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AGING IN PLACE WITH SMART HOME TECHNOLOGY

A THESIS APPROVED FOR THE
CHRISTOPHER C. GIBBS COLLEGE OF ARCHITECTURE

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Terms and Definitions

Accessibility— refers to the construction or modification of housing to enable independent living for persons with disabilities (Kelley, 1997).

Adaptability--The ability of certain building spaces and elements, such as kitchen counters, sinks, and grab bars, to be added or altered so as to accommodate the needs of individuals with or without disabilities or to accommodate the needs of persons with different types or degrees of disability. (ADA National Network, n.d.)

Aging in Place—when a person lives and ages in their residence of choice, for as long as they can. (Aging in place—what does aging in place really mean?, n.d.)

Certified Aging-in-Place Specialists-- It is used to identify those that have been trained to help seniors & older adults live in their homes safely as they age. (What is a certified aging in place specialist and how can they help, n.d.)

Medicare— is the federal government program that provides health care coverage (health insurance) if you are 65+, under 65 and receiving Social Security Disability Insurance (SSDI) for a certain amount of time, or under 65 and with End-Stage Renal Disease (ESRD). (Introduction to medicare, n.d.))

Medicaid—Medicaid is a health care program that assists low-income families or individuals in paying for doctor visits, hospital stays, long-term medical, custodial care costs and more. Medicaid is a joint program, funded primarily by the federal government and run at the state level, where coverage may vary. (Kagan, 2018)

Mobility Device—any assistive technology that aids the movement of people with physical impairments. (Mobility device, n.d.)

Retrofit/Alteration-- any change to an existing building or facility that affects usability (ADA National Network, n.d.)

Smart Home Technology—Smart home is a term that refers to modern homes that have appliances, lighting and/or electronic devices that can be controlled remotely by the owner, often via a mobile app. Smart home-enabled device can also operate in conjunction with other devices in the home and communicate information to other smart devices. (Chen, 2018)

Quality of Life—the standard of health, comfort, and happiness experienced by an individual or group (Jenkinson, 2016)

Abstract

This paper evaluates technologies currently available for aging in place and considerations that might limit homeowners from considering or using technology that would allow a homeowner to age in place or prolong the length of time a homeowner can safely live at home. It reports the results of a small-scale qualitative study of aging-in-place-certified residential builders and homeowners who are either currently aging in place, planning to age in place, or caring for another person who is aging in place. The majority of responding homeowners were unaware of existing technology or conflated mobility-assistive devices and home retrofits with aging-in-place technology. Another concern is that the population of adults who might currently benefit from aging-in-place technology may have an inherent distrust of the technology due to privacy concerns or a fear that these technologies would lead to decreased face-to-face human interactions. The study results indicate the need to better educate those planning to age in place about the available technologies. In addition, a review of current research indicates a need for those developing new technologies to address privacy and de-socialization concerns.

CH I. INTRODUCTION

Background and Research Question

Imagining your dream home at age 30 or 40 does not always include considering what life will be like when you have reached the age of 65 or older. During the design process, your primary goals might not include a focus on what your health might be like 30 years later, and what assistance you might need to stay in your home 40 years later. Builders who specialize in aging in place encourage homeowners to think about what their later years might be like and how to live comfortably in their homes at any age. That planning process requires considering the physical and mental challenges that might come and how to harness technologies to overcome physical limitations and maintain a high quality of life for as long as possible.

Today in the United States the number of those age 65 and over has reached an all-time high of 52 million (Kilduff, Mather, & Scommegna, 2019). By the year 2060, the number of Americans age 65 or older is expected to nearly double, from 52 million to 95 million (Population Reference Bureau, 2019). Along with the increased population of adults who are 65 and older, there is ever-increasing ethnic and cultural diversity within that population (Kilduff, Mather, & Scommegna, 2019). The cultural norms for caring for aged family members vary widely across different cultures: it may be common for younger family members to move in with elderly family members in order to care for them; it may be common for aging family members to move in with younger members of the family; or geographical distance among family members may mean that elderly adults are primarily on their own until a crisis of some sort requires family members to look for third parties, including long-term care facilities, to assist the elderly in the last stage of life. But regardless of the cultural norms, almost 73% of adults say they would prefer to live in their own homes for as long as possible. (Khalfani-Cox, 2017).

Assisted living and long-term care facilities, considered secondary housing options in the United States, currently cost the average American approximately $4,000 per month (2019, August 26). For those with dementia or related diagnoses who need the more specialized care available only in memory care units can expect to spend $6,000-$8,000 per month (2019, August 26). Most Americans, regardless of preference, will be required to grow old at home simply because they cannot afford to move into secondary housing until their assets are depleted.

Using smart home technology can allow the elderly to remain home more safely and comfortably, retaining maximum independence, and avoiding the always-difficult transition to unfamiliar spaces. The homeowner can maintain independence and quality of life by embracing technological advances that can help bridge the gap between living a fully autonomous life and the need to rely on external help. Americans will be able to harmonize their preference to remain home with a very real increase in the ability to do so safely through use of smart home technologies. Children responsible for the welfare of an aging relative can check on them through monitoring technology placed within the home, often at a cost far lower than that of assisted living or long-term care. Current safety technologies available to help seniors age in place include fall detection sensors or protective mats that can be placed next to a bed, daily life pattern detectors, and automatic daily medicine dispensers. Even when aging-in-place technologies were not integrated within a home's original design, most homes can be retrofitted to make spaces safer for the individuals to live in during their aging years.

Research Goal

The goal of this study was to identify the top smart home technologies currently available and suited both for aging-in-place new-home design and remodeling of homes that need retrofitting to be suitable for aging in place. The study was also intended to help homeowners

find the best technologies for a specific home. A thorough literature review was performed to gain a better understanding of the current status of aging-in-place home design and retrofits, technologies that are currently available, the specific requirements users will need to adapt the technologies into their lives, and available product information for smart home technologies. Further, two separate surveys were completed by homeowners and by home builders who are certified aging-in-place specialists. The goal of the home-owner survey was to identify the most commonly used technologies for aging in place and evaluate homeowners' knowledge of available smart home technologies. The goal of the home builders' survey was to identify the most widely adopted smart home technologies and evaluate client satisfaction. The research question presented for the study is as follows: *How can technology be implemented to make homes suitable for aging in place?*

The objectives below introduce the framework of this study and help determine the answers to the study's research question.

Research Objective

1. Literature review on back ground of aging in place and technologies available.
2. Conduct two separate online surveys to homeowners and builders to identify the top technologies for aging in place.
3. Compare the homeowner and builder surveys to find the technologies with top user satisfaction.
4. Identify the technologies most commonly used in homes designed for aging in place.

Research Strategy

Study Subjects

Homeowners

1. Currently aging in place
2. Planning to age in place
3. Caring for someone aging in place

Certified Aging-in-Place Home Builders

1. National Association of Home Builders (NAHB), International Interior Design Association (IIDA), Occupational Therapists (OT), American Institute of Architects (AIA), National Kitchen and Bath Association (NKBA).
2. Completed education and met insurance requirements

An online survey was selected as the tool to identify aging-in-place technologies used by homeowners in their own homes and to identify other technologies the homeowners would prefer to use in their own homes when they do begin to age in place. The survey also compares the homeowner data with what the builders selected as their preferred and most-often-used technologies in homes they are building for clients. In both the homeowners' and the builders' survey, the participants are asked how aging-in-place projects are financed and who is ultimately paying for the technologies. This question could lead to further investigation on how the elderly could afford to age in place using smart home technology if it is too expensive for the individuals.

Research Method and Outcome

Two online surveys were created to gather information on smart home technologies available and how they are currently used or might be used in the future. The first survey was sent to homeowners who are (1) planning to age in place, (2) currently care for someone who is aging in place, or (3) currently aging in place. The second survey was sent to builders who currently build homes that incorporate some type of technology that would enhance aging in place. The data received from the two surveys are compared to identify the most widely adopted smart-home technologies.

The qualitative survey is intended to identify the top technologies used by builders and homeowners in planning aging-in-place homes and determine how those technologies are actually used within homes. The results from the homeowners' survey identifies both the technologies that work best within homes and those that do not. The surveys are built based on the literature review, and the builders and homeowners had the option to add in any technology they used if they did not see their preferred answers. A master list has been presented to show the top smart home technologies currently being used, and smart home technologies that are preferred for the future. In considering this process, it is important to remember that builders will select brands to work with that they are either familiar with or that have worked well for the builders in the past, and homeowners may also tend to select the brands that have performed the best for them in the past, so selecting technologies based on the survey must be done considering the built-in purchasing bias. The literature review will show how technology has changed over the last few years and how it is currently being implemented in design today.

Limitations/Delimitations

Based on the questions in the survey, builders may select their favorite technologies—the brands or types they routinely prefer to work with in the homes they build. Those technologies may not work for every person who is aging in place, and those may not actually be user-friendly to the homeowner. If technologies are installed, yet homeowners do not receive training on using those technologies, the homeowners may have a negative perception about the particular technologies that might be unrelated to the actual usefulness of the technologies; this bias might also negatively impact their perception on use of all technology within their homes. If homeowners do not understand how to utilize the technology that is supposed to improve their quality of life, then how can they give accurate feedback about the technology?

Questions common to both the survey for the builders and homeowners only ask about certain technologies found from the content analysis. The questions will pertain to the technology due to the research done as it pertains to this study. Builders and homeowners will also have the opportunity to list technologies they have used if their preferred answers do not appear on their survey.

Builders who are certified in aging-in-place may also find themselves leaning toward working with clients who have sought out those certified builders because the clients are already educated and more comfortable with beginning the aging-in-place process. A builder who increasingly works with these more knowledgeable clients may develop a bias against other clients who do not begin the building or retrofitting process with a high level of knowledge or understanding of the importance of planning for aging in place. Those clients may not receive the same level of attention and education as other clients who began the design/build/retrofit process focused on aging in place.

