating another scraping command. Some of the datasets required a longer wait time, but overall, the scraping software extracted all the product reviews across.

The second limitation concerns the reviews' quality, as some of the reviews contained spelling or grammar errors that affected the meaning of sentences. Also, some of the reviews lacked information such as age, gender, socioeconomic status, and health status. The lack of information made it difficult to determine how to code some of the reviews; however, to limit selection bias, reviews with clear and objective sentiments were included while excluding all reviews that sounded vague or did not include objective information. Due to the study's nature, there is a potential bias when reviewing and selecting certain reviews as examples throughout the study. The reviews selected were limited to one company and one device, and there is a need to do research on other devices available on the market. There is a need for research to look at other aspects of VIPA devices' usage and utilization that cover a wider range of users with clear demographic information. That said, this exploratory study can help as a starting point for future research on VIPA devices usage to support aging in place.

Thesis Outline

Chapter 1 includes the introduction, which consists of background regarding the topic, purpose of study, research question, and study goal. Chapter 2 includes detailed background information, including background on aging in place homes and VIPA devices' history. Chapter 2 also includes a literature review, which will discuss previous

studies and methods regarding the topic and behavioral theories that apply. Chapter 3 includes the study's method and measuring tool, as well as the data analysis procedure. Chapter 4 includes an in-depth data analysis and reviewing of the findings. Lastly, chapter 5 involves discussing the data analysis results and findings and recommendations for future studies.

Conclusion

The first chapter introduces the thesis topic that involves exploring if VIPA devices improve the Quality of Life (QoL) of older adults who choose to age in place. When designing a suitable home for aging, there are multiple safety considerations that designers need to be aware of, but most specifications cater to physical safety and accessibility. Seniors are at risk of other health issues related to psychological wellbeing, such as loneliness and depression. However, including smart home technology as part of older adults' daily routines might improve their QoL and broaden the social circle and healthier interaction. Moreover, including smart home technologies, specifically VIPA devices, might help elevate the ease of completing daily tasks, allowing further independence. The research questions include looking into the current uses of VIPA devices to see if they help generate positive engagement, better relationships and see if utilizing such devices would ease caregivers' load. The research will also involve looking into design-related issues that might be acceptance barriers for older adults and explore what is missing from the current aging in place homes regarding design considerations related to technology.

Literature Review

Overview

The literature review includes four topics that help understand critical aspects of the current issues with aging in place homes and determine if the implementation of VIPA devices would benefit seniors' wellbeing. The first section discusses the historical background of aging in place as a concept, as it helps in understanding what the design goals and standards focus on and what is currently missing. The second section involves looking at the loneliness rates among older adults and the factors that affect loneliness reports. The third section discusses technology adoption rates and behaviors among older adults and the factors that promote easier adoption and usage of the current technologies. Lastly, the final section overviews smart home technologies' current uses to explore the current behavior and adoption rate of VIPA devices among users.

Historical Background

Enduring and sustaining a healthy lifestyle in one's home is the foundation of aging in place as a concept, as it started to gain prevalence among older adults in the late 1990s. The goal then was to allow older adults to age in their homes via design modifications that supported their physical and safety needs while allowing for the continuation and expansion of older adults' social and professional lives. One of the first questions regarding providing suitable homes for older adults to age in safely questioned what properties a home would have to support aging in place. The majority of the questions around providing homes to support aging in place often revolved around the physical environment and how to make it safer according to the occupants' health status and needs. Another aspect that makes aging in place desirable is the idea that it allows for

lower dependence on caregivers and provides older adults a degree of autonomy when it comes to daily habits. An example of that is to provide enough space in entryways to allow for more effortless movement and prevent crowding. In cases where older adults suffer from cognitive decline, some design implementations may consider adequate wayfinding solutions to allow the occupant to maneuver the space efficiently (Ahn, Kwon, & Kang, 2020; Lawlor & Thomas, 2008).

The narrative around aging in place homes evolved to include the idea of developing and integrating technology that further enhances and supports aging in place. To strengthen the level of independence within the physical environment, early concepts of smart devices capable of delivering services or help complete daily tasks started to gain attention. While some of those devices' concepts and designs were merely primitive, they helped pave the way to develop some of today's smart home devices. There are multiple types of smart home technologies that support aging in place, such as motion sensors and ambient sensors that can detect falls and walking patterns that alert caregivers when accidents happen (Finch, Griffin, & Pacala, 2017; Yang, Miao, & Shen, 2015). However, in this study, the focus is on digital voice assistants, which allows for a different set of assistive services. The earliest prototypes of digital assistants were in a study by Mynatt, Melenhorst, Fisk, and Rogers (2004).

In the study, Mynatt et al. (2004), the authors discuss the feasibility of utilizing smart gadgets to help older adults complete different sets of daily tasks and maintain their independence. Also, to enable seniors to utilize such devices to learn new skills and new communication methods in a cost-effective manner. The prototypes featured in the study include three simple devices that each targets a specific task. The first device is a

pendant, which the user can wear and use hand gestures to initiate commands such as closing the blinds or turning the lights on and off. Moreover, the pendant acts like a sensor, similar to the sensors that detect and records walking patterns, but in a manner that can detect fine-motor skills decline, which is present in the elderly who develop Parkinson's disease. The importance of incorporating a gesture-based device is not only for tracking the wearer's health status but also for providing an easy learning curve for those who are not familiar with using technology (Peek et al., 2016).

The second device is essentially a digital notebook that focuses on helping the elderly with cognitive impairment or declining memory. The device records and stores steps needed to complete daily activities such as cooking a meal, and the user can access those records later if needed. The device essentially acts like secondary memory storage that aids in recalling instructions similar to various phone and computer applications on the market today. The last prototype focuses on familiarity, which is a crucial element to sustain within aging in place homes. The last prototype focuses on familiarity, which is a crucial element to sustain within aging in place homes. The prototype is a home monitoring device that displays the older adult's activity logs and health status to the caregiver that is highly similar to a recently released service by Amazon.com, Inc. The device itself is supposed to act as a sensor. It can gather information as the older adult starts their day and the information portrayed on the device like a picture frame, showing the user's picture and health status, allowing the caregiver peace of mind (Mynatt et al., 2004). The prototypes mentioned in the study are quite similar to an array of smart home technologies on the market today that are part of a network, the Internet of Things (IoT), which connects physical objects with numerous software via the internet and radio

technology. As the number of internet users rises, the development of physical devices that manage and automate prevailed. In the realm of architecture and interior design, several companies developed a set of devices that each serve a purpose, with all focusing on reducing the human effort to complete tasks (Risteska Stojkoska & Trivodaliev, 2017).

Loneliness in Older Adults

As the loneliness rate among older adults increases, social relationships' quality drops, contributing to decreasing physical and mental health. The lifestyle differences from a senior to another make it harder to determine the exact levels of loneliness in older adults, but that said, there are cases where individuals lack social settings that keep them consistently socially active. Seniors are at a high risk of reporting loneliness due to various reasons such as loss of family members and friends, not belonging to a group, or medical ailments that prevent them from interacting with others (National Academies of Sciences & Medicine, 2020). In a study by Newall and Menec (2017), the authors mention that there is no definitive method to measure loneliness, but that said, there are factors that help identify why an individual might feel lonely. The scales include the nature of the individual's social relationship and how the individual views their socialization level, which is often subjective.

Moreover, loneliness's subjectivity is often affected by the quality and quantity of social relationships and each individual's needs. However, it is essential to note that a socially isolated individual does not necessarily mean they are lonely. The authors define in their study four distinct groups that examine both social isolation and loneliness as linked concepts that affect the individual's social life quality. The groups rank the

severity of the individual's wellbeing and how vulnerable they are according to their social life characteristic. The most vulnerable are the socially isolated and lonely individuals, as they are unsatisfied with their quality and quantity of social interactions. The socially isolated and lonely individuals often suffer from a decline in physical and psychological health, resulting in an increased mortality rate (Kemperman, Van Den Berg, Weijs-Perrée, & Uijtdewillegen, 2019; Newall & Menec, 2017).

Other factors contributing to increased loneliness in older adults include their dwelling location, mobility status, and living environment condition. While the idea of aging in place provides independence and control for seniors, it might contribute to an increased sense of loneliness in older adults. The accessibility to their social circle, activity centers, and social events may differ depending on their mobility status and the location of their homes. In an article by Kemperman et al. (2019), the authors conducted a study where they surveyed 182 adults aged 65 and over to determine the qualifications of healthy neighborhoods that promote seniors' social activities. The authors set the measures to include sociodemographic information, mobility status, frequency of social participation, condition of the living environment, and how lonely the participants feel. The authors found that older adults who reported feeling incredibly lonely were also unsatisfied with their social network, which meant a correlation between social life quality and loneliness.

