PERCEIVED SMART TECHNOLOGY NEEDS AMONG ELDERS WITH MOBILITY IMPAIRMENTS: AN ETHNOGRAPHIC APPROACH

By

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To my parents, brother, and all who nurtured my intellectual curiosity, academic interests, and sense of scholarship making this milestone possible.

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Comparatively little research has been conducted regarding the smart technology needs of the elder population despite the proliferation of smart technology prototypes. The purpose of this study was to explore the perceived smart technology needs of elders with mobility impairments while constructing a preliminary decision tree model of how these decisions are made. An ethnographic research approach, with a decision tree modeling component, was utilized to explore the complex variables surrounding the elder ST need decision process. In-depth individual interviews with 11 elders aged 65 and older with mobility impairments, and their in-home observations, provided insight into how elders perceived smart technology. Audio-taped interviews were transcribed verbatim and then analyzed for key phrases that represented participant decision criteria. Decision criteria concepts were combined to construct an elder smart technology decision tree model.

The model identifies that elder participants must first determine if they are satisfied or not satisfied with their current activity performance level. If satisfied with their activity performance level then the elders do not critically consider the ST device. However, dissatisfaction with current activity level is no assurance that elder participants will desire ST to assist with their daily activity needs, due to the numerous other potential barrier criteria identified in the model

(i.e., not practical, not easy to use/learn, not reliable, or whether it may add more problems). If any of the other barriers are a concern then elders will not desire the ST device. The model also identifies important facilitator criteria (i.e., decreasing imposition on family/friends, increasing sense of autonomy, assisting with difficult tasks, replacing existing technology in order to perform task safely, providing a safety net, and enhancing the monitoring of their health) that could motivate elders to adopt ST assistance. This decision model adds to the elder ST needs literature and potentially will help future designers create appropriately matched technological devices that will assist in the care of aging baby boomers with mobility impairments.

CHAPTER 1
INTRODUCTION

Introduction

This chapter includes three sections. The first section introduces smart technology's potential to help elders and how the private smart technology industry is expected to have a technology boom over the next 20 years. The second section examines the product development cycle and how today's technology devices have not been designed well for elder needs. The third section outlines the purpose of the study and the specific research questions addressed in the study. The last section describes how suited the conceptual model is in exploring the complex nature of an elder's perception of his/her problems and the solutions.

Problem

The potential to help elders ($\geq$ 60 years old) maintain independence has increased extensively with recent advancements in smart technology (Eriksson & Timpka, 2002; Haigh, 2002; Said, 2005). Future smart technology (ST) will assist elders in their homes by providing medication, hydration, and activity reminders; monitoring body temperature, heart rate, sleep patterns; detecting falls; and assisting with meal preparation and transfers (Carnegie Mellon University, 2004; Said, 2005). In the near future elders with mobility impairments (MI) may no longer need a cane or a walker, and instead will don a lower extremity exoskeleton to assist with ambulation (Kawamoto, Lee, Kanbe, & Sankai, 2003). In the distant future high-level quadriplegic patients will benefit from advances in experimental implantable electrode arrays that will allow their mind to control a robotic arm (Duke Med News, 2003, 2004). ST innovation will provide one of the solutions to the growing needs of the aging population.

While early prototype ST is costly and unwieldy, the private sector ST industry of today is expected to have a boom similar to advancements seen over the past 20 years with the personal