Another limitation of the survey is the fact that homeowners may conflate mobility assistive devices and smart home technologies in answering the online survey.

This study is only applicable to builders and homeowners who have built and or live in homes intended for aging in place. Those who have not built, designed, or lived in homes intended for aging in place do not qualify for this survey due to the limitations of their knowledge about aging in place and the technology. Homes currently being retrofitted for aging in place will also be considered for this research.

Other limitations of the study include the following: What technologies would be available in homes not connected to the internet or power sources? Should homeowners plan to have a backup generator in the home to ensure the technologies continue running even if the regular power source goes down (or should the technologies always include a third-party notification system in case the power source fails)? Homeowners may not consider backup power systems to be critical in initial designs for aging in place, and it is another aspect that must be kept in mind when the ability to safely age in place is increasingly dependent on technology that requires, at least for now, continual power sourcing for sustainability.

Conclusion

This study aims to find the top smart home technologies currently being used by homeowners and home builders. Through the literature review of current technologies available and the two separate surveys the master list of technologies has been produced to show what is currently being used within the built environment.

CH. II LITERATURE REVIEW

The purpose of the literature review was designed to define aging in place, the benefits of smart home technologies, and determine how products are specific for different homeowners' needs, including new smart home devices that will allow remote caregivers to watch over the homeowners while allowing for the homeowners to maintain their independence within their own home.

What is Aging-in-Place?

Our current aging population, defined as that age sixty-five and over, is expected to make up nearly 71 percent of the American population by the year 2020 according to the U.S. Census Bureau (Iniondo & Jordan, 2018). The population of sixty-five and over will reach nearly 74 million people, and a study performed by AARP found that 90 percent of Americans who were the age of 65 or older want to stay in their own homes as they aged, and not move into a secondary housing, such as assisted living (Khalfani-cox, 2017). Lozell states in her article that a study by the University of Wisconsin found one third of the households in America are home to one or more of those who are ages 60 and up (2017). Of those households, the study found that many cannot afford to move to secondary housing currently available in the United States.

Currently in the United States, the cost of secondary care, also known as assisted living, continues to rise. According to AARP the cost of assisted living for the median household is $4,000 a month. Families who are looking for care facilities that cover memory care living the cost of those jump up to ~$6,000 a month (Khalfani-cox, 2017). Aging in Place, also known as AIP, combines smart home technology to allow more people the comfort of knowing they can live in their own home, at least for a longer time, during their older years. The caregivers and

those receiving the care should see the quality of life improve through the use of smart home technology (Cheek, Nikpour, and Nowlin, 2005). The smart home technology allows for those aging at home to maintain their independent lifestyle without having to pay a monthly fee of $4,000 - $6,000.

The best time to plan for aging in place is when the homeowner is planning to build a new construction home. The builder and homeowner can begin to work together to implement smart home technologies in the "forever home." Even if the homeowner can no longer drive, there is still a sense of freedom tied to aging in place due to the technologies that will help the homeowner stay connected to those caring for them (Jopp et al, 2010**)**.

Family support can be critical to helping the elderly maintain their preferred lifestyle by remaining at home. Families bring in an improved level of support if they live with their aging family, as they can assist with monitoring the family members to make sure they are successful during their transition to their new aging-in-place lifestyle (Luijkx et al, 2016). Homes that are currently not ready for aging in place can be modified for the homeowners to be able to successfully age in place. Ballanco suggests that one solution is for homeowner to make small adjustments to their home throughout the years to make their home aging in place ready when the homeowners need more assistance in order to remain in the home (2011).

Wellness Benefits of Aging in Place

Using smart home technology, an aging population will be better suited to remain in their own homes for a longer time with decreased risks of injuries and the benefits of a stable and familiar environment. Smart-home technology can lower the risk that aging homeowners will fail to take their prescribed medications, that they might fall and not be found in time to receive

appropriate medical care, and that they will prematurely lose the independence that is likely to help maintain a good quality of life by allowing the homeowner to stay in familiar surroundings and continue to interact with neighbors, pets, and treasured belongings.

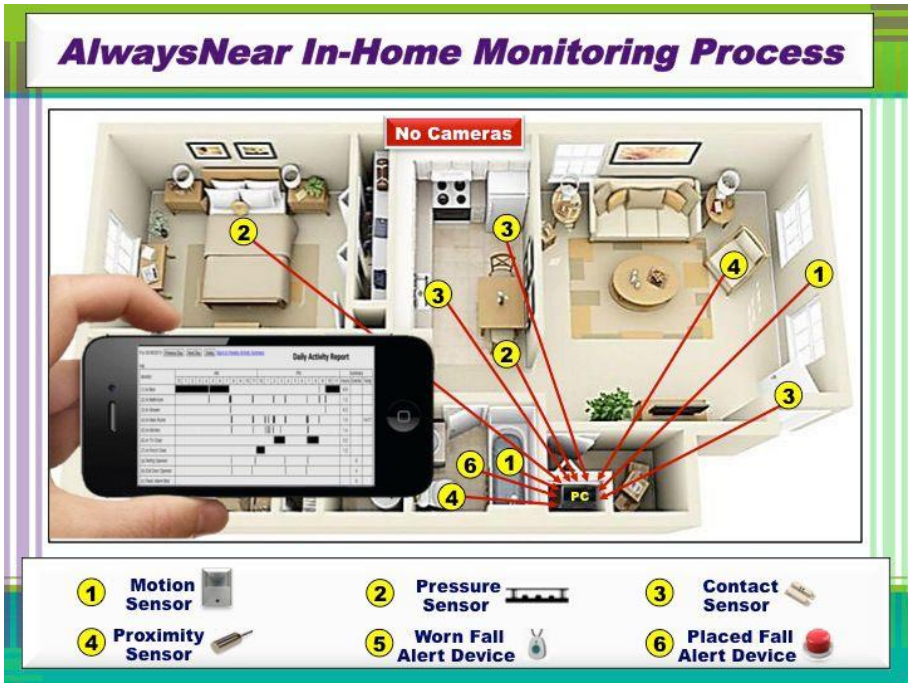
Technologies for Aging in Place

Homeowners can now walk around their homes in what is known as "the second-generation emergency assistance" shirt (Cheek, Nikpour, and Nowlin, 2005). The shirt works as a mobile vital-sign tracker that continuously measures the wearers' vital signs and sends continuous results to a remote site to be tracked for early signs of a medical threat to the homeowners' well-being. Technology like the vital-sign tracking shirt allows the homeowner to safely monitor their health without having to leave their home for non-emergency well checks at a doctor's office. Cheek, Nikpour, and Nowlin continue in their article to state that caregivers and patients can share the information from the vital sign shirt on a website, so everyone is able to say up-to-date on the changing health and need for additional medical treatment of the monitored homeowner (2005).

Another available smart-home technology for aging in place is a fall detection device that scans the room using doppler features, new technology reported by Amin and Erol (2016). Their article states the device is constantly scanning the room searching for the human factors it has been trained to search for and, if the human factor is not found within the designated space, the device will send an alert to the emergency contact. The emergency contact will then be able to check on or send help to aid the person who may have fallen or suffered a health emergency that requires immediate attention.

O’Brien and Ruairi have created a master list of smart-home technologies for those who are starting their plan to age in place (2009). Within the list, the two authors combined current technologies and up-and-coming technologies for aging in place and show how those technologies could be successfully implemented within the home. Two options from their list could be used to assist the homeowner in keeping track of their daily lives and staying on track with their medications: the RFID and Object Locator work together in the PROACT system to monitor daily tasks through a glove that is to be worn while the homeowner is completing certain tasks. The glove can sense objects through RFID tags that have been placed on the objects throughout the house, thereby tracking whether certain tasks, such as feeding a pet or taking medication at a specific time, have been completed.

Figure 1: AlwaysNear Image



(Proactive Health Management, n.d.)

AlwaysNear, another aging-in-place technology, works as a smart-home technology that establishes a homeowner’s baseline of daily activities and then monitors the homeowner’s daily

activities. When the system notices a change in the user's activity, such as when a person's activity level has unexpectedly decreased, given the time of day, of example, the device will send a notice to a designated family member or other caregiver to alert them of this change. According to Aden-Buie et al, this type of device works best when paired with the user's health care providers, so it has access to health records and can bring the provider into the process of monitoring health, along with the family or other caregivers (2015).

Figure 2: GrandCare System



(GrandCare for Family Caregiving, n.d.)

The GrandCare system is mentioned in *The Technology for Aging in Place* from the New York Times (Taub, 2010). GrandCare allows a family member to set up parameters within the home of an elderly relative, for example, so that the system sends alerts to the family member's phone if the elderly relative does not get out of bed by a certain time in the morning or if they open an outside door. The New York Times article notes that the company can also send photo updates to the caregivers so they can monitor in close-to-real-time how their family member is doing in the home. The Times article also dives into smart technology that provides a system for dispensing medicine for the homeowners too. This table-top device can be loaded with 60 doses

of the user's medication, and the machine will speak to the user to direct the user to push a button to release the dose into a small cup. If the dose has not been released within 90 minutes after the scheduled time, the device will alert a caregiver or family member by sending a message explaining that the user has not pushed the medication dispensing button. This technology prevents the homeowner from taking an overdose of any medication and makes it less likely that the homeowner will forget to take necessary medications, but one downside is that the homeowner could potentially push the button but still forget or refuse to actually take the medication one it has been dispensed.

User Requirements

Through the review of past literature, it was found that adults who were already aging in place were more timid about bringing technology into their homes. These adults reported their anxiety levels were higher when they considered installing computers or camera systems within their homes due to their vulnerability or the fear of the lack of privacy that could occur through use of computers or cameras (Elers et al, 2018). Adults who were considering aging in place were also worried about losing their face-to-face connections with their family and friends. They knew the technology would allow them to stay in their homes, but they did not want to lose their connections to the outside world as a result of increased reliance and dependence on smart home technologies.