Social isolation and loneliness increase the health risks among older adults, as most older adults continue to experience poor social life and often fail to maintain their social circle. The impact of social isolation and loneliness in older adults affects older adults' health status and contributes to increased mortality, worsened physiological

health, and increased risk of developing depressive symptoms. Moreover, seniors who experience social isolation and loneliness often self-reported worse physiological and psychological health (Blazer, 2020; Chambers & Beaney, 2020; Taylor, 2020). A significant find in a study by Zeytinoglu et al. (2021) concerning the association between social isolation and morbidity and mortality of older adults established that older adults suffering from social isolation had an increased risk of falling. Falling is the most common cause of morbidity and mortality in older adults, and falling accidents occurring within the home environment contribute to a severe decline in seniors' overall health (Gazibara et al., 2017). Also, Shaw et al. (2017) noted a correlation between social isolation and increased health services use, including more frequent hospital visits and emergency hospitalization. Also, there is a correlation between older adults suffering from social isolation and loneliness and increased Medicare spending. Medicare is a federal health plan dedicated to providing healthcare coverage for people who are 65 or older, younger people with specific disabilities, and people who suffer from end-stage renal disease. Three distinct parts form Medicare, which includes hospital insurance, medical insurance, and prescription drug coverage (Medicare.gov, n.d.). For older adults suffering from isolation, Medicare spends approximately $1640 more on socially isolated seniors than those who have healthy social interactions.

Acceptance Attitudes Towards Smart Home Technologies

Older adults' behavior towards technology is an important aspect worth considering when discussing implementing smart home technologies in dwellings. There are earlier reports on low adoption rates of technology among older adults caused by inadequate understanding of certain products and services due to multiple factors that

create barriers to learning and adoption (Berkowsky, Sharit, & Czaja, 2018). Also, stereotyping creates a barrier for older adults to learn and utilize available technologies for different tasks as it causes seniors to feel less confident about adopting new technology. Technology's rapid development and the rate at which companies release new products make it extremely difficult for those who are not well versed in technology to embrace what is available on the market and use it to better the quality of their lives (C. Lee & Coughlin, 2015; Yusif, Soar, & Hafeez-Baig, 2016). Multiple factors affect the rate of technology adoption among older adults, which C. Lee and Coughlin (2015) discussed in their study. The study aimed to identify what affects technology adoption behavior in older adults and how seniors implement the technology within their daily routine via observing patterns in the literature that discuss technology adoption. The factors included value, usability, accessibility, technical and social support, experience, and confidence, where these factors indicate how significant a piece of technology is to the user. Consumers would be inclined to purchase and use technology that they perceive helpful for specific tasks. It is critical to observe the behavior around the potential benefit of smart devices. If a smart device's perceived usefulness aligns with the expectation and value, the consumer is inclined to adopt that device and learn how to utilize it (Koon, McGlynn, Blocker, & Rogers, 2020; Trajkova & Martin-Hammond, 2020).

Seniors are inclined to use devices that are easy to learn, interact with, and require low maintenance. It is crucial to keep in mind that not all consumers are the same when it comes to learning and using technology, and having an easy setup is essential for older adults to adopt a new piece of smart home technology. An easy setup of any technology service or device includes design-related details that concern the device configuration,

instruction packet, and user interface. Such elements should be easy to read, learn, and non-error-inducing as they can drastically affect the learning curve and usability (Carnemolla, 2018). Further, previous literature indicates that there are adoption models that illustrate factors that determine technology adoption and determine how individuals behave when it comes to accepting new technology. An example of a popular adoption model is the Davis' Technology Acceptance Model (TAM) states that a new technology's innovations, features, and abilities highly affect individuals' motivation and willingness to accept, learn and utilize new technology. The TAM model predicts that if the individual perceives three factors, including convenience, ease of use, and value in terms of services and functions, the adoption rate is higher. The three factors can be highly subjective as they depend on the individual's technology literacy and general attitude towards devices that affect their QoL (Berkowsky et al., 2018; Marangunić & Granić, 2015). Unfortunately, the adoption models often do not represent older adults' acceptance behaviors and often disregard age and gender. However, the Unified Theory of Acceptance and Use of Technology (UTAUT) is an acceptance model that takes gender, age, and personality traits into account and other factors such as expected performance, value, social influence, and accessibility (Berkowsky et al., 2018; Venkatesh, Morris, Davis, & Davis, 2003).

The importance of understanding predictors of acceptance behavior is to understand the deterrents that often seniors face when faced with new technology. Recognizing the obstacles that older adults face when it comes to using new devices on the market helps developing new technology that caters to their needs (Czaja, Boot, Charness, Rogers, & Sharit, 2018; Mitzner et al., 2018). Mitzner et al. (2018) conducted a

study to develop a comprehensive adoption model that considers behavior, personality traits, age, gender, and cognitive abilities of older adults to determine new technology's adoption attitudes. The authors mention that the issue with acknowledged adoption models is that they are not examined with technology catered to or adopted by older adults. Also, most technologies available on the market often do not consider seniors in terms of long-term adoption and usability (Ahn, Beamish, & Goss, 2008). The authors followed a method that includes a computer system, the Personal Reminder Information and Social Management (PRISM), to measure and determine the factors that influence older adults' acceptance behavior. The PRISM system in this study is the point of comparison to the typical computer systems, which helps in understanding the barriers that seniors face when learning how to use a new device or operating system. The study sample included 150 participants aged between 65 to 98 years old, 77 males and 119 females, with all self-reporting their health status as good in general. The variables looked at computer proficiency, experience, general physical and psychological health, personality traits, abilities, and acceptance attitudes. The results indicate that having a senior-friendly user interface (UI) and easy to navigate design increases older adults' chance of adopting it mid-term and long-term, especially those with high confidence and experience.

A vital aspect of seniors' high acceptance attitudes toward new technology is enhanced psychological health and healthier social life. Older adults' frequency and quality of their social habits are also related to technology use, specifically utilizing social media platforms and devices that help them stay connected to their social circles, such as smartphones. Interacting with people on social media improves the QoL as it

helps maintain healthy cognitive functions, especially memory functions, for seniors. Also, the internet allows older adults to broaden their social networks as globalization aids in connecting with different people with similar interests (Myhre, Mehl, & Glisky, 2016). According to the AARP, 51% of seniors residing in the United Stated invested in new devices that include smartphones, computers, smart televisions, tablets, wearable devices, and smart home technology products. Also, the adoption and acceptance rates are higher among older adults because they feel more confident in learning and trying new technologies for functions that involve socialization, security, and home automation. Seniors' behavior towards adopting new technology seems to be on the rise, as older adults are looking for new ways to implement technology in their daily routines (Kakulla, 2020).

Current Use of Voice Intelligent Personal Assistants

There are multiple arrays of smart home devices that enable the users to integrate within their home environment to create a system that makes their homes streamlined. The most common activation method of current smart homes is via speech, where multiple devices' controls depend on voice commands to activate. The ecosystem of smart homes often depends on central control equipment or a hub that enables smart devices to communicate with each other via internet connection (Juniper, 2018). Moreover, this allows companies and manufacturers to create multiple devices that allow for functions to help the users complete tasks with ease. There are convenient smart home devices that depend on voice commands, often referred to as Voice-controlled Intelligent Personal Assistants (VIPA). VIPA are smart devices that offer the user a hands-free experience via voice commands, and each smart speaker activates when the user speaks

the activation. An example of an activation word is "Alexa," which the user needs to vocalize before initiating a request from Amazon's smart speakers (Lau et al., 2018; Lopatovska et al., 2019). The technological advancement of VIPA devices depended on developing a proper infrastructure that enabled such devices to interconnect within a system called the Internet of Things (IoT), which involves multiple devices communicating to coordinate a set of commands. The integration of multiple devices via a shared network narrows the gap between machine and human interaction and helps narrow down the number of commands required to run a task. VIPA devices generally come with built-in speakers and a microphone to allow for the main controls, and some include a few buttons for manual interactions if needed. Moreover, VIPA can communicate with other smart devices such as smart lighting, home environmental controls, and security systems to enable the users to employ VIPA devices as the main control panel of their homes using only voice commands. The utilization of voice commands makes VIPA devices unique in the way they operate, as they also remove some barriers that often deter people from using technology (Kowalczuk, 2018; Risteska Stojkoska & Trivodaliev, 2017).

The placement and usage of VIPAs in a home environment differ depending on the users' lifestyle and needs. Also, the adoption behavior and usage are affected by the users' technology experience. The most common uses of smart speakers include home controls, such as controlling the lights, thermostat, and other smart home appliances if the user obtained a few to integrate with the smart speaker (Mtshali & Khubisa, 2019). Other uses also include reminders and alarms, which are qualities that are common in smartphones. However, the critical difference in setting reminders via the VIPA device is

that the reminders' notifications are audible. The smart speaker verbalizes the reminders' content rather than only notifying the user via a tone (Beaney, Kalirai, & Chambers, 2020). Moreover, other uses for VIPA devices involve communication, a critical feature that allows users to initiate phone calls or call emergency services via voice commands. There are various features that differ depending on the type and brand of the smart speaker. They have the potential of shifting the way users complete their daily tasks and interact with others, and they have the potential to help older adults age in place (Hoy, 2018; Koon et al., 2020).