computer industry (Kanellos, 2004; Valigra, 2004). With a technology boom there is a projected natural reduction in associated manufacturing costs (Kanellos, 2004; Said, 2005; Valigra, 2004). However at present the mass produced technology products for business and communication have primarily benefited younger cohorts (Eriksson & Timpka, 2002). As a result elders commonly use devices that have not been designed for their needs (Eriksson & Timpka, 2002; Lee & Liao, 2003). For example: cell phone interface designs and feature options are targeted at younger populations (Davenport, Mann, & Helal, 2005; Lee & Liao, 2003; Mann et al., 2004); and software and web page designers continue to use non-elder friendly small font sizes, along with pull down menus that may be difficult for elders with an unsteady hand to navigate (Becker, 2004). Commonly, designers choose to address the physical interface problems of their products, while failing to address the underlying design needs for the elder population. For instance while designers of the web interface for the new Medicare Part D prescription drug program included both an alternative larger font and screen reader versions (Centers for Medicare & Medicaid Services, 2006), elders found the overall web interface to be confusing and frustrating, which deterred many from enrolling in the new federal government prescription drug program (Alonso-Zaldivar, 2005; Basler, 2006; Eastern Virginia Medical School, 2006). To avoid future technology-person mismatches a better understanding of ST design needs of the elder population is essential.

Product development is costly and it takes a long time to bring a product to market, with no guarantee that the technology will not become obsolete during the development cycle (Dekker, Nyce, & Hoffman, 2003). Therefore designers must decide on the amount of time and resources that will be invested in research during the development cycle. Figure 1-1 illustrates

where user research (needs analysis and prototype evaluation) could be used to improve product design and validate design choices (Anderson, 2001; Fleck, 2002).

As Figure 1-1 illustrates the product development cycle ideally begins with needs analysis research, however developers typically end up investing a majority of resources during the prototype evaluation phase. Path A in Figure 1-1 illustrates how usability testing can be used to guide the refinement of a prototype's design. Usability testing (Path A) is ubiquitous in the ST literature and typically involves quantitatively evaluating the interaction between the user and prototype. Path B illustrates how needs analysis research could be used to provide guidance for major revisions if a product has been released and receives exceedingly poor usability ratings. Needs analysis research can help reveal any missed consumer needs and guide development of future prototype concepts (Anderson, 2001; Fleck, 2002). A resourceful way to avoid major problems late in the development process is to initially perform a comprehensive needs analysis to gain clues on any unmet needs and how to address the needs (Anderson, 2001). However the problem lies in the fact that there is a deficiency of needs analysis research on what prototypes should be created in the ST literature, particularly pertaining to the needs of the elder population (Baillie, 2003; Mihailidis, Cockburn, & Longley, 2005).

Purpose

The purpose of this study was to explore the perceived smart technology needs of elders with mobility impairments while constructing a preliminary decision tree model of how these decisions are made. The three research questions in this study were:

- **Research Question 1:** What do elders with MIs perceive as their areas of difficulty in maintaining independence?
- **Research Question 2:** Which ST(s) do elders with MIs perceive as solutions (or encumbrances) in helping maintain their independence?

- **Research Question 3:** How do elders with MIs make decisions in choosing which ST is needed or not needed?

Conceptual Framework

A conceptual model recognized in rehabilitation science was utilized to provide a basis for exploring the various health, psychosocial, and environmental factors surrounding the perceived ST needs of elders with MIs. The World Health Organization International Classification of Functioning, Disability and Health (ICF) model was used as the framework for this study (Schneidert, Hurst, Miller, & Ustun, 2003). The ICF model was well suited to explore the complex nature of an elder's perception of problems and the solutions. The ICF model classifies disability as a dynamic multidimensional phenomena (Schneidert et al., 2003; World Health Organization, 2001). This dynamic nature of the ICF model assisted when exploring elders with MIs perception of their areas of difficulty in maintaining their independence (research question 1). Figure 1-2 illustrates where the research questions 1-3 fit into the ICF model.

The ICF is able to document a barrier whether located at the body structure, activity limitation, or participation restriction level (Schneidert et al., 2003; World Health Organization, 2001). If the solution to a barrier is perceived to be at the environmental level it can be documented within the contextual factors component of the ICF model (research question 2). For example if a participant cited difficulty climbing stairs, a robotic walking aid may be perceived as a solution to this activity.