During the developmental stage of building a new home or retrofitting a current home with aging in place technologies, it is important to prioritize the homeowners' wishes and to find technology that meshes with the user's requirements at a particular time (Luijkx et al, 2016). The builder should not install the state-of-the-art technology simply because it is being installed across the globe but must listen to the homeowner's specific needs and find technology that will

work to best benefit the homeowners. Technology is far more likely to be used in the home if it was carefully selected for the homeowners, and they are readily able to incorporate it into their daily lives.

Wilcox found that homeowners want more control over their environment assisted by technology (2007). Homeowners can create more control over their environment through use of security features in the home, and are more likely to use it if they see how they can create a home that is more comfortable and safe for them to age in over time. They recognize that smart home technology may provide them with more control over their lives than they might have if they moved into secondary housing.

Sociability of Aging in Place

An article from PR Newswire found that, currently, almost two million seniors rarely leave their homes, and seniors who become homebound permanently tend to develop severe cases of depression and loneliness (2018). Agree et al, found 40 percent of Americans living in secondary housing live with a form of a disability, and that number is expected to continue to rise as the population continues to age (2011). While researching for the article, they found that having a community group of nurses, handymen, and occupational therapists who visited regularly increased the quality of life for those still living at home versus those living in secondary housing. Those living with a disability were often still able to live at home because their community group allowed for them to best maintain their independence within the home.

Elers et al found older adults fear that increasing their dependency on technology would cause them to lose valued social time with friends and family (2018). Face-to-face interactions are very important when considering aging in place, and the homeowners wanted to make sure

they would still see and interact regularly with their family and friends, even when using the smart home technology. These adults did not want to see a decline in their social interactions because they began to rely increasingly on technology as they began to age in place.

Scientists have created a social robot named Dali who was created to follow a user around in the user's home to monitor their daily routines and send updates to the user's doctors and caregivers or family (Lee, Park, Um, and Shin, 2018). Dali was found to be useful in some ways, such as gathering data for clients in the early stages of aging in place, but for those living with mid-to-late-stage cognitive impairments, the social robot began to cause some confusion as it followed the user around their homes. According to Lee, Park, Um, and Shin, the user could not understand what was following them around or why they needed something in their house following them around (2018). Another downside is that a device like *Dali* could potentially become a hazard within the home if the device is not charged frequently and runs out of battery in the middle of the home, as the homeowner could trip and fall over the device.

Smart home technologies are available for homeowners that allows them to maintain their sense of community engagement from their home. However, homeowners who were not trained on how to currently use their technology failed to learn how it could help them maintain their community engagement from their home, according to Matlabi et al (2011). Smart home technologies have been created to improve the lives of those who are aging in place and, if they cannot successfully use their technologies to stay in touch with their friends and families, then the technology fails at helping them maintain a social network in their lives. Instead, the technology can actually begin to isolate them from the outside world. Homeowners fear their face-to-face interactions with other humans will become fewer and fewer with the use of new

technology within their homes, and they fear they will become more dependent on technology to maintain social contact with family and friends (Matlabi et al, 2011).

General Products

A research program currently underway by Carnegie Mellon University and the University of Pittsburgh is focused on developing smart home technology that can be trained to learn daily patterns of the homeowner and respond to the homeowner or a remote caregiver if something atypical occurs. The device allows for an increased quality of life as a result of the pattern recognition in their daily lives, and continuous monitoring of routines (Bharucha et al, 2007).

Another article looked into the difference between "young-old adults" and "old-old adults" and their perception on the use of smart home technology within the home (Jopp et al, 2010). It was found in the article that "young-old adults" were more perceptive and welcoming to smart home technology within their home and figured out how to use it more frequently in their daily lives, in contrast to the "old-old adults" who are also aging in place alongside them. The "young-old adults" were not as intimidated by the technology within their home as the "old-old adults" showed.

Elers et al found the technology to be installed within the home should be at the lowest cost possible for homeowners (2018). Homeowners during interviews talked of their concerns about overpaying for smart technology, and they want to make sure they are not taken advantage of in what they perceive to be a more vulnerable financial state. Elers et al also mentions how the smart home technology should, as much as possible, use products already in the home rather than be simply another thing for the homeowners to sit on top of a countertop or shelf (2018).

Keeping the products simple to use is also important as it allows homeowners to more easily transition into the part of their lives where they require additional assistance and imposes less stress during the switch to their smart home technology and aging in place.

Conclusion

Smart home technology allows for homeowners to maintain autonomy within their homes while allowing remote caregivers to check on them through technology. For most homeowners, the quality of life improves with the ability to stay in their own home near neighbors, pets, and important personal belongings. Technologies keep the homeowner on track with their daily lives and allow for slight adjustments to be made to the homeowner's daily life without causing much stress upon the homeowner's normal routines.

CH. III METHODOLOGY

The purpose of this study was to identify (1) the awareness of current and prospective aging in place homeowners about the available smart home technologies, and (2) the smart home technologies that are currently being adopted or considered by home builders who use aging-in-place technologies. An online survey was created to gather the data from the two groups: the homeowners and the builders. Using two separate surveys allowed the researcher to ask questions specific to each group about awareness of, adaptability of use, and popularity of different smart home technologies.

Why an online survey?

Online surveys have significant advantages over print-based surveys. Online survey participants can provide private responses to questions with added security as to the anonymity of the participant, and participants have the additional flexibility to complete they survey at their convenience, completing all questions at once or in parts, potentially allowing for more measured responses. There is no time limit in taking the survey, and the participant has the ability to complete the survey wherever they are most comfortable. Participants are less likely to feel pressured to answer any questions in a certain way because they are not in a group setting with other people nearby and because they are less likely to feel implicit pressure to respond to the surveyor, the answers may be more accurate. Finally, the response rate may be slightly higher because participants do not have to spend time mailing a paper survey back to the researcher.

Study Area

The population sample for the aging-in-place homeowner survey was limited to persons 18 years of age or older who are (1) currently caring for someone aging in place, (2) planning to

age in place, or (3) currently aging in place. The population sample for the aging-in-place builder survey was persons 18 years of age or older who currently design or build homes using aging-in-place technologies. Survey participants must have access to the internet to take the survey. Contact emails were gathered through the National Association of Home Builders, The City of Norman, VillagesOKC, local church organizations, and local builder association websites. The total number of e-mails sent out was 300.

Method of Contact

The University of Oklahoma Institutional Review Board (IRB) approved the two separate studies, and permissions to contact the aging-in-place homeowner and aging-in-place home builders were received on September 19, 2019, and October 15, 2019, respectively. The consent pages were loaded into the online surveys, and the two separate survey links were placed into the recruitment e-emails that were sent out. The online surveys are completely anonymous, and the only way a subject could be identified is if the subject emailed the investigator about the online survey and also informed the investigator of one or more of the subject's answers.

Data Collection

As the survey was sent out to people in a variety of locations and ranging in age from 18-90 years old, the survey was only available online. The questionnaire was created through an online database that kept the data secure and anonymous.

When sending out emails recruiting subjects to take the survey, there were two options: (1) load the e-mails into the online database contact lists and send the e-mails through the system, or (2) send them individually. Sending the recruitment e-mails through the contact system meant more time could be spent on the results and analysis portion. While keeping in

mind that some respondents may have preferred a paper survey over an online survey, the online system was selected because it allows for faster data entry of the results.

The anonymous survey link was loaded into a recruitment e-mail that was then sent out through the survey system. By clicking on the link, the participants were directed to the online survey consent page. Upon agreeing to the online consent, participants were then directed to the rest of the survey.

Participants

The aging-in-place homeowner study includes participants who (1) currently care for someone, (2) are currently aging in place, or (3) plan to age in place. The aging-in-place home builder study includes participants who currently build homes for those who plan to age in place. Members of the two groups are located throughout the United States.

The data from the two separate surveys were compared to each other during analysis to find out what type of technologies homeowners are currently installing within their homes and what types of technologies residential home builders are currently using. The data from homeowners who identified as not currently live in aging-in-place homes were also compared to the builder data.

The preferred smart home technologies listed in the aging-in-place homeowner survey have been compared to the builder survey data. The question in the homeowner survey asking about the preferred technology (See Appendix C) was asked to find out which technologies the homeowners would likely use later in the aging-in-place process.

Technology Survey

Introduction

To develop questions during the process of creating the online survey, the research was evaluated to best determine which current technologies the participants would most likely be aware of. Developing the survey required several trial periods to determine how the survey should flow for participants taking the survey, and if participants were likely to encounter any difficulties in responding to questions. Once the flow of the survey was improved, the survey was published.

The survey has five different parts: (1) the online consent, (2) demographics and information, (3) smart home technologies, (4) training and (5) costs. The purpose of the aging-in-place homeowner survey and the reason for breaking it into these sections was to find out how much the homeowners know about the smart home technologies available to them, and what technologies builders are currently providing in their scope of work.

Section 1: Online Consent

Before responding to the survey, the participants are required to complete the online consent page (See Appendix **A & B**). This page provides participants with the necessary information about the investigator and the investigator's contact information in case participants have for any queries or suggestions related to the survey. The participants are required to agree that they are over the age of eighteen in order to take the survey. A person under eighteen cannot participate in this survey for smart home technologies. Upon completing the consent page, the participants are allowed to take the survey if they are age 18 or over.