Conclusion

The literature review examines the feasibility of utilizing VIPA devices to help seniors age in place from different aspects that involve previous tests of primitive smart gadgets, acceptance attitudes towards technology, and current use of common VIPA devices in the home environment. The literature review also focuses on social isolation and loneliness in older adults, as there are prominent issues that affect older adults. Some studies examined developing gadgets that help with specific sets of tasks, created for the sole purpose of helping seniors streamline their daily tasks and help them stay connected. The notion behind exploring such gadgets and ideas is to create devices that improve the QoL of older adults as they age. However, one of the issues when it comes to smart technology is the acceptance attitudes of older adults towards adopting and utilizing such devices. That said, some studies indicate there is a rise in older adults' adoption behavior, which is a promising indication to explore further the topic of utilizing VIPA devices to help age in place.

Methodology

Datasets

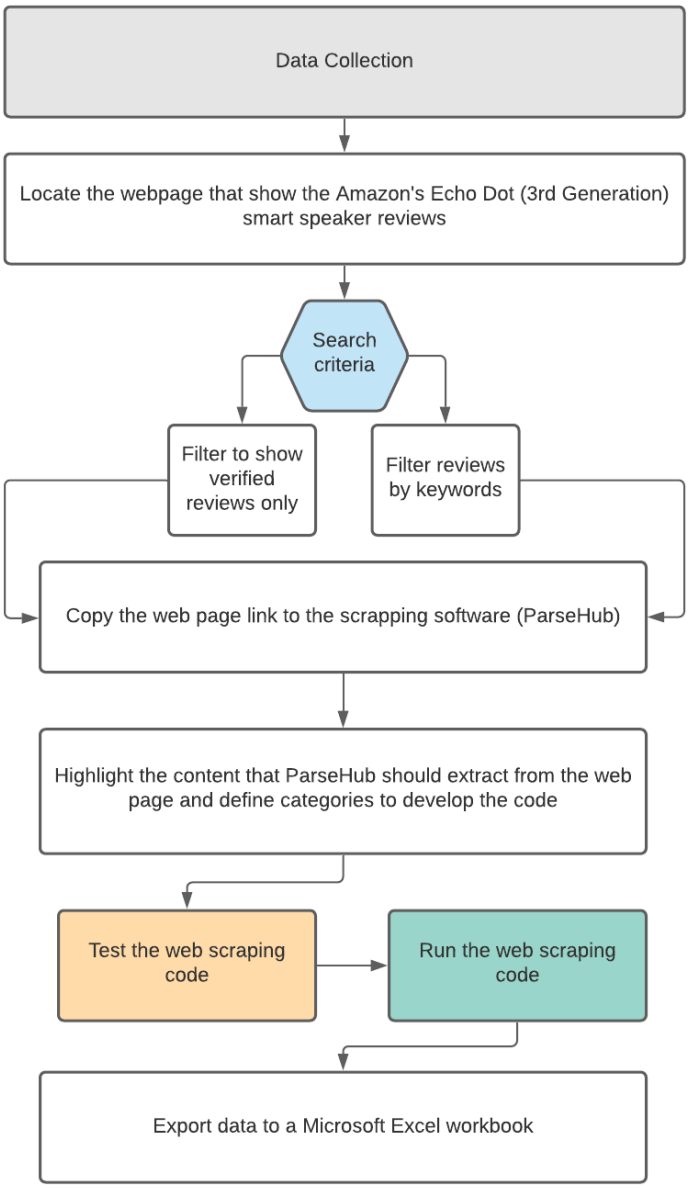
The study followed a qualitative thematic analysis that examined verified online product reviews posted by users who acquired and used Amazon Echo Dot 3rd Generation smart speaker, focusing on users who mentioned using the smart speaker to help them age in place (Figure 1). The consideration for thematic analysis as the method stemmed from the necessity to determine themes to learn how seniors use VIPA devices in their home environment via product reviews (Kowalczuk, 2018; O'Brien et al., 2020). The procedure began with choosing the most bought and reviewed Amazon VIPA device on Amazon's website. The initial search results indicated that the Amazon Echo Dot 3rd Generation smart speaker showed is the most reviewed product that falls under the VIPA devices category. The sample selection consisted of filtering the available online product reviews, which consisted of 1,048,808 ratings, via search criteria that filtered to only show verified product reviews that involve the keywords selection senior, elderly, grandparents, and caregiver (O'Brien et al., 2020).

ParseHub, a web scraping software, helped obtain and organize the product reviews as datasets and export them to a Microsoft Excel workbook. The data scraping started with obtaining the webpage link after filtering the reviews according to the search criteria to add it to a new project in ParseHub. The webpage link served as the starting point for ParseHub to collect the product reviews and served as a foundation to prepare the initial steps to specify the categories. The categories consisted of the product review elements that PaseHub should look for and extract to the Microsoft Excel workbook via a built-in code. The categories included the reviewer's name, rating, review title, date, and

review content. After establishing the categories, the code went through a test run to determine if the categories worked adequately before running the full code to scrape the data. After ParseHub completed the scraping process, the software allowed for the data exportation as a Microsoft Excel workbook.

Figure 1

Data Collection Method



Data Storage

The exported Microsoft Excel workbooks storage method involved renaming the files to organize them by keyword. The action of renaming the workbooks allowed for recognizing the product reviews for analysis. The exported workbooks storage location included a smart-synced DropBox located on a personal computer to allow further data protection against unexpected loss.

Data Analysis Method

Overview

The data analysis method involved an inductive content analysis of the verified online product reviews to determine relevant themes (Kowalczuk, 2018; O'Brien et al., 2020). The reviews determined the themes depending on a set of keywords that related to each topic (Figure 2). For example, if the reviewer mentioned using the VIPA device to listen to music, it was included in the "Entertainment" theme. A few reviews did not indicate a clear indication of how the smart speaker was used, nor indicated enough information about the user. Such reviews were excluded to maintain the consistency of the data analysis procedure. Moreover, some reviews indicated multiple uses, meaning that one review can fit into multiple themes. However, the coding process for such reviews followed the same procedure.

Themes Development

The process incorporated eight themes extracted depending on the most common usages of the Amazon Echo Dot smart speaker, which included entertainment, communication, companionship, learning and news, emergency and security, reminders and alarms, home automation, and shopping. The eight themes helped categorize the

product reviews posted on Amazon.com to prepare them for qualitative analysis and coding using Microsoft Excel. The first theme, entertainment, included product reviews that mentioned using the Amazon Echo Dot smart speaker for music, games, and jokes. The second theme, communication, included product reviews that mentioned using the drop-in feature, which allows users to use the Amazon Echo Dot smart speaker as an intercom via voice commands, without the need to resort to a phone. The communication theme excluded the use of the drop-in feature for emergencies. The third theme, companionship, includes product reviews that indicated viewing the device as a companion, assistant, friend, or a new family member. The fourth theme, learning and news, included product reviews where users utilized the device for asking questions and listening to the news. The fifth theme, emergency and security, included product reviews that mentioned using the device to call emergency services such as 911 or calling a caregiver if they fall. Also, the fifth theme included product reviews mentioning utilizing the device to alert against home break-ins. The sixth theme involved product reviews that mentioned users using the device to set reminders for medication, appointments, and social events such as birthdays or gatherings. Also, the theme included product reviews that mentioned using the alarm feature to set alerts for morning or night routines, cooking food, or while working out. The seventh theme included product reviews that mentioned users utilizing other smart products such as light bulbs, speakers, television, security systems, or home appliances to allow home control via voice commands. The last theme involved product reviews that mentioned utilizing the shopping feature to note shopping lists or order items from Amazon.com (Table 2).