The dynamic nature of the ICF model assisted in exploring how elder participants made decisions in choosing which ST device was needed or not needed (research question 3). The ICF was able to illustrate how a smart technology device may be affected by the various component areas (i.e., body structure or function, the impact of personal factors, and an individual's

immediate or surrounding environment) of the ICF model. For example when a participant is deciding if a robotic walking aid device is needed, the ICF model illustrates that the participant's decision could be affected by either the body structure component area in the form of a previous stroke, or the personal factors component area in the form of a perceived stigma associated with wearing the robotic walking aid. The multidimensional nature of the ICF model was one of the primary reasons it was chosen as the overall conceptual framework for this study.

Summary

Smart technology is being looked towards as a possible solution to the growing needs of our aging population. At present there is a deficiency of needs analysis research on what ST prototypes should be created, particularly pertaining to the needs of the elder population. Further exploration is needed into how elders perceive their ST need. This study explored the perceived smart technology needs of elders with mobility impairments and constructed a preliminary decision tree model of how these decisions were made. The decision model will add to the elder ST needs literature and potentially will help future designers create appropriately matched technological devices that will assist in the care of aging baby boomers with mobility impairments.

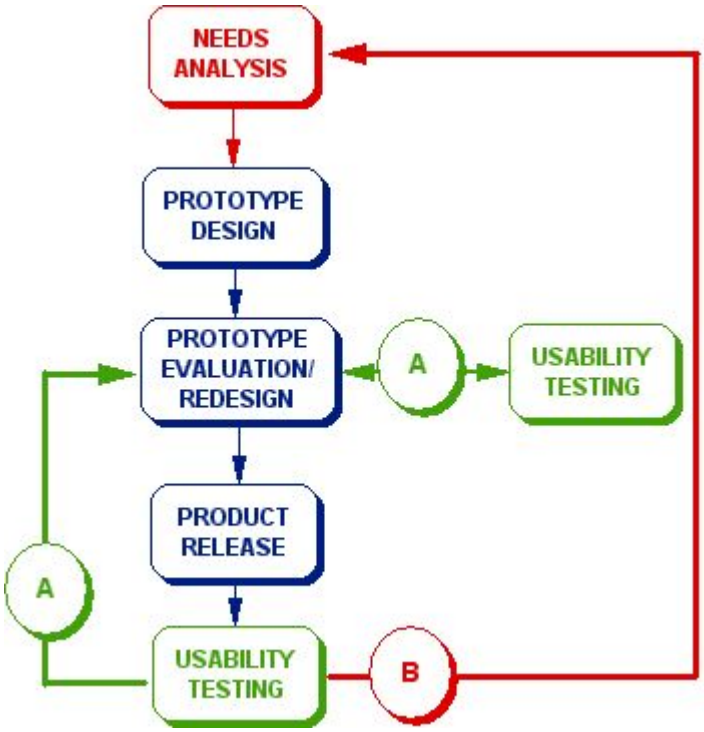

Figure 1-1. User research in product development cycle. [Adapted from Anderson, G. (2001). *Making use of user research.* Retrieved July 20, 2006, from http://www.cooper.com/newsletters/2001_09/making_use_of_user_research.htm.]