Section 2: Demographic Information

In the demographic section of the two surveys the respondents were asked to provide as much information about themselves as they can without revealing their identities to the investigator. The demographic information provided by the participants allows for groupings to be made when comparing answers in the results and data section. The survey gather the following data:

Homeowner background information

- Home currently aging in place or retrofitted for aging in place
- How many residents are currently aging in place or will at some point age in place
- Current state of overall health
- Age of participants

Builder background information

- Whether currently build aging-in-place homes
- Number of aging-in-place homes built per year
- Length of time builder has been building homes
- Age of builder

See Appendix **C & D** for online survey's background section.

Section 3: Aging in Place Technology

The third section of the survey determines each homeowner's awareness about available smart home technologies and knowledge of the technologies adopted within their homes. The

homeowners were asked whether they have aging-in-place smart home technologies within their homes. The builders were presented with a different set of questions asking the same questions about technologies as were the homeowners, but how, as builders, they perceive these technologies. Both groups had the options to list additional technologies they preferred in a text box within the survey.

Homeowner technology questions

- Have you installed any smart home technologies in your home?
- Have you purchased any other type of technologies?
- Please list the top three technologies you would prefer to install in your home.

Builder technology questions

- Have you installed smart home technologies in homes you have built?
- Please rank from best to worst the technologies that are most commonly requested by clients.
- Please rank smart-home technologies in order of client satisfaction.

See Appendix **C &D** for online survey's technology section.

Section 4: *Training and Who is Paying for the Technology*

Training in proper use of the technology is important for both the homeowner and the builder. The homeowners must learn how to use their technology in order to incorporate it into their everyday life, and the builders can assist them in this process. The survey asked both homeowners and builders if any training is provided for smart home technology and the time frame for the training if it is provided.

Homeowner and builder questions

- Is training provideda/
- When does the training for the technology occur?

See Appendix **C & D** for online survey's training section.

The survey asked about the financing of the aging-in-place project to identify who is providing payment for the technologies in the aging-in-place project. During the literature review, it was found clear that many homeowners are nervous about the transition to aging-in-place because of the cost. Many homeowners stated they did not have the necessary finances to cover the costs of implementing the smart home technologies in their current residence. In the survey, homeowners and builders were both asked how the technologies were being paid for because learning how homeowners are purchasing aging-in-place technologies.

Homeowner and builder questions

- How is the technology paid for?
    - Answers…
        - Homeowners
        - Medicare
        - Medicaid

See Appendix **C & D** for online survey's payment section.

Summary

As previously explained, the online study provides feedback on what smart home technologies homeowners and builders use and prefer. Once the surveys have been recorded

online, their data will be transferred to a spreadsheet for analysis. Chapter four will discuss the results and analysis from the two surveys, and how they reflect on each other.

CH IV. RESULTS & ANALYSIS

The purpose of this study was to identify the available aging in place technologies for the homeowners and builders. The study was divided into two parts: (1) a survey to homeowners, and (2) a survey to home builders who are certified aging-in-place specialists. Presented in this chapter are the demographics and data from the two surveys. A summary at the end of the chapter will demonstrate the level of awareness about the technologies available for aging in place.

Demographics

The respondents from the two surveys consists of 33 homeowners and 12 builders. A majority of the homeowners were between the ages of 51 and 70 (39.4%), and most of the builders were between the ages of 51 and 64 (41.7%). Sixty percent of the homeowners reported as married and working more than 40 hours during the week. Forty five percent of the homeowners reported they were in very good health, but fifty four percent reported two members in the household would require aging-in-place assistance. This information can be viewed in Table 1 with demographic profiles of the homeowner respondents provided on the next page. Thirty-three percent of the builders reported they had been building for fewer than five years, and sixty six percent of those builders had received their bachelor's degree. The builder demographic can be viewed in Table 2 with demographic profiles of the builder respondents summarized on the page following Table 1. Of the homeowners, one went to high school or the equivalent, three had completed some college, fifteen had received their bachelor's degree, nine had received their master's degree, and five had completed a professional degree: M.D., J.D., etc.

Table 1
Demographic Profiles of the Homeowner Respondents

Demographic Characteristics		Frequency	Percent
Age			
	19-30	9	27.3
	31-40	2	6.1
	41-50	4	12.1
	51-60	6	18.2
	61-70	7	21.2
	71-80	4	12.1
	81-90	1	3.0
Gender			
	Male	5	15.2
	Female	28	84.8
Race			
	White or Caucasian	31	93.9
	American Indian or Alaska Native	2	6.1
	Asian	1	3.0
	Black or African American	0	0.0
	Native Hawaiian or Other Pacific Islander	0	0.0
	Other	1	3.0
Education			
	Grammar School	0	0.0
	High school or equivalent	1	3.0
	Vocational/technical school (2 years)	0	0.0
	Some college	3	9.1
	Bachelor's Degree	15	45.5
	Master's Degree	9	27.3
	Doctoral Degree	0	0.0
	Professional Degree (MD., J.D., etc.)	5	15.2
	Other:	0	0.0
Marital Status			
	Divorced	3	9.1
	Living with significant other	3	9.1
	Married	20	60.6
	Separated	0	0.0
	Single	5	15.2
	Widowed	2	6.1
Employment Status			
	Homemaker	2	6.1
	Retired	9	27.3
	Student	0	0.0
	Unemployed	0	0.0
	Employed < 40 hours a week	4	12.1
	Employed 40 hours a week	18	54.5

Health Status		
Excellent	8	24.2
Very Good	15	45.5
Good	8	24.2
Poor	2	6.1
Very Poor	0	0.0
Not Known	0	0.0
Number requiring aging in place		
0	9	27.3
1	6	18.2
2	18	54.5

Table 2

Demographic Profiles of the Builder Respondents

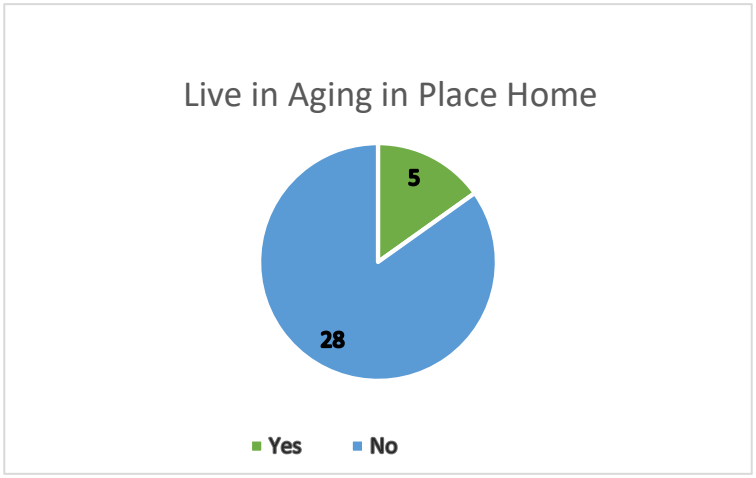
Demographic Characteristics		Frequency	Percentage
Age			
	19-30	1	8.3
	31-40	0	0.0
	41-50	2	16.7
	51-64	5	41.7
	65-75	3	25.0
Gender			
	Male	8	66.7
	Female	4	33.3
Race			
	White or Caucasian	11	91.7
	American Indian or Alaska Native	1	8.3
	Asian	0	0.0
	Black or African American	0	0.0
	Native Hawaiian or Other Pacific Islander	0	0.0
	Other		
Education			
	Grammar School	0	0.0
	High school or equivalent	0	0.0
	Vocational/technical school (2 years)	0	0.0
	Some college	2	16.7
	Bachelor's Degree	8	66.7
	Master's Degree	2	16.7
	Doctoral Degree	0	0.0
	Professional Degree (M.D., J.D., etc.)	0	0.0
	Other:	0	0.0
How long you have been building			
	Less than 5 years	4	33.3
	5 - 10 years	2	16.7
	10 - 19 years	1	8.3
	20 - 29 years	1	8.3
	30 - 39 years	2	16.7
	More than 40 Years	2	16.7

Technology Awareness

Homeowner's Perspective

The homeowner survey allowed for the participants to give feedback on the smart-home technology they use in their homes or would prefer to use in their homes in the future. Most homeowners reported they are not currently aging in place, 84% to be exact, but the respondents were able to include in a text box the technologies they would prefer to install in their homes in the future. Table 3, *Smart Home Technology,* shows the technologies homeowners added in the text boxes and how often the technologies were mentioned. Table 4, *Technology Used by Homeowners,* shows the technologies selected by homeowners currently living in aging-in-place homes. The two tables show the stark contrast between the use of the smart home technologies by those who are currently aging in place and those who are not yet at the point in their lives to need aging-in-place technologies. The survey asks whether the homeowner is currently living in an aging-in-place home, and Figure 3, *Lives in AIP Homes,* shows the exact number respondents who do not currently live in aging-in-place homes. From their responses, it can be inferred that

Figure 3: Live in AIP Homes



even the respondents who responded with ‘no’ might be thinking about their future and aging in place.

Homeowners, when selecting the technologies, they would prefer to have in their homes in the future, tended to select smart technologies like the “Daily Pattern Sensors” along with the “Fall Detection Scanners.” The technologies most often listed as currently being used by homeowners are “Wireless Transceiver Fall Detection” and “Fall Detection Scanner.” These two devices protect a homeowner *after* they have fallen inside the home and cannot make it to a telephone to call for assistance. The devices most often selected by homeowners currently using assistive devices could be due to their age and discomfort with installing additional smart technologies within the home or these devices could be most commonly used because fall assistance technology in the form of emergency call buttons/necklaces have been widely advertised for some time and older respondents could have been more comfortable installing those technologies. It is also possible that these were the only smart technologies available at the time these respondents began needing aging-in-place assistance. The common selections between the already installed technologies and the future preferred technologies show increased interest in the technologies that can be connected to the homeowners’ smart phones and tablets and to remote caregivers’ smart phones and tablets.