Figure 2

Data Analysis Method

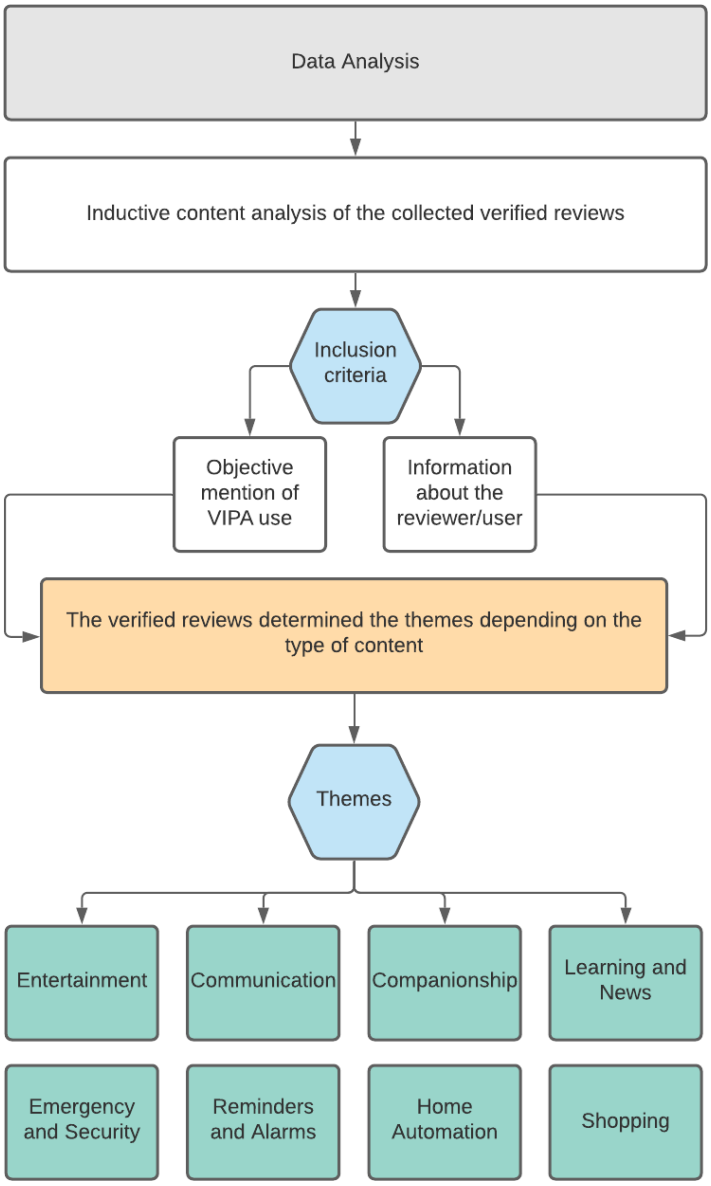


Table 2

Themes' Development and Inclusion Criteria of the Verified Reviews

Theme	Uses
Entertainment	Utilizing the device for music, games, and jokes
Communication	Using the drop-in feature
Companionship	Sentiments indicating emotional attachment
Learning and News	Asking questions, getting the weather, and news
Emergency and Security	Calling a caregiver or 911
Reminders and Alarms	Setting alarms or reminders
Home Automation	Integrating other smart home devices
Shopping	Utilizing the shopping list feature

Conclusion

The study's method involved a qualitative thematic analysis of online product reviews posted on Amazon's website for Amazon Echo Dot 3rd Generation smart speaker. The search criteria included only verified reviews that had the keywords senior, elderly, grandparents, and caregiver. A web scraping software was used to obtain the verified reviews. The software incorporated a built-in code to collect and export the reviews' content to a Microsoft Excel workbook. The coding process and theme development consisted of establishing categories to understand further how the VIPA device is used by caregivers and older adults in the home environment. All web scraping data, including the Microsoft Excel workbooks, were renamed depending on their set category and stored in a smart-synced DropBox folder located on a personal computer for ease of access and protection in case of an unexpected loss.

Results

Overview

The initial sample of verified online product reviews included 414 reviews that involved the keywords "senior," "elderly," "grandparents," and "caregiver" collectively. Moreover, the development of themes included filtering the product reviews to determine eight themes that specified how older adults or caregivers utilized the smart speaker to help age in place. The product reviews did not include information that specifies age, gender, socioeconomic status, health status, but some users included some personal information in their review that gave insight into their status. However, the themes' development did not include any personal information due to the lack of consistency. After the coding process, the results for each theme included 132 mentions of entertainment, 75 mentions of communication, 31 mentions of companionship, 85 mentions of learning and news, 56 mentions of emergency and security use, 63 mentions for reminders and alarms, 45 mentions of home automation, and 12 mentions of shopping feature (Table 3). The reviews' content provided insight into how caregivers and older adults purchased and used the VIPA device. The majority of the reviews indicated that caregivers purchased the smart speaker in the hope of helping a senior family member or friend age in place. Also, some seniors bought the smart speaker to have access to entertainment applications such as music or radio. However, some of the older adults who bought the VIPA device noted that they use it for reasons other than entertainment. The reviews' content indicated that the VIPA device brought some positive changes into the home environment, as users mentioned that some tasks were easier to accomplish with the smart speaker's help.

Themes

The development of the eight themes depended on qualitative observation and the identification of keywords within each review, highlighting the objective use of the VIPA, Amazon Echo Dot 3rd Generation smart speaker. Some of the reviews included subjective information that were not included in the process of establishing themes. One of the limitations of the data collection process was that some of the reviews did not include enough information to determine if the reviewer fits the study's criteria. Moreover, any information within the review's content that was not clear enough or included information outside the study's scope was not included in the themes' coding process.

Entertainment

The most common utilization of the VIPA among older adults involved entertainment (Figure 3). The entertainment theme included usages involving using the smart speaker for listening to music, radio shows, and audiobooks and playing voice-based games, and asking the smart speaker to tell jokes. Some of the reviewers indicated that the entertainment features helped in accessing media that is familiar to the elderly users, such as listening to music from a particular genre or time, without looking them up on a phone or a computer. An example of a caregiver noting a senior using the VIPA for music was, "Gave this to my mom and she loves it. She is elderly and loves to ask Alexa to play her favorite oldie but goodie tunes." Moreover, some of the reviews mentioned that the entertainment features helped visually impaired elderly members access media without the caregiver's help. The ability to listen to music, audiobooks, games and

interact with the smart speaker via joke allowed elderly users a sense of independence via accessibility to media via voice commands.

Communication

The communication theme involved all reviews that state the seniors or caregivers utilizing the VIPA's drop-in feature. The feature allows users to use the smart speaker for vocal communication without pushing buttons, looking up phone numbers, or reaching a phone. The majority of the reviewers mentioned that they got multiple smart speakers to place them around the home, mainly in living rooms, kitchens, and bedrooms. A few reviewers mention the method by which they use the VIPA device, such as, "We brought this for my mother, 78 years old who had had two strokes and voice is weak. It works very well at recognizing her voice. I particularly like the drop-in feature as she has trouble with answering her phone." The placement of multiple smart speakers allowed the users to instantly connect all spaces and occupants via voice commands to check on or talk to each other. Moreover, the drop-in feature works between devices in different homes regardless of distance as long as there is an internet connection, so the elderly user does not have to locate or use their phone to answer phone calls.

Companionship

One of the interesting aspects regarding interactions with the smart speaker mentioned in the reviews was companionship sentiments as reviewers expressed viewing the VIPA as a friend, new family member, or an assistant that they heavily rely on to complete daily tasks. Also, some reviews indicated that the users interact with the smart speaker when they are alone to keep them company or entertained. Some of the reviewers indicate that they often casually talk to the smart speaker and refer to it when they feel

lonely. Another mention of companionship that indicated an elevation of older adults' QoL was utilizing the device to combat the frustration that stems from cognitive impairment such as memory loss. Since the smart speaker has a feature where it can answer questions, most older adults who suffer memory loss used that feature to keep the users informed about various topics of interest. A reviewer mentioned, "Why? Because it is the future. This device works well and is worth every moment. It is like having a companion around all the time. Probably awesome for many situations and especially for the elderly. It is super responsive, and we love it. Thank you, Amazon for a great extra companion in our home." highlighting that the user sees the device as a companion to keep them entertained and safe.

Learning and News

The second most common utilization of the VIPA was answering questions, getting the weather forecast, time, and news. The reviewers mentioned using the features for various reasons, including to help them stay updated with current world affairs and getting answers to questions they had. Moreover, users who had vision impairment benefited from this feature as they only needed to initiate voice commands to get their information via the smart speaker. One of the reviewers noted, "I put one of these in the bedroom for my elderly blind father. Now he can ask it the time, find out the weather and listen to music while in bed. It has been great to see how much happiness such an inexpensive device has provided. I also put a full-size in the living room and he gets a lot of enjoyment from it." The notion that the device helped an older adult, in this case, a visually impaired older adult, get information at any time of the day indicates that the smart speaker has improved a portion of the user's life.