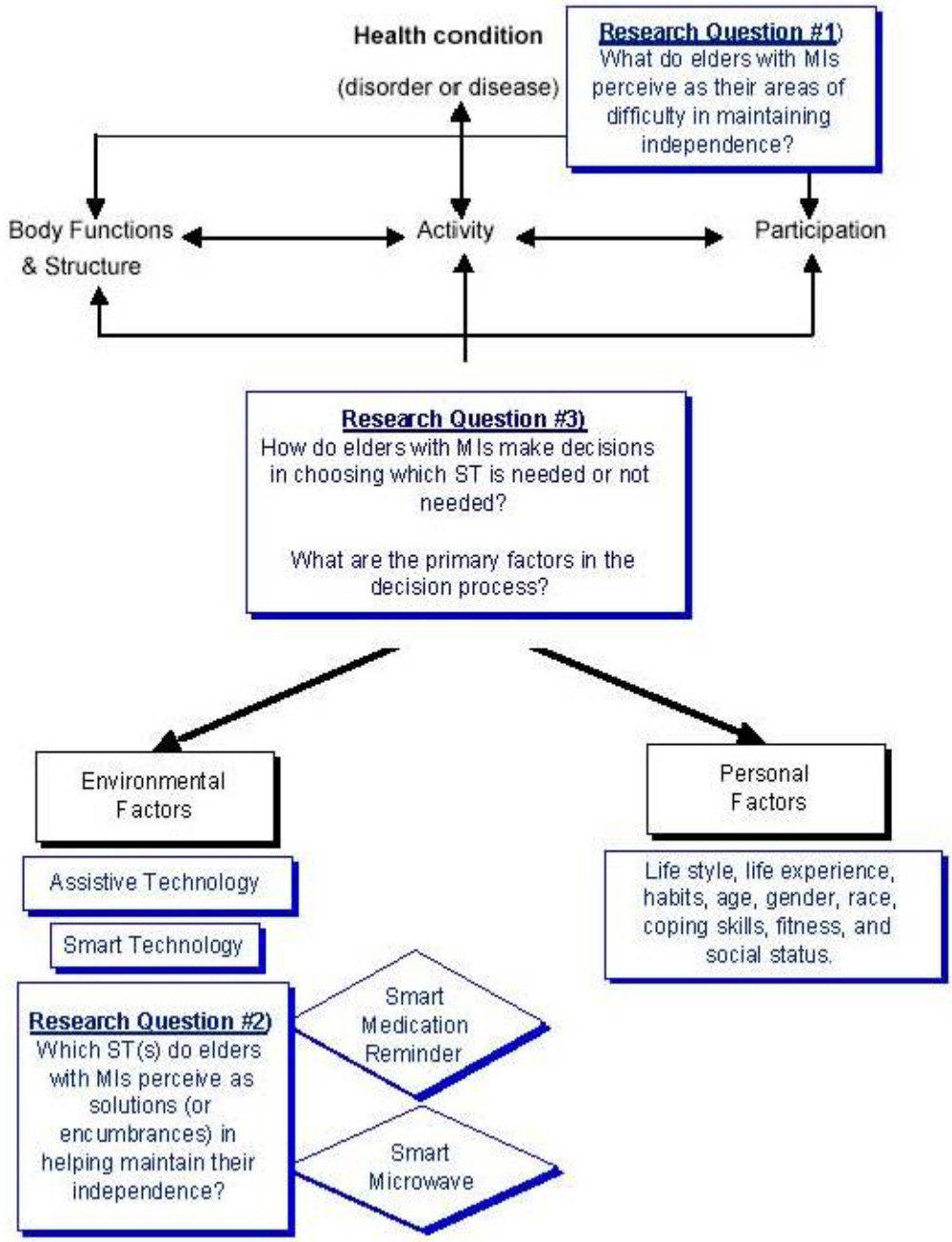

Figure 1-2. Research questions 1, 2, and 3 inputted into the ICF Model.

CHAPTER 2
REVIEW OF LITERATURE

Introduction

This review focuses on the issues related to smart technology. This chapter reports on the various terms associated with smart technology (including assistive device and assistive technology); emergence and definition of the term ‘smart technology’; and multiple definitions of ‘smart home technology’. It also looks at the state of smart technology development around the globe, including both commercial and university-based smart technology ventures. The chapter concludes with a review of needs analysis research that focuses on prototype smart technology development.

Assistive Technology

Assistive technology (AT) and assistive devices (AD) have multiple meanings in the literature (Mann, Hurren, Tomita, & Charvat, 1995). This study will use the term AT as entailing a “broad range of devices, services, strategies, and practices that are conceived and applied to ameliorate the problems faced by individuals who have disabilities” (Cook & Hussey, 2002, p. 5). The specific definition used in the 1998 Assistive Technology Act Public Law 105-394 states an AD is, “any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities” ("Assistive Technology Act," 1998). The Assistive Technology Act broadly defines the term AD, and what might be an AD for one person may not be considered an AD for another person. An oversized universal remote control or large button telephone may be considered a standard product marketed to the general public (the oversized buttons would be viewed as a convenient feature). However an elder individual with fine motor impairment would consider the same oversized universal remote control or large button telephone an AD. ADs and

the application of the devices are unique to every circumstance (Cook & Hussey, 2002). Therefore ADs are challenging to categorize (Cook & Hussey, 2002). This study will potentially explore many forms of ADs, therefore the more global term AT will be utilized.