Participants were also asked who would be ultimately responsible for paying the costs of installed technology. This question was an important component of the survey, as it could show a potential need for future studies to determine whether (1) technology will be sufficiently affordable to allow widespread aging in place, or (2) homeowners are not inclined to use technology available to support aging in place due to their lack of knowledge of affordable products. 30% of homeowners reported they would likely pay for the technology on their own,

while 3% reported they believed Medicare would pay, and another 3% reported they believed Medicaid would cover the costs of aging-in-place technology.

Table 3
Future Selections for Smart Home Technologies

	Preferred for Future
Automatic Thermostats	1
Computer Community Outreach	0
Vital Sign Tracking	1
Assisted Bathing Facility	0
Automatic Window Openers	0
Daily Pattern Sensors	2
Fall Detection Scanner	2
Wireless Transceiver Fall Detection	3
Telehealth Monitor	3
Floor Sensors	1
Pool Alarm	2
Automatic Lighting	1

*This information was created from the answers given from the homeowner survey. The question asked what technology the homeowner would prefer in their home in the future.

Table 4
Currently Installed Technologies

	Installed in the Home
Automatic Thermostats	0
Computer Community Outreach	0
Vital Sign Tracking	0
Assisted Bathing Facility	0
Automatic Window Openers	0
Daily Pattern Sensors	0
Fall Detection Scanner	2
Wireless Transceiver Fall Detection	1
Telehealth Monitor	0
Floor Sensors	0

*This information was created from the answers given from the homeowner survey. The question asked what technologies were installed in the homes currently for aging in place.

Builder's Perspective

The technology gathered from the builder survey showed the responding builders are installing smart home technology to help those aging in place. Table 5 shows the technologies that are currently being installed by the builders and the frequency of their use. The technologies the builder respondents selected are those that easily allow for quality of life to be maintained by the homeowners. Thermostats can be programmed to change automatically, and windows can be programmed to open and close as required to accommodate the daily needs of the homeowner. The builder can offer automatically performing technologies for homeowners who are unable to use the technologies to control these items themselves or can provide options to allow remote caregivers to control the technologies from an offsite location.

Table 5
Builder Smart Home Technologies

Smart Home Technology	Frequency
Automatic Thermostats	2
Computer Community Outreach	0
Vital Sign Tracking	0
Assisted Bathing Facility	0
Automatic Window Openers	1
Daily Pattern Sensors	0
Fall Detection Scanner	1
Wireless Transceiver Fall Detection	1
Telehealth Monitor	0
Floor Sensors	0

*This information was created from the answers given from the builder survey. The question asked what technologies were installed in the homes currently for aging in place.

The technologies listed in Table 5 are the suggestions the builders commonly provide to their clients during the planning stages of building new homes. The advantage of having a builder with certification as an aging-in-place specialist is that the builder will be more attuned to offering aging-in-place technologies and will have more expertise in knowing which

technologies work well and which will best assist the client in planning for aging-in-place, with safety, quality of life, and cost having top priority.

The builder survey also asked respondents to report how these technologies would be paid for. 42% reported the client would pay for the technology and, in a remarkable divergence from the 6% of homeowners who believed Medicare or Medicaid would likely pay for aging-in-place technologies, none of the builders chose Medicare or Medicaid as potential payors

Despite the assumptions by 6% of respondent homeowners that Medicare or Medicaid would pay for aging-in-place technologies, those assumptions are largely incorrect, at least for now. Neither Medicare nor Medicaid would generally pay for aging-in-place technologies, even though Medicaid will pay for some types of home remodeling if the remodel will allow a person to remain in the home and out of a long-term-care facility and Medicare may cover devices that are prescribed by a physician for medical reasons (Chandler, 2019). But as a general rule, Medicaid assistance would be primarily limited to waivers provided to make changes needed to provide wheelchair access, such as installing ramps, widening doors, and modifying bathrooms in order to keep a person out of a nursing home, modifications generally known as "Environmental Accessibility Adaptations." States vary significantly in what will be covered in a waiver, as Medicaid is a state-administered program (Medicaid Programs that Pay for Home Modifications for Aging & Disabilities, 2019).

Homeowners Conflated Mobility Devices as Technology for Aging-in-Place

Smart home technology was frequently mistaken as being limited to mobility devices during the survey. Both the homeowner and the builder surveys asked about mobility devices within the homes, but those were separate questions from the smart-home-technology questions.

Homeowners listed mobility devices as “wants” in answering the question of what smart home technology they would prefer in the future for aging in place. The notion that that mobility devices can be used as smart home technology when aging in place is a common misconception, but the smart home technology being studied is not intended to aid the homeowner in moving around inside the home or making the home physically accessible to those with mobility limitations. The smart technology focused on in this study is technology that will allow the homeowner to access services that improve their safety and independence, for example, a telehealth monitor that connects the homeowner to a health-care provide without the homeowner having to leave home. While the end result might be similar to that achieved by improving accessibility to the home through ramps and widened doorways, the essential purpose of smart technology is to provide services necessary to allow a person to age in place, which is often tied to providing remote access to services or allowing remote monitoring of things such as a homeowner’s movements and compliance with medication regimens. The frequency with which mobility devices are mentioned in the survey in place of smart home technology can be found in figure 4.

Figure 4: Mobility Devices from Survey

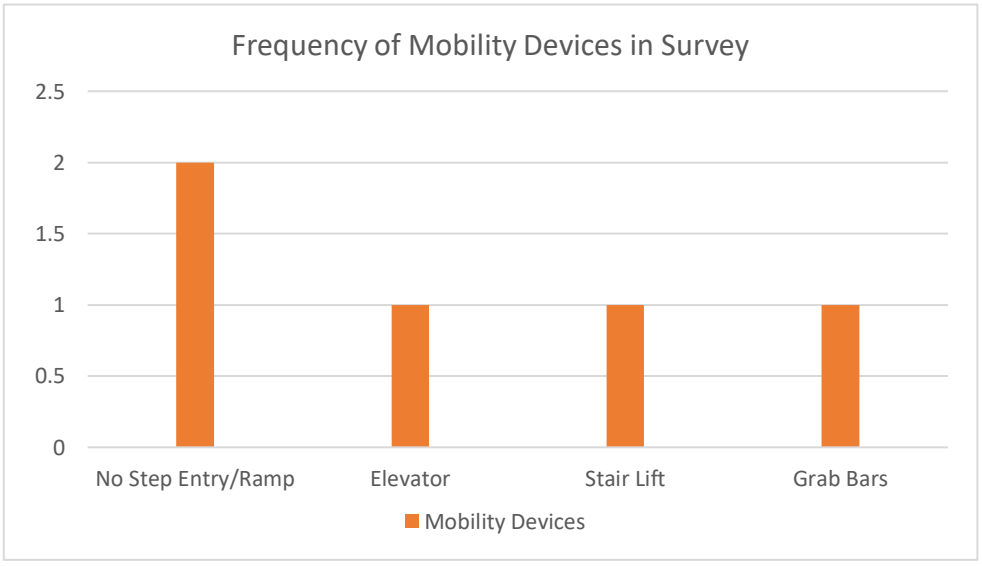


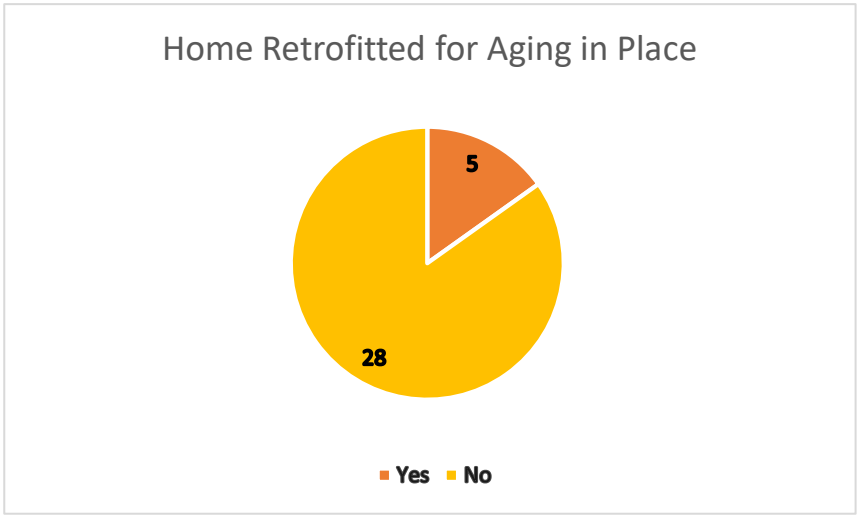
Figure 2 From the homeowner survey showing how often mobility devices were listed in place of smart home technology.

Analysis

Homeowner Responses

The homeowner survey included 28 homeowners who are not currently living in aging-in-place homes, as viewed in Figure 3. Figure 5 shows five responding homeowners are currently living in homes suitable for aging in place. The survey data shows that four of those five homeowners currently living in aging-in-place homes had retrofitted their homes to allow them to age in place. One homeowner lived in a home that had been retrofitted but was not suitable for aging in place.

Figure 5: Live in Retrofitted Homes



The respondents age 19 to 30 are currently looking at what their future life could look like if they began to plan their aging in place living early. Smart technology will very much be different by the time they retire and are perhaps in their 70s and 80s. The 51 to 60-year-old participants still have the option to plan as well, but technology will be less likely to change as much over the next ten years. The technology mentioned in this survey could potentially be

similar to the technology the 61 to 70-year-olds will use when retrofitting their homes for aging in place.