Emergency and Security

The reviews mentioning utilizing the VIPA for emergency communication involved users purchasing or using the device to employ in case of an emergency. The reviewers utilized three main features: contacting family members or friends in case of an emergency, contacting emergency services such as 911, and combining the smart speaker with other home security smart devices. The most stated concern that both caregivers and elderly users mention was falling, as most acquired the smart speaker to call for help if they fall. Also, few reviewers mention an application titled "Ask My Buddy," a personal alert network that enables smart speakers to check in on the users and allow them to call for help when needed (E. Lee, Vesonder, & Wendel, 2020). There is a mention of another feature that Amazon recently debuted called "Care Hub," which a few of the reviewers discussed. A reviewer mentioned a mention of Amazon's new services, saying, "I set this up at my mother's. She is 78 and has no tech abilities. We can drop in on each other with Care Hub whenever she wishes, no more long-distance telephone fees for her (no cell phone). It is fun to see her ask Alexa the weather every day. Slowly but surely, she will get more accustomed to using Alexa for more things besides the weather. The best part is the Care Hub. I set it up to alert me if there is an emergency and I can check in to see what she has been asking Alexa. The drop-in feature is a Godsend for distant caregivers that cannot be there as frequently as we would like." The Care Hub feature is a new application that targets older adults and caregivers to allow for more specialized services to help seniors age in place and stay safe within their home environment. The critical detail the application provides is the ability to have an activity feed that alerts the caregiver of the older adult's activity throughout the day (Amazon.com, n.d.).

Reminders and Alarms

Several reviewers mentioned using the VIPA to set reminders for multiple tasks. The users stated that the reminders feature helped, especially those who suffer from memory loss, as the feature helped them keep up with medication, appointments, and important dates such as birthdays and anniversaries. The reviewers also mentioned the reminders' security aspect, as it helped seniors with memory loss to remind them to lock their doors or turn off appliances, "My kids made fun of me. Not anymore. If I could name one thing that has improved my life, it is Alexa and the dots! She is ever attentive, ever patient, extremely knowledgeable, with myriad features, fun, space saving, reliable and a favorite for my granddaughters and my disabled elderly husband and makes me laugh! She surprises me often. I told her good night where I had set up a routine. Alexa then said by the way, your front door is unlocked. Would you like me to lock it for you? I am 71 and was already tucked in. I was thrilled that she automatically checked the door lock and then locked it for me. She is a fabulous personal assistant, with no salary to be paid. I especially love the shopping list feature and the routines." Some of the reviewers mentioned appreciating the reminders and alarm features, such as "Love it. I am a senior and live alone so it helps if I need to know things. I love that I can ask it to remind me of things. Told my children it is my new roommate!"

Home Automation

The home automation theme involved all mentions of reviewers using their VIPA with other smart devices or noting that they are interested in purchasing other smart devices to integrate them with the VIPA. The most mentioned smart devices that users integrate with the VIPA were smart light bulbs, as many found it helpful to automate

home lighting controls. Moreover, reviewers with visual or mobility impairment found automating the home's lighting system beneficial due to the lower risk of injuries. An example of a senior utilizing the VIPA device for light controls was, "As an elderly woman who lives alone, these help me feel safer. I can ask it to place a call for help to any of my relatives. I have given these to several of my elderly friends. Also great for asking it to turn on lights before I have to walk in to a dark room to walk across the room to turn on the lamp." Another aspect of home automating the lights was setting up VIPA routines, which consists of a set of commands that allow the user to set up alarms, light controls, and sound control for their day. Some of the reviewers also noted that they purchased multiple VIPAs to automate different parts of their homes, including the living room, bedroom, and kitchen.

Shopping

The least mentioned feature by users is the shopping list feature, which allows users to use their VIPA to add to their Amazon shopping list. This feature only works with Amazon's website and allows users to utilize voice commands to add any product available on the website. While this is the least mentioned feature, it is critical to understand the scope of the uses that the VIPA provides and how seniors are utilizing VIPA in their homes. Most of the reviewers who noted using the shopping list feature did not elaborate on whether they purchased any of the items on their list or using the shopping list feature as a note-taking application. However, users mentioned utilizing the shopping feature to remember important matters such as, "I do not have a smart home, but Alexa is great at keeping track of things for me. From my shopping lists to calendar

and appointments to reminders, she has proven to be quite an asset. Especially for a senior who forgets a lot of things!"

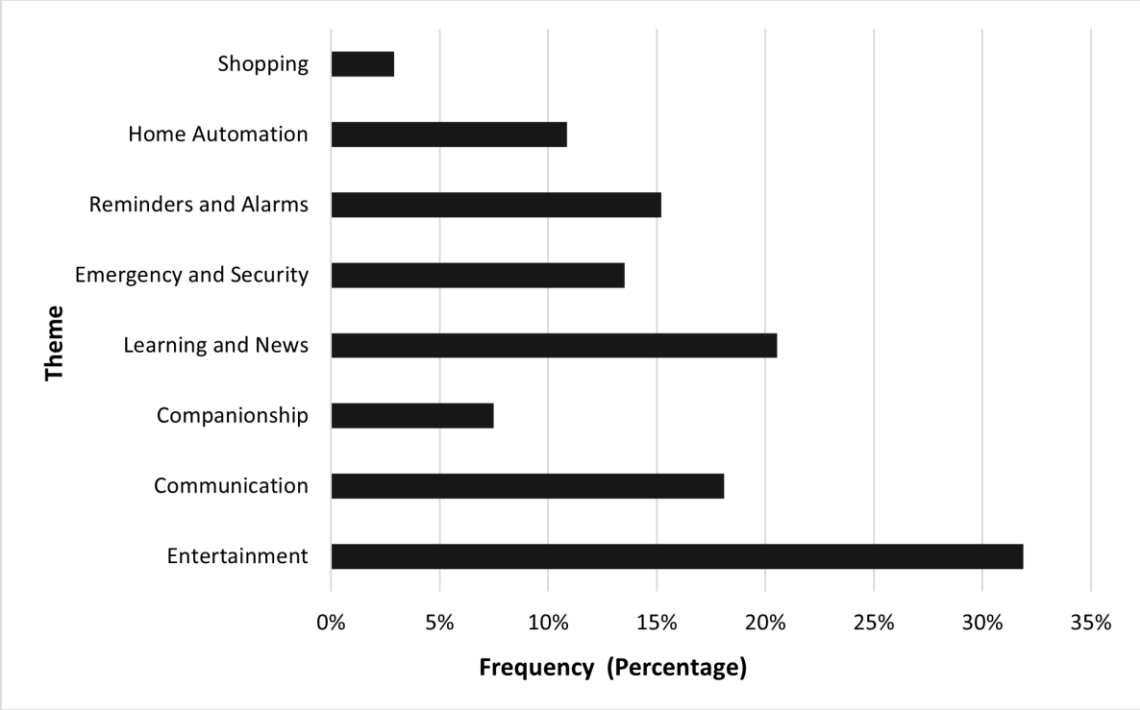
Table 3

The Results of Each Theme After the Coding Process with Examples

Theme	Frequency	Example
Entertainment	132	"I was amazed at the sound quality. I am an elderly person, who enjoys music."
Communication	75	"Now my mom can use it to contact me, she is elderly and frequently needs me. This works perfect."
Companionship	31	"This item was purchased for a senior citizen who was struggling with memory recall and has been a life saver as well as a constant companion to an elderly person who spends a lot of time alone."
Learning and News	85	"Purchased for my elderly father to support him in remembering appointments and accessing information. He loves it!"
Emergency and Security	56	"I purchased two of these for my elderly parents. I wanted them to be able to call in case of emergencies."
Reminders and Alarms	63	"I purchased this for my grandmother to help with her daily activities. Helping to remind her of important dates, doctors' appointments and alarms."
Home Automation	45	"As a disabled senior citizen, I appreciate having these in every room. Not only can Alexa tell me jokes but she can connect me to my family, turn on my security cameras, turn on the robot vacuum only to mention a few things."
Shopping	12	"As a caregiver for a legally blind 81 years old woman, I am impressed by the independence this device has given her. She can once again write her own shopping list, look up information and recipes, and call up any music that she wants."

Figure 3

Percentages of the Themes' Frequencies



Note. The total number of the analyzed reviews was 414 review. Some of the reviews belonged to multiple themes, as the users mentioned that they utilized the device for different sets of tasks.

Conclusion

The results involved a qualitative analysis of 414 verified Amazon Echo Dot 3rd Generation reviews that included the keywords senior, elderly, grandparents, and caregiver. The development of the themes involved depending on the reviews' content to identify adequate themes via observing reviewers' objective attitude and usage towards the smart speaker, excluding all subjective judgments. The themes included the following categories: entertainment, communication, companionship, learning and news, emergency and security, reminders and alarms, home automation, and shopping. The

coding process resulted in 132 mentions of entertainment, 75 mentions of communication, 31 mentions of companionship, 85 mentions of learning and news, 56 mentions of emergency and security use, 63 mentions for reminders and alarms, 45 mentions of home automation, and 12 mentions of the shopping feature. The results also included other information that provided insight into different uses of the VIPA device, such as integrating other applications such as Ask My Buddy or utilizing the smart speaker to help remind older adults to lock their doors or turn off appliances.