Smart home technology for every homeowner should not be a one-size-fits-all. Homeowners who selected their preferred technologies in the survey are shown to most often have selected fall-prevention technologies along with technologies that will alert their families if they do not perform daily tasks. The selection of these daily pattern sensors in the list is an important part of new technology because it both improves the safety on homeowners in their own home and allows for a remote caregiver to receive updates on the homeowner if they do not perform certain tasks according to their daily routine. Cameras installed in the home learn "the traffic patterns" of the homeowner's daily routine, and if a routine task, such as opening blinds or going to the bathroom are not performed by the anticipated time of day, a remote caregiver will receive a message. Selecting this type of technology in the preferred section shows that younger respondents both plan and are comfortable with having remote caregivers tracking their daily lives within the home. This technology will allows for the homeowner to maximize their freedom by staying out of assisted living or a long-term care facility and potentially not requiring live-in or daily personal assistance in order to remain in the home.

Survey Data Comparisons

The technology selected by the builders, as shown in Table 5, compared to the technology selected by the homeowners who are currently aging in place, as shown in Table 4, shows that most homeowners are not fully aware of the available technologies for aging in place. The builders, all of whom are certified aging-in-place specialists, know far more about the technologies available to use within the homes for aging clients, as would be expected. The homeowners are only aware of what they have read about or what their designers or builders

inform them of when working with them on home design. The wireless transceiver fall detector and the fall detection scanner were the two technologies that were both selected between the builders and the homeowners who are already aging in place. Seeing this technology selected shows these homeowners are primarily concerned with falling risks within the home and little else, or they are simply not aware of other technologies, such as the daily pattern sensors.

The most popular smart home technology for both builders and future aging-in-place homeowners was the automatic thermostat. This technology selection allows remote caregivers to control from a smart device the temperature within the homeowner's home without having to be there. The automatic thermostat maintains the correct temperature throughout the home and alerts the caregiver if any adjustments are made to the temperature by the homeowner—a safety control that will prevent inadvertent overheating or cooling. While keeping an eye on temperature may not seem important, sudden or inappropriate changes in temperature can sometimes be deadly to some aging adults who cannot readily adapt to excessive heat or cold and lack the physical or mental capability of responding appropriately.

Figure 6 and figure 7, on the next page, show the stark contrast between what homeowners are currently looking for in technology for their future smart home technologies, and what homeowners are currently installing in the homes of their clients who are aging in place. Figure 4 shows the homeowners are taking initiative and looking into more smart home technologies available today for their future aging in place technologies, while the builders are installing a smaller selection of basic smart home technologies within their homes. These technologies like the automatic thermostats will allow for the homeowners to maintain a comfortable climate within their home, but as seen in figure 4 there are more smart home

technologies the homeowners are looking to install within their homes to make their aging in place process more adaptable to their lifestyles.

Figure 6: *Future Smart Home Technologies Pie Chart*

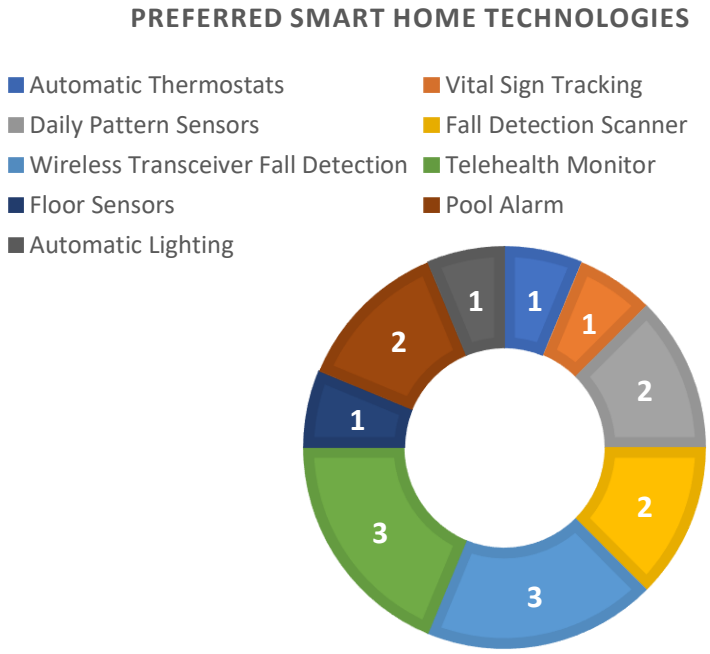
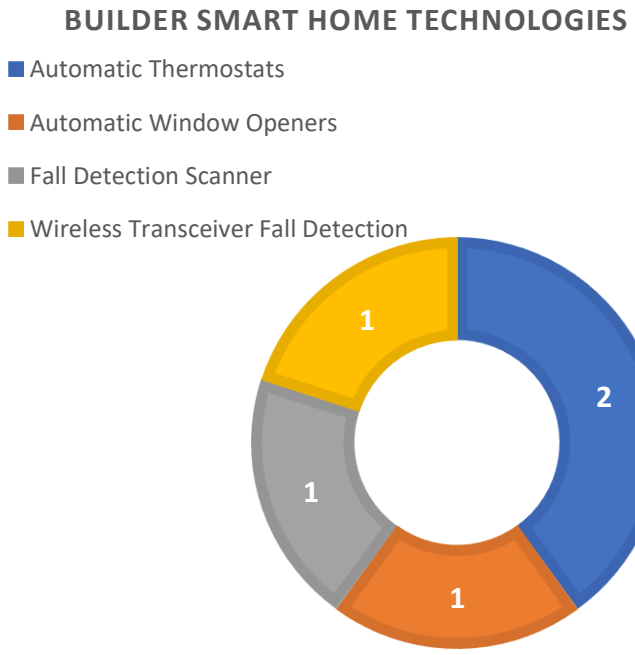


Figure 7: *Builder Smart Home Technologies Pie Chart*



Builder's Responses

The data from the builder survey showed that it is more common for builders to retrofit homes to become aging-in-place-friendly homes than to build new homes suitable for aging in place. Figures 8 and 9 show the difference between the numbers of builders who build new aging-in-place homes compared to those who retrofit existing homes for aging in place. 5 builders responded they do not build aging-in-place homes, but 6 responded they do build aging-in-place homes. When asked about retrofitting existing homes, the numbers changed dramatically, with two builders responding that they do not retrofit homes for aging-in-place, while nine builders responded that they do retrofit existing homes for aging in place.

Figure 8: Build AIP Homes

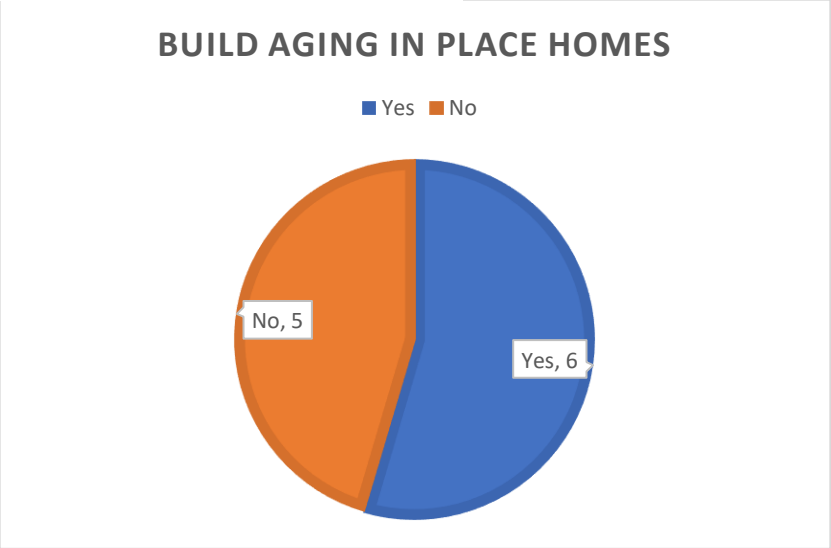
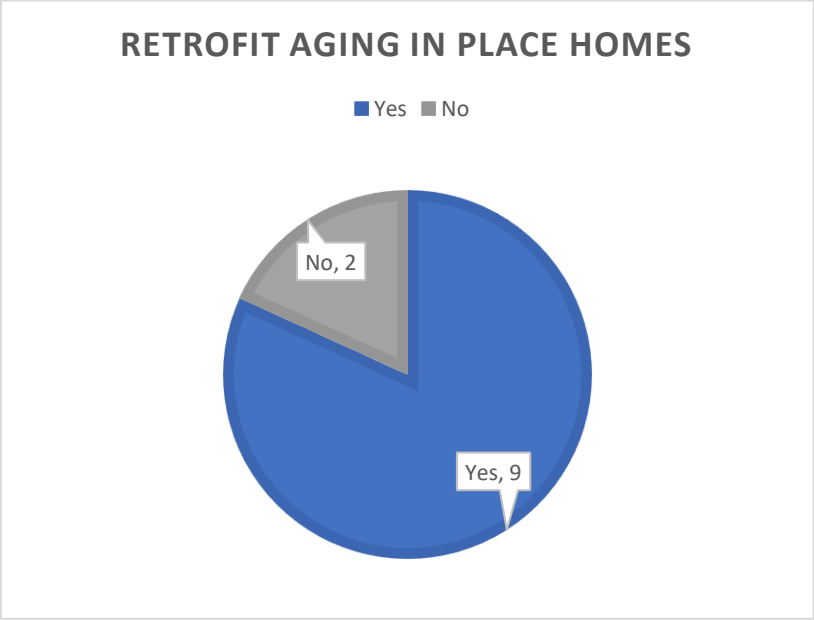


Figure 9: Retrofit AIP Homes



Summary

The survey data shows most homeowners are not currently aware of the many types of existing smart home technologies that can be built in or added to homes to make them suitable for aging in place, and the respondents did not understand the difference between mobility and accessibility devices and smart home technology. The data showing homeowners do not clearly understand the differences between mobility devices and smart home technologies shows the need for more homeowner education on how smart home technology can improve the quality of life within the home. On a positive note, the survey data shows that homeowners are generally aware of the potential for aging in place and the benefits of planning ahead. One concern is that 6% of the responding homeowners assumed that Medicare or Medicaid would assume the costs of incorporating technology into the home, which is unlikely to happen, at least under current government policies.

CH. V CONCLUSION

This chapter introduces conclusions based on the results of the study. The conclusions include a final list of the technologies currently being integrated into homes built or retrofitted for aging in place, and technologies that may be adaptable for future use. The homeowner's survey and the builder's survey final analysis introduce smart home technology that is available but not limited to use in designing new homes suitable for aging in place and retrofitting of current residential homes. This study of smart home technology application within aging in place is a smaller sample size, and conclusions from this sample were taken from within this study's research and findings, but the purpose was to help determine the focus of a large subsequent survey.

Technology

The combination of smart technology that is currently available and in common use with the technology that may exist and be preferred in the future is used to create a list for technology useful for homeowners as they begin search for smart technology suitable for aging in place to use in their own homes. Smart home technology for aging in place is not a one-size-fits-all for homeowners, and each homeowner will need to be educated on how to best select technologies suitable for their needs now and in the future. Selecting from among the options will be individual, but by presenting a broad spectrum of options to homeowners will allow them to better anticipate their future needs and become better educated as to what is available as they plan for aging in place.

The most common smart home technologies are based on the most frequently mentioned technologies in the lists provided in Table 3, Table 4, and Table 5. Aging-in-place smart home

technologies have been combined into a new Table that states how often each was mentioned, but it is important to note that one technology's popularity does not necessarily imply that one technology is better than another or useful to all homeowners. Each of these technologies are used in very different ways, although all have the common goal of helping a homeowner to maintain a good quality of life while also aging in place.

Barriers Toward Implementation of Aging in Place Technologies

The study of smart home technologies for aging adults must address the inherent limitation that can exist when a smart home technology fails to protect or maintain a quality of life for an individual homeowner. Introducing new technology into the home of an aging adult can potentially make the homeowner vulnerable to marketing that "oversells" what the product can do, can cause the homeowner to fall prey to vendors who take financial advantage of potentially vulnerable older adults, and can result in purchase of technology that will not be used if the homeowner or other caregivers are not properly trained in how to effectively use the technology. Older adults, particularly the "older-old," may need significant time and instruction to become comfortable enough with unfamiliar technology to actually use it after it is in place. Ensuring a high level of comfort with the technology will be key to translating purchase of technology into an actual increase in the wellbeing of the homeowner and the ability to age in place.

Creating dependence on technology may cause a strain on human relationships, but it will allow homeowners to live more safely at home for a longer time. Technology is developing at a pace that was unthinkable only a decade ago, so it is likely that existing smart home technologies used by both builders and homeowners today in the aging-in-place process are merely the

beginning of what cannot even be imagined today. The possibilities seem to be limited only by cost and the willingness of individuals to embrace the next technologies.

The homeowner's survey results also highlighted the fact that homeowners generally lacked information on which smart home technologies are available and how those technologies can benefit the homeowner who seeks to age in place. The results show a lack of education on how currently available products can benefit the user and increase their quality of life during the aging-in-place process. Educating the homeowner will require a high level of education and patience on the part of builders, designers, family members, and homeowners.

Technology is rapidly changing every year and asking a survey respondent to think ahead by 20-30 years makes selecting technology for aging in place nearly impossible for a younger homeowner. The value of any technology falls precipitously once a new and better device comes out to replace an earlier version. Upgrading to a new device will inevitably cost more money for the homeowner and, if the device is difference from the former version, the homeowner will need additional training on how to use the latest version.

Another limiting factor in thinking about aging-in-place technology is cost. While some homeowner's responding to the survey seemed to believe that government healthcare programs, such as Medicare and Medicaid, would bear the cost of in-home technology, as a general rule, that is not the case, as Medicare pays only for direct health care, and even Medicaid waiver programs generally focus on home modifications that will improve accessibility, such as ramps and widened doorways. One limitation of this study is that responding homeowners were likely just that—homeowners. For the population of aging adults who do not own their own homes, retrofitting to allow for aging in place will be highly unlikely at best, whether because of a

landlord's reluctance to allow or pay for modifications or the adults lack of financial resources to pay for the latest technology.

Finally, one of the biggest concerns voiced by researchers is the concern older adults have about losing human connections and human contacts as technology effectively takes over caretaking that formerly had to be done in person: health care; daily monitoring; conversations; assistance in cooking, bathing, and taking medication. Technology is often viewed as replacing these connections and, unless that loss of human connection can be mitigated, it is likely to continue to be a barrier to widespread adoption of smart home technologies installed into a home for aging-in-place they are depending on their technologies more than their human connections day to day.

Future Research

The small response size of the study also limits the conclusions that can be drawn. Because the homeowner's survey was limited to those are currently aging in place, planning to age in place, or currently caring for a person who is aging in place, it is not possible to draw conclusions about the larger general population. Aging in place is a concept that is likely not at the forefront of the minds of most people until or unless circumstances bring it into the family. A larger sample size would also allow for more information to be extrapolated from the homeowners' and builders' responses on smart home technology. A future study including a larger sample size could provide a greater spectrum of data on the most-often used technologies and a greater spectrum of data on the varied needs of an aging population.

The homeowner and builder survey ask how the technology is currently being paid for, and this question suggests an option for future research. Smart home technology devices and

installation are a viable option for homeowners who do not wish to move into assisted living facilities, but how will they procure the funds to pay for the technology if they do not have the ability to pay for it? A future study into how homeowners can pay for the technology, and what legislation is currently under consideration or should be considered to provide government funds to pay for home-based technology to be installed for those who are currently eligible for Medicare or Medicaid.

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Appendix A: IRB Consent Form

INFORMED CONSENT

OU-NC IRB Number: 11180 Approval Date: 9/19/2019

You are invited to participate in research about how home-based technology can be implemented within aging in place homes.
If you agree to participate, you will **complete this online survey.**
There are no risks or benefits.
You will not be reimbursed for your time and participation in this research.
Your participation is voluntary, and your responses will be **anonymous**
We will not share your data or use it in future research projects.
Even if you choose to participate now, you may stop participating at any time and for any reason.
Data are collected via an online survey system that has its own privacy and security policies for keeping your information confidential. No assurance can be made as to their use of the data you provide

If you have questions about this research, please contact:
Student Principal Investigator:
Kelsey Mullins, 405-694-8316, kelsey.r.mullins-1@ou.edu
Faculty Advisory:
Suchi Bhattacharjee, suchi@ou.edu

You can also contact the University of Oklahoma – Norman Campus Institutional Review Board at 405-325-7110 or irb@ou.eduwith questions, concerns or complaints about your rights as a research participant, or if you don't want to talk to the researcher.

Please print this document for your records. By providing information to the researcher(s), I am agreeing to participate in this research.

Are you 18 years of age or older?

_____ Agree

_____ Disagree

Appendix B: IRB Consent Form

INFORMED CONSENT

OU-NC IRB Number: 11270 Approval Date: 10/15/2019

You are invited to participate in research about how home-based technology can be implemented within aging in place homes.
If you agree to participate, you will **complete this online survey.**
There are no risks or benefits.
You will not be reimbursed for your time and participation in this research.
Your participation is voluntary, and your responses will be **anonymous**
We will not share your data or use it in future research projects.
Even if you choose to participate now, you may stop participating at any time and for any reason.
Data are collected via an online survey system that has its own privacy and security policies for keeping your information confidential. No assurance can be made as to their use of the data you provide

If you have questions about this research, please contact:
Student Principal Investigator:
Kelsey Mullins, 405-694-8316, kelsey.r.mullins-1@ou.edu
Faculty Advisory:
Suchi Bhattacharjee, suchi@ou.edu

You can also contact the University of Oklahoma – Norman Campus Institutional Review Board at 405-325-7110 or irb@ou.eduwith questions, concerns or complaints about your rights as a research participant, or if you don't want to talk to the researcher.

Please print this document for your records. By providing information to the researcher(s), I am agreeing to participate in this research.

Are you 18 years of age or older?

_____ Agree

_____ Disagree

Appendix C: Homeowner Survey

Are you 18 years of age or older?

- ○ Agree (4)
- ○ Disagree (5)

Skip To: Q1 If Are you 18 years of age or older? = Agree

Q1 Please indicate your age

- ○ 19 - 30 (1)
- ○ 31 - 40 (2)
- ○ 41 - 50 (3)
- ○ 51 - 60 (4)
- ○ 61 - 70 (5)
- ○ 71 - 80 (6)
- ○ 81 - 90 (7)
- ○ 91 and above (8)

Q2 Please select your gender

- ○ Male (1)
- ○ Female (2)
- ○ Other (3)
- ○ Prefer not to answer (4)

Q8 Please indicate the Race/Ethnicity of the household members [Check all that apply]

- ☐ American Indian or Alaska Native (1)
- ☐ Asian (2)
- ☐ Black or African American (3)
- ☐ Native Hawaiian or Other Pacific Islander (4)
- ☐ White or Caucasians (5)
- ☐ Other (6)

Q9 Highest level of education completed by the head of household

- ○ Grammar School (1)
- ○ High school or equivalent (2)
- ○ Vocational/technical school (2 years) (3)
- ○ Some College (4)
- ○ Bachelor's degree (5)
- ○ Master's degree (6)
- ○ Doctoral degree (7)
- ○ Professional degree (MD, JD, etc.) (8)
- ○ Other (9)

Q10 Your marital status

- ○ Divorced (1)
- ○ Living with significant other (2)
- ○ Married (3)
- ○ Separated (4)
- ○ Single (5)
- ○ Widowed (6)

Q11 How long have you been living in this house?

- ○ Less than 5 years (1)
- ○ 5 - 10 years (2)
- ○ 10 - 19 years (3)
- ○ 20 - 29 years (4)
- ○ 30 - 39 years (5)
- ○ More than 40 years (6)

Q12 Which of the following categories best describes your primary are of employment (regardless of your actual position)?