Discussion

The study's objective was to examine if caregivers' and older adults' utilization of VIPA devices could help them age in place, provide them a safe home environment, and allow them independence when completing daily tasks. The research questions explored the feasibility of utilizing smart home technologies, specifically VIPA devices, to help caregivers and older adults who chose to age in place, and were stated as the following:

- Would VIPA devices help generate positive emotions, engagement, positive relationships, meaning, and a sense of accomplishment?
- How does the daily routine of both elderly and the caregivers differ in the presence of VIPA devices?
- Do people who choose to age in place need VIPA devices designed and programmed to cater to their needs? Or are the current options available on the market sufficient to substantially improve cognitive, emotional, and safety aspects?
- What is missing from the current aging in place homes, and how can integrating VIPA devices or similar devices change how we design aging in place homes?

The method involved analyzing and coding 414 verified Amazon Echo Dot 3rd Generation online reviews to gain insight into caregivers' and older adults' utilization of the VIPA to help them age in place. Moreover, the reviews' content helped establish eight themes that helped define the primary uses of the VIPA device among caregivers and older adults. The themes included entertainment, communication, companionship, learning and news, emergency and security, reminders and alarms, home automation, and shopping. The reviews' content suggests that VIPA devices could be effective means to

support aging in place while providing entertainment, social, safety, and cognitive support compared to other sensor-based technology (Chen et al., 2015). The usual technology options that support aging in place often concern implementing sensors-based technology that often requires remodeling or intensive installing applications. Also, the sensor-based technology might seem intrusive to some of the older adults, as such technology monitors the occupants throughout the day to ensure their safety. Constant monitoring, while in theory sensors are a safety measure for older adults choosing to age in place, it often takes away some of the occupant's autonomy (Berridge & Wetle, 2019). The current VIPA devices on the market allow individuals to buy a smart home device capable of completing an array of daily tasks while remaining affordable and require less setup when it comes to installation. Moreover, the sensor-based does not grant control of the home environment. Sensor-based technology is designed for monitoring purposes, unlike the VIPA devices, where the occupant can employ the device to control their home environment (Hoy, 2018). The research questions involved investigating if VIPA devices help older adults elevate their engagement levels, uplift their emotional state, and provide a sense of accomplishment. Also, to examine how the VIPA device's presence would affect caregivers and older adults' behavior within the home environment. According to the results, the reviewers indicated that the VIPA device impacted their emotional and social quality on multiple occasions.

Utilizing VIPA Devices to Help with Loneliness and Social Isolation

As older adults suffer from social isolation and loneliness, employing a VIPA device reduced the feeling of being socially isolated and lonely in some cases. As most of the VIPA devices have somewhat of a natural engagement quality, the results suggested

some of the reviewers noted that the smart speaker kept them company when they were alone. Moreover, since the VIPA device has entertainment-based features such as music, storytelling, and jokes, it helped the older adult engage with the device personally. Some of the reviews also indicated that the users view the device as a companion, friend, personal assistant, or roommate, indicating a degree of emotional attachment development (Lopatovska et al., 2019). While such a notion might sound trivial, it is quite an essential indication of how the users view the VIPA device. There was a clear suggestion that the older adults formed a sense of trust and that, in return, shaped the way the users behave towards the VIPA device. The smart speaker was viewed as a companion that eased the feeling of loneliness in some cases (Chambers & Beaney, 2020). Moreover, the small features, such as commanding the smart speaker to tell jokes or play games, enhanced the social and companionship aspect (Koon et al., 2020; Reis et al., 2018). The users established a connection with the VIPA device that allowed them to break that machine-to-human barrier via forming trust and developing interest in the device. Another aspect that affected the severity of loneliness in older adults involved the location of their residence and mobility status. The VIPA device allowed users, regardless of their location and mobility status, to engage at the same level and gain access to information via simple voice commands. This notion is especially critical for older adults who suffer from decreased mobility or disabilities as they were able to engage with the device and initiate commands regardless (Mtshali & Khubisa, 2019). A reviewer stated an example of such a situation with a disabled, elderly husband who could listen to music, engage with the VIPA device, and control the lights with his voice. Moreover, users with visual impairment noted that engaging with the VIPA device to tell

them the weather, time, date, and news was significant as they felt connected with their surroundings.

Acceptance Attitudes and Daily Routine Enhancements

According to some studies, the acceptance attitudes of smart technology among older adults are on the rise but not as high as younger adults' acceptance behaviors. The acceptance attitudes are an essential aspect of developing traction towards new technologies on the market. The issue with some current and previous new technology devices is that the learning curve and functions often require a steep learning curve for those who lack the technical confidence and experience. Moreover, most of the technology device marketing strategies depend on how well-versed the user is with the current devices and applications available on the market, regardless of age or gender (Ahn et al., 2008). According to the literature, older adults' acceptance attitude towards new technology is affected by perceived value, usability, accessibility, technical support availability, technical experience, and confidence. However, the results showed that the acceptance attitudes of the VIPA devices are slightly different due to multiple factors. The results indicate that most of the VIPA devices' purchasing and setup was done by the caregiver, with a few exceptions where older adults were interested in the technology and bought the device themselves. The caregivers who purchased the VIPA device helped set up the smart speaker for their older adult user, and most claim that the setup's instructions were overall easy to follow. The smart speaker setup requires an email address and a smartphone to run the compatible application to modify some of the smart speakers' features. That said, some reviewers indicated that there are often workarounds to make the setup process easier for older adults, which often requires creating another account

and registering the VIPA device to the secondary account. It is worth mentioning that the smart speaker only requires an initial setup, and there is no need to use a computer or smartphone for the included features. However, some applications require the integration of smartphones, such as the Care Hub application, which requires the caregiver to use a smartphone application to receive and monitor an older adult's daily routine.

Nevertheless, a handful of older adults noted that they handled the initial setup by themselves and mentioned that it was easy to follow the instructions, and noted that the VIPA device is user-friendly. The ease of usability and setup is a critical aspect of technology adoption, and the results indicate that the VIPA device is easy to set up and use. The perceived value is another aspect mentioned in the literature that involves how individuals feel about a smart device before purchasing. It is worth mentioning that this specific VIPA device, the Amazon Echo Dot 3rd Generation, does not advertise specifically for older adults. The company created the device as a smart speaker to entertain and assist individuals regardless of their age. That said, the VIPA gained caregivers' and older adults' attention as they saw the potential in helping them with specific tasks that are deemed difficult due to age, health status, and lifestyle. The caregivers who purchased the device for an elderly individual mentioned that they got the VIPA to help an older adult stay connected, access entertainment features, and use the device to call for help in case of an emergency. Moreover, some caregivers noted that while some seniors were against the VIPA device, they grew accustomed to it and started to enjoy some of the smart speakers' features. As for the older adults who purchased the device independently, the perceived value mainly focused on emergency and security. The reviews' content indicated that seniors who acquired the device sought an option to

help them stay connected with caregivers or emergency services if they need it. The seniors who bought the device for emergencies also utilized other features as well as some noted that they started learning to utilize the VIPA device to its full potential. The ease of use enabled the older adults to feel confident about learning more about the smart speaker's available functions and enhance their experience.

The Need for VIPA Devices Designed for Older Adults

The current use of VIPA devices, according to the results, varies from one user to another. However, there were recognizable patterns in how caregivers and older adults are utilizing the smart device. The most utilized features of the smart speaker belonged to the entertainment category. The reviewers indicated that they enjoy the ability to access and listen to different music genres, listen to different radio channels at any given time, the ability to play games, and ask the VIPA device to tell them stories or jokes. The ability to have easy access to an extensive library of media that the older adult can enjoy was noted as a QoL improvement by most reviewers (O'Brien et al., 2020). Other uses reported by caregivers and older adults included an array of functions to help with daily activities. While some of these might seem trivial, the results indicated that utilizing a VIPA device within a home environment impacted older adults' QoL in a positive manner. Also, caregivers noted peace of mind after purchasing and giving the VIPA device to a senior to help them stay connected, keep them company, and access information and media. However, it is essential to note some of the reviewers' negative notions regarding the smart speaker's usability and functions. Some of the reviews indicated that the smart speaker had a few issues with detecting low-volume sounds, especially when interacting with soft-spoken seniors. Other reviewers also noted that the

smart speaker often had trouble with heavy accents or understanding requests fully (Lopatovska et al., 2019; Palanica, Thommandram, Lee, Li, & Fossat, 2019). There have been a few instances where the user neglected the VIPA device due to inconsistent outcomes when trying to initiate a command. These issues can arise from the lack of a proper software implementation that caters to older adults. As mentioned before, such devices' marketing tactics did not include a specified age group or gender. That might have contributed to creating a VIPA that only works with a particular age group with standard health status. However, some companies such as Amazon are creating and developing VIPA devices and applications to cater to specific age groups. An example is the debut of a kid-friendly Echo Dot with additional entertainment, learning, security, and parental control features that are considerably different from the main product.

The need for a VIPA device that targets and focuses on older adults' needs might be the next step to improve usability and engagement. The most common issues mentioned in the reviews involved speech recognition, sound volume, sound depth, placement concerns, and errors arising when asking the smart speaker to do some tasks. Issues concerning speech were the most commonly mentioned, as caregivers and older adults noted that the device could not hear their requests or mishearing their commands or questions. This issue might relate to the smart speaker's microphone sensitivity and range. However, another issue related to speech was the VIPA's inability to understand the requests due to the user's accent. This issue is still a prominent concern with artificial intelligence-based technology, where the device cannot recognize speech due to accent, mispronunciation, length of request, or loud background noises (Abdolrahmani et al., 2018). That said, there are clear indications that companies are working on developing

applications that help to reduce such errors and cater to a broader crowd. An example is Amazon's recent smartphone application, "Care Hub," which can be integrated with Amazon's Alexa smart speakers and was marketed towards caregivers and older adults who chose to age in place. That said, there are clear indications that companies are working on developing applications that help to reduce such errors and cater to a broader crowd. An example is Amazon's recent smartphone application, "Care Hub," which can be integrated with Amazon's Alexa smart speakers and was marketed towards caregivers and older adults who chose to age in place. The application helps caregivers keep track of the older adults' daily routine by sending them notifications of how the older adult uses the app. An example would be if an older adult asks their VIPA for weather, the caregiver can see the request with a date stamp on their feed in the application (Amazon.com, n.d.). Developing smart devices and applications that cater to a specific group indicates a rise in the adoption rate and demand for smart home technologies that offer services to help individuals within their home environment.

VIPA Devices Placement in the Home Environment

The placement of the VIPA devices was mentioned a few times, as caregivers and older adults placed their smart speakers depending on the most utilized space in their homes. The location of the VIPA devices included living rooms, bedrooms, and kitchens. Most of the reviewers also mentioned placing the devices all around their houses, which indicated that they created their personal smart speakers' ecosystem to integrate with other smart devices or use as an intercom system. The other reason behind placing multiple VIPA devices around the home was integrating other smart home devices such as light bulbs, switches, televisions, security systems, thermostats, and compatible home

appliances. The most cited VIPA device and smart home technology integration was concerned with lighting. The availability of various smart light bulbs that enable users to control via their smartphones and voice commands allowed them to streamline their lighting settings and controls. Also, controlling the lights and switches allowed older adults with physical and visual impairment to control their lights with ease. These sentiments are critical to consider when designing a home for a senior choosing to age in place to elevate their QoL by modifying how they control their home environment. What might be missing from the design requirements for aging in place homes is how to integrate the new technologies available on the market as an affordable, easy to learn, and easy to operate support alternative to the sensor-based technologies. Also, to consider such smart home technologies during the design process as an affordable and easy to install option to mention and discuss with caregivers and seniors.

Conclusion

Based on this study's results, the feasibility of utilizing smart home technologies available on the market, specifically VIPA devices, to help caregivers and seniors within the home environment is achievable. There is a growing need to provide emotional support for older adults who choose to age in place, and VIPA devices might be the solution to elevate seniors' mood. Moreover, there is a need to provide caregivers with peace of mind via affordable options that allow them to stay connected with senior family members. The study looked at how caregivers and older adults adopt and use VIPA devices and how they are integrating them with other smart home technologies such as smart lighting, security devices, and home appliances. There is a notable improvement in the QoL of caregivers and especially older adults who use VIPA devices, as it gave them

access to services and applications that support their lifestyle. Further research should focus on studying and providing insight into improving the VIPA devices and their applications to accommodate more services targeting seniors who choose to age in place. It is also important for interior designers to look into such smart home technologies when conducting research and during the design process and specify and talk about VIPA devices when designing home environments for seniors.

References

Abdolrahmani, A., Kuber, R., & Branham, S. M. (2018). *"Siri Talks at You": An Empirical Investigation of Voice-Activated Personal Assistant (VAPA) Usage by Individuals Who Are Blind*. Paper presented at the Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility, Galway, Ireland. https://doi.org/10.1145/3234695.3236344

Ahn, M., Beamish, J. O., & Goss, R. C. (2008). Understanding Older Adults' Attitudes and Adoption of Residential Technologies. *Family and Consumer Sciences Research Journal, 36*(3), 243-260. doi:10.1177/1077727x07311504

Ahn, M., Kwon, H. J., & Kang, J. (2020). Supporting Aging-in-Place Well: Findings From a Cluster Analysis of the Reasons for Aging-in-Place and Perceptions of Well-Being. *Journal of Applied Gerontology, 39*(1), 3-15. doi:10.1177/0733464817748779

Alam, T., Salem, A. A., Alsharif, A. O., & Alhujaili, A. M. (2020). Smart Home Automation Towards the Development of Smart Cities. *International Journal of Applied Sciences and Smart Technologies, 1*(1), 17-25. doi:10.2139/ssrn.3638964

Amazon.com. (n.d.). The Care Hub. Retrieved from https://www.amazon.com/b?node=21390531011

Beaney, P., Kalirai, H. S., & Chambers, R. (2020). “Alexa… what pills do I need to take today?”. *Prescriber, 31*(6), 20-23. doi:10.1002/psb.1849

Becker, S. E., Dickinson, J. I., Sullivan, K., & Cline, H. (2020). Baby Boomer Knowledge and Stigma Toward Aging in Place and Residential Assistive Devices. *Journal of Interior Design, 45*(3), 43-61. doi:10.1111/joid.12176

Berkowsky, R. W., Sharit, J., & Czaja, S. J. (2018). Factors Predicting Decisions About Technology Adoption Among Older Adults. *Innovation in Aging, 1*(3). doi:10.1093/geroni/igy002

Berridge, C., & Wetle, T. F. (2019). Why Older Adults and Their Children Disagree About In-Home Surveillance Technology, Sensors, and Tracking. *The Gerontologist, 60*(5), 926-934. doi:10.1093/geront/gnz068

Blazer, D. (2020). Social Isolation and Loneliness in Older Adults—A Mental Health/Public Health Challenge. *JAMA Psychiatry, 77*(10), 990. doi:10.1001/jamapsychiatry.2020.1054

Carnemolla, P. (2018). Ageing in place and the internet of things – how smart home technologies, the built environment and caregiving intersect. *Visualization in Engineering, 6*(1), 7. doi:10.1186/s40327-018-0066-5

Chambers, R., & Beaney, P. (2020). The potential of placing a digital assistant in patients' homes. *British Journal of General Practice, 70*(690), 8-9. doi:10.3399/bjgp20X707273

Chen, Y.-H., Tsai, M.-J., Fu, L.-C., Chen, C.-H., Wu, C.-L., & Zeng, Y.-C. (2015, 2015). *Monitoring Elder's Living Activity Using Ambient and Body Sensor Network in Smart Home.* Paper presented at the IEEE International Conference on Systems, Man, and Cybernetics.

Choi, Y., Demiris, G., & Thompson, H. (2018). FEASIBILITY OF SMART SPEAKER USE TO SUPPORT AGING IN PLACE. *Innovation in Aging, 2*(suppl_1), 560-560. doi:10.1093/geroni/igy023.2073

Czaja, S. J., Boot, W. R., Charness, N., Rogers, W. A., & Sharit, J. (2018). Improving Social Support for Older Adults Through Technology: Findings From the PRISM Randomized Controlled Trial. *Gerontologist, 58*(3), 467-477. doi:10.1093/geront/gnw249

Ermolina, A., & Tiberius, V. (2021). Voice-Controlled Intelligent Personal Assistants in Health Care: International Delphi Study. *Journal of Medical Internet Research, 23*(4), e25312. doi:10.2196/25312

Finch, M., Griffin, K., & Pacala, J. T. (2017). Reduced Healthcare Use and Apparent Savings with Passive Home Monitoring Technology: A Pilot Study. *Journal of the American Geriatrics Society, 65*(6), 1301-1305. doi:10.1111/jgs.14892

Gazibara, T., Kurtagic, I., Kisic-Tepavcevic, D., Nurkovic, S., Kovacevic, N., Gazibara, T., & Pekmezovic, T. (2017). Falls, risk factors and fear of falling among persons older than 65 years of age. *Psychogeriatrics, 17*(4), 215-223. doi:10.1111/psyg.12217

Glez-Peña, D., Lourenço, A., López-Fernández, H., Reboiro-Jato, M., & Fdez-Riverola, F. (2014). Web scraping technologies in an API world. *Briefings in Bioinformatics, 15*(5), 788-797. doi:10.1093/bib/bbt026

Hoy, M. B. (2018). Alexa, Siri, Cortana, and More: An Introduction to Voice Assistants. *Med Ref Serv Q, 37*(1), 81-88. doi:10.1080/02763869.2018.1404391

Juniper, A. (2018). *The Smart Smart Home Handbook: Control Your Home With Your Voice*. London, United Kingdom: Octopus Books.