- ○ Homemaker (1)
- ○ Retired (2)
- ○ Student (3)
- ○ Unemployed (4)
- ○ Employed < 40 hours a week (5)
- ○ Employed 40 house a week (6)

Q13 Do you live in an Aging in Place home?

- ○ Yes (1)
- ○ No (2)

Q15 Has your home been retrofitted to meet Aging in Place needs?

- ○ Yes (1)
- ○ No (2)

Q16 How would you rate your overall heath condition?

- ○ Excellent (1)
- ○ Very Good (2)
- ○ Good (3)
- ○ Poor (4)
- ○ Very Poor (5)
- ○ Not Know (6)

Q17 Total number in the household that requires or will require aging in place.

_____

Q16 What are three things needed to keep up your quality of life within your home?

_____

_____

_____

_____

_____

Q17 What were your top three safety concerns within your home currently?

_____

_____

_____

_____

_____

Q18 Have you installed any Aging in Place (AIP) home-based technologies in your home? (examples are fall detection, floor sensors....)

- ☐ Yes (1)
- ☐ No (2)

Skip To: Q19 If Have you installed any Aging in Place (AIP) home-based technologies in your home? (examples are f... = No

Q27 If YES, please select from the list of home-based technologies you have installed in within your home.

- ○ Automatic Temperature Thermostats (1)
- ○ Computer Community Outreach (2)
- ○ Vital Sign Tracking (3)
- ○ Assisted Bathing Facility (4)
- ○ Automatic Window Openers (5)
- ○ Daily Pattern Sensors (6)
- ○ Fall Detection Scanner (7)
- ○ Wireless Transceiver Fall Detection (8)
- ○ Telehealth Monitor (9)
- ○ Floor Sensors (10)

Q19 Have you purchased any other type of technology that is not listed above to be installed? If YES, please provide the name of the technology that you have purchased.

- ○ Yes (1)
- ○ No (2)

Skip To: Q20 If Have you purchased any other type of technology that is not listed above to be installed? If YES,... = No

---

Q28 If YES, please provide the name of the technology that you have purchased.

_____

_____

_____

_____

_____

Q20 If you have not purchased any AIP home-based technology, please list your top three technologies you would prefer to install into your home...

_____

_____

_____

_____

_____

Q21 If you have installed AIP home-based technology within your home, please rank your top five AIP home-based technologies in order from 1-5. 1 being the highest and 5 being the lowest.

_____

_____

_____

_____

_____

Q22 Have you purchased any mobility devices to be installed within your home?

- ○ Yes (1)
- ○ No (2)

Skip To: Q24 If Have you purchased any mobility devices to be installed within your home? = No

Q23 If yes, please provide the name of the mobility device that was installed.

_____

_____

_____

_____

_____

Q24 Have you received any training on how to use your new AIP home-based technology or mobility devices?

- ○ Yes (1)
- ○ No (2)

Skip To: Q26 If Have you received any training on how to use your new AIP home-based technology or mobility devices? = No

Q25 If yes, then when was training provided to you for your devices?

- ○ At time of installation (1)
- ○ At time of punch list (2)
- ○ At time of closing (3)
- ○ At regular interval during the 1st year (4)
- ○ Any time in the first two years as requested (5)

Q26 How is the technology being paid for?

- ○ Medicare (1)
- ○ Medicade (2)
- ○ By the homeowner (3)

End of Block: Default Question Block

Appendix D: Home Builder Survey

Q29 Are you 18 years of age or older?

- ○ Agree (1)
- ○ Disagree (2)

Skip To: Q1 If Are you 18 years of age or older? = Agree

Q1 Please indicate your age range

- ○ 19-30 (1)
- ○ 31-40 (2)
- ○ 41-50 (3)
- ○ 51-64 (4)
- ○ 65-75 (5)

Q2 Please select your gender

- ○ Male (1)
- ○ Female (2)
- ○ Other (3)
- ○ Prefer not to answer (4)

Q3 Please indicate your Race/Ethnicity. [Check all that apply]

- [ ] American Indian or Alaska Native (1)
- [ ] Asian (2)
- [ ] Black or African American (3)
- [ ] Native Hawaiian or Other Pacific Islander (4)
- [ ] White or Caucasian (5)
- [ ] Other (6)

Q4 Highest level of education completed.

- ○ Grammar school (1)
- ○ High school or equivalent (2)
- ○ Vocational/technical school (2 year) (3)
- ○ Some college (4)
- ○ Bachelor's degree (5)
- ○ Master's degree (6)
- ○ Doctoral degree (7)
- ○ Professional degree (MD, JD, ect.) (8)
- ○ Other (9)

Q6 How long have you been building.

- ○ Less than 5 years (1)
- ○ 5 - 10 years (2)
- ○ 10 - 19 years (3)
- ○ 20 - 29 years (4)
- ○ 30 - 39 years (5)
- ○ More than 40 years (6)

End of Block: Demographic Information

Start of Block: Aging in Place Building

Q7 Do you build Aging in Place (AIP) homes?

- ○ Yes (1)
- ○ No (2)

Q8 Do you retrofit existing homes to meet AIP needs?

- ○ Yes (1)
- ○ No (2)

Q9 Please enter the average number of AIP homes you build/retrofit every year.

- ○ Less than 5 (1)
- ○ 5 - 10 (2)
- ○ 10 - 14 (3)
- ○ 15 - 19 (4)
- ○ More than 20 (5)

Q12 Have you installed any Aging in Place (AIP) home-based technologies in your home? (examples are fall detection, floor sensors....)

- ☐ Yes (1)
- ☐ No (2)

Skip To: Q14 If Have you installed any Aging in Place (AIP) home-based technologies in your home? (examples are f... = Yes

---

Q14 If YES, please select from the list of home-based technologies you have installed in within your home.

- ○ Automatic Temperature Thermostats (1)
- ○ Computer Community Outreach (2)
- ○ Vital Sign Tracking (3)
- ○ Assisted Bathing Facility (4)
- ○ Automatic Window Openers (5)
- ○ Daily Pattern Sensors (6)
- ○ Fall Detection Scanner (7)
- ○ Wireless Transceiver Fall Detection (8)
- ○ Telehealth Monitor (9)
- ○ Floor Sensors (10)

Q15 Please rank the home-based technologies from best to worst that are most commonly requested by clients. (1 is best, and 10 is worst)

_____ Automatic Temperature Thermostats (1)
_____ Computer Community Outreach (2)
_____ Vital Sign Tracking (3)
_____ Assisted Bathing Facility (4)
_____ Automatic Window Openers (5)
_____ Daily Pattern Sensors (6)
_____ Fall Detection Scanner (7)
_____ Wireless Transceiver Fall Detection (8)
_____ Telehealth Monitor (9)
_____ Floor Sensors (10)

Q16 Please list the top ten home-based technologies in the order of client satisfaction. (1 is most satisfied, and 10 is least satisfied)

_____ Automatic Temperature Thermostats (1)
_____ Computer Community Outreach (2)
_____ Vital Sign Tracking (3)
_____ Assisted Bathing Facility (4)
_____ Automatic Window Openers (5)
_____ Daily Pattern Sensors (6)
_____ Fall Detection Scanner (7)
_____ Wireless Transceiver Fall Detection (8)
_____ Telehealth Monitor (9)
_____ Floor Sensors (10)

Q17 Please list the top ten home-based technologies in the order of ease of installation. (1 is easiest, and 10 is hardest).

_____ Automatic Temperature Thermostats (1)
_____ Computer Community Outreach (2)
_____ Vital Sign Tracking (3)
_____ Assisted Bathing Facility (4)
_____ Automatic Window Openers (5)
_____ Daily Pattern Sensors (6)
_____ Fall Detection Scanner (7)
_____ Wireless Transceiver Fall Detection (8)
_____ Telehealth Monitor (9)
_____ Floor Sensors (10)

End of Block: Aging in Place Building

Start of Block: Mobility Devices

Q19 Please select the mobility devices that you have installed in AIP homes in the last five years?

- ☐ Stair lift (1)
- ☐ Elevator (2)
- ☐ Wheelchair lift (3)
- ☐ Ceiling track lift (4)
- ☐ Automatic blinds (5)

Q20 Have you installed any other type of mobility devices that is not listed above?

- ○ Yes (1)
- ○ No (2)

Skip To: Q21 If Have you installed any other type of mobility devices that is not listed above? = Yes

Q21 If yes, please provide hte name of the mobility device that you installed in AIP homes.

_____

_____

_____

_____

_____

Q22 Please list the top mobility device technologies in the order of client satisfaction (1 being most satisfied, and 5 being least satisfied)

_____ Stair lift (1)
_____ Elevator (2)
_____ Wheelchair lift (3)
_____ Ceiling track lift (4)
_____ Automatic blinds (5)

Q23 Please list the top five mobility device technologies in the order of ease of installation. (1 is easiest, and 5 is hardest).

_____ Stair lift (1)
_____ Elevator (2)
_____ Wheelchair lift (3)
_____ Ceiling track lift (4)
_____ Automatic blinds (5)

End of Block: Mobility Devices

Start of Block: Client Training

Q26 Do you provide client training as part of your service?

- ○ Yes (1)
- ○ No (2)

Skip To: Q27 If Do you provide client training as part of your service? = Yes

Q27 If yes, when do you provide the training?

- ○ At time of installation (1)
- ○ At time of Punch list (2)
- ○ At time of Closing (3)
- ○ At regular interval during the 1st year (4)
- ○ Any time in the first two years as requested. (5)

Q28 How is the technology being paid for?

- ○ By the client (1)
- ○ By medicade (2)
- ○ By medicare (3)

End of Block: Client Training