Kakulla, B. N. (2020). Older Adults Keep Pace on Tech Usage: 2020 Tech Trends of the 50+. doi:https://doi.org/10.26419/res.00329.001

Kemperman, A., Van Den Berg, P., Weijs-Perrée, M., & Uijtdewillegen, K. (2019). Loneliness of Older Adults: Social Network and the Living Environment. *International Journal of Environmental Research and Public Health, 16*(3), 406. doi:10.3390/ijerph16030406

Koon, L. M., McGlynn, S. A., Blocker, K. A., & Rogers, W. A. (2020). Perceptions of Digital Assistants From Early Adopters Aged 55+. *Ergonomics in Design, 28*(1), 16-23. doi:10.1177/1064804619842501

Kowalczuk, P. (2018). Consumer acceptance of smart speakers: a mixed methods approach. *Journal of Research in Interactive Marketing, 12*(4), 418-431. doi:10.1108/jrim-01-2018-0022

Lau, J., Zimmerman, B., & Schaub, F. (2018). Alexa, Are You Listening? *Proceedings of the ACM on Human-Computer Interaction, 2*(CSCW), 1-31. doi:10.1145/3274371

Lawlor, D., & Thomas, M. A. (2008). *Residential Design for Aging in Place*: John Wiley & Sons.

Lee, C., & Coughlin, J. F. (2015). PERSPECTIVE: Older Adults' Adoption of Technology: An Integrated Approach to Identifying Determinants and Barriers. *Journal of Product Innovation Management, 32*(5), 747-759. doi:10.1111/jpim.12176

Lee, E., Vesonder, G., & Wendel, E. (2020, 2020). *Eldercare Robotics - Alexa*.

Lindeman, D. A., Kim, K. K., Gladstone, C., & Apesoa-Varano, E. C. (2020). Technology and Caregiving: Emerging Interventions and Directions for Research. *The Gerontologist, 60*(Supplement_1), S41-S49. doi:10.1093/geront/gnz178

Lopatovska, I., Rink, K., Knight, I., Raines, K., Cosenza, K., Williams, H., . . . Martinez, A. (2019). Talk to me: Exploring user interactions with the Amazon Alexa. *Journal of Librarianship and Information Science, 51*(4), 984-997. doi:10.1177/0961000618759414

Marangunić, N., & Granić, A. (2015). Technology acceptance model: a literature review from 1986 to 2013. *Universal Access in the Information Society, 14*(1), 81-95. doi:10.1007/s10209-014-0348-1

Medicare.gov. (n.d.). What's Medicare? Retrieved from https://www.medicare.gov/what-medicare-covers/your-medicare-coverage-choices/whats-medicare

Mitzner, T. L., Savla, J., Boot, W. R., Sharit, J., Charness, N., Czaja, S. J., & Rogers, W. A. (2018). Technology Adoption by Older Adults: Findings From the PRISM Trial. *The Gerontologist, 59*(1), 34-44. doi:10.1093/geront/gny113

Mtshali, P., & Khubisa, F. (2019, 2019). *A Smart Home Appliance Control System for Physically Disabled People.* Paper presented at the Conference on Information Communications Technology and Society (ICTAS).

Myhre, J. W., Mehl, M. R., & Glisky, E. L. (2016). Cognitive Benefits of Online Social Networking for Healthy Older Adults. *The Journals of Gerontology: Series B, 72*(5), 752-760. doi:10.1093/geronb/gbw025

Mynatt, E. D., Melenhorst, A. S., Fisk, A. D., & Rogers, W. A. (2004). Aware technologies for aging in place: understanding user needs and attitudes. *IEEE Pervasive Computing, 3*(2), 36-41. doi:10.1109/mprv.2004.1316816

National Academies of Sciences, E., & Medicine. (2020). *Social Isolation and Loneliness in Older Adults: Opportunities for the Health Care System*. Washington, DC: The National Academies Press.

Newall, N. E. G., & Menec, V. H. (2017). Loneliness and social isolation of older adults: Why it is important to examine these social aspects together. *Journal of Social and Personal Relationships, 36*(3), 925-939. doi:10.1177/0265407517749045

O'Brien, K., Liggett, A., Ramirez-Zohfeld, V., Sunkara, P., & Lindquist, L. A. (2020). Voice-Controlled Intelligent Personal Assistants to Support Aging in Place. *Journal of the American Geriatrics Society*, *68*(1), 176-179. doi:10.1111/jgs.16217

Palanica, A., Thommandram, A., Lee, A., Li, M., & Fossat, Y. (2019). Do you understand the words that are comin outta my mouth? Voice assistant comprehension of medication names. *NPJ Digit Med, 2*, 55. doi:10.1038/s41746-019-0133-x

Peek, S. T. M., Luijkx, K. G., Rijnaard, M. D., Nieboer, M. E., van der Voort, C. S., Aarts, S., . . . Wouters, E. J. M. (2016). Older Adults' Reasons for Using Technology while Aging in Place. *Gerontology*, *62*(2), 226-237. doi:10.1159/000430949

Perissinotto, C. M., Stijacic Cenzer, I., & Covinsky, K. E. (2012). Loneliness in older persons: a predictor of functional decline and death. *Arch Intern Med, 172*(14), 1078-1083. doi:10.1001/archinternmed.2012.1993

Rahman, M. I., Fahim, S. R., Avro, S. S., Sarker, Y., Sarker, S. K., & Tahsin, T. (2019, 2019). *Voice-activated Open-loop Control of Wireless Home Automation System*

for Multi-functional Devices. Paper presented at the IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE).

Reis, A., Paulino, D., Paredes, H., Barroso, I., Monteiro, M. J., Rodrigues, V., & Barroso, J. (2018, 2018). *Using intelligent personal assistants to assist the elderlies An evaluation of Amazon Alexa, Google Assistant, Microsoft Cortana, and Apple Siri*.

Risteska Stojkoska, B. L., & Trivodaliev, K. V. (2017). A review of Internet of Things for smart home: Challenges and solutions. *Journal of Cleaner Production, 140,* 1454-1464. doi:https://doi.org/10.1016/j.jclepro.2016.10.006

Shaw, J. G., Farid, M., Noel-Miller, C., Joseph, N., Houser, A., Asch, S. M., . . . Flowers, L. (2017). Social Isolation and Medicare Spending: Among Older Adults, Objective Isolation Increases Expenditures While Loneliness Does Not. *Journal of Aging and Health, 29*(7), 1119-1143. doi:10.1177/0898264317703559

Taylor, H. O. (2020). Social Isolation's Influence on Loneliness Among Older Adults. *Clinical Social Work Journal, 48*(1), 140-151. doi:10.1007/s10615-019-00737-9

Trajkova, M., & Martin-Hammond, A. (2020). *"Alexa is a Toy": Exploring Older Adults' Reasons for Using, Limiting, and Abandoning Echo*. Paper presented at the Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, Honolulu, HI, USA. https://doi.org/10.1145/3313831.3376760

Vanleerberghe, P., De Witte, N., Claes, C., Schalock, R. L., & Verté, D. (2017). The quality of life of older people aging in place: a literature review. *Quality of Life Research, 26*(11), 2899-2907. doi:10.1007/s11136-017-1651-0

Venkatesh, V., Morris, M., Davis, G., & Davis, F. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly, 27*, 425-478. doi:10.2307/30036540

Wang, S., Bolling, K., Mao, W., Reichstadt, J., Jeste, D., Kim, H.-C., & Nebeker, C. (2019). Technology to Support Aging in Place: Older Adults' Perspectives. *Healthcare, 7*(2), 60. doi:10.3390/healthcare7020060

WHO. (n.d.). WHOQOL: Measuring Quality of Life. Retrieved from https://www.who.int/tools/whoqol

Wiles, J. L., Leibing, A., Guberman, N., Reeve, J., & Allen, R. E. S. (2012). The Meaning of "Aging in Place" to Older People. *The Gerontologist, 52*(3), 357-366. doi:10.1093/geront/gnr098

Yang, Q., Miao, C., & Shen, Z. (2015, 2015). *Digital services innovation for aging-in-place.* Paper presented at the IEEE International Conference on Industrial Engineering and Engineering Management (IEEM).

Yusif, S., Soar, J., & Hafeez-Baig, A. (2016). Older people, assistive technologies, and the barriers to adoption: A systematic review. *International Journal of Medical Informatics, 94*, 112-116. doi:https://doi.org/10.1016/j.ijmedinf.2016.07.004

Zeytinoglu, M., Wroblewski, K. E., Vokes, T. J., Huisingh-Scheetz, M., Hawkley, L. C., & Huang, E. S. (2021). Association of Loneliness With Falls: A Study of Older US Adults Using the National Social Life, Health, and Aging Project. *Gerontology and Geriatric Medicine, 7*, 2333721421989217. doi:10.1177/2333721421989217