One way researchers have attempted to categorize AT is by grouping them as either 'high' or 'low' tech. This clarification scheme reflects the rapid advancement of electronic technology over the past two decades (Cook & Hussey, 1995). The number of AT that employ electronics has increased while the cost has decreased (Cook & Hussey, 1995). Low technology devices are typically simple to create and easy to acquire (Cook & Hussey, 1995). High technology devices are often high-priced, more challenging to make, and more difficult to acquire (Cook & Hussey, 1995). Examples of low-tech AT are transfer benches, sock aids, modified eating utensils, and communication boards. Examples of high-tech AT are powered wheelchairs, electronic communicative devices, and environmental control units. A rapidly growing sector of AT is in the field of smart technology (Eriksson & Timpka, 2002; Said, 2005).

Smart Technology

The term smart technology (ST) is said to have emerged during the early 1980s when researchers working within the United States defense system were combining computer systems with advanced sensors and materials (Goddard, Kemp, & Lane, 1997). These compact computer systems could monitor their environment in real-time and independently counteract (Goddard et al., 1997). While the technology has improved since the 1980s the definition of ST still remains imprecise (Goddard et al., 1997; Worden, Bullough, & Haywood, 2003) and at times is used strictly for marketing purposes (Worden et al., 2003). After considerable research of the literature databases: (ISI Web of Knowledge), (National Library of Medicine and the National Institutes of Health), (CINAHL Information Systems), (IEEE Publications Online), (Association for Computing Machinery), (CiteSeer), (NetLibrary), (Books24x7), and online websites: online

technology dictionaries and smart technology related websites, only a few definitions of ST were discovered. Caldwell (2001) globally defines ST, as a "design philosophy concerned with integrating materials, sensing, processing, actuation and control into structures which should be able to adaptively respond to their environment to optimize their operating conditions" (p. 965). Worden (2003) stresses that in order to be classified as smart technology the devices should "possess an awareness of their situation….capable of reacting to it" (p. 1). For the purposes of this study Goddard's 1997 categorization of the term ST will be utilized. Goddard (1997) classifies ST as any enabling technologies that intermingle to produce a 'smart structure'. Goddard defines all structures, such as actuators, sensors, control hardware, control algorithm, and structural members, that assist a structure in becoming aware and automatically optimizing and reacting as smart technology (Figure 2-1) (Goddard et al., 1997).

Goddard emphasizes that there are not any commercially available 'smart structures' on the market and for a structure to be classified as smart it must have the ability to improve "its performance over years of adapting to changes in its environment by learning from past operating experience" (1997, p. 131). While there are not any smart structures in product form, there are plenty of ST that can intermingle to produce structures that are moving closer to meeting the definition of a smart structure. For example ST exists in: automobiles that can sense an object in its path and alerts the driver by beeping or shaking the drivers seat (McCormick, 2005); movie theaters that can detect how many people are in the theater with carbon-dioxide detectors and automatically adjust the climate controls, as well as automatically be notified if bathroom supplies are low (Dyer, 2006); and elementary schools that can automatically take attendance and monitor bathroom use with radio frequency identification (RFID) tags (Bradner,

2005; Gibbs, 2005). The remainder of this literature review will concentrate on the broad range of ST that can be applied in the home to assist elders in their daily tasks.

Smart Home Technology

While definitions of ST may be insufficient, definitions of ST for the home are reported more frequently in the literature. Table 2-1 documents various definitions of smart home technology.

For the purpose of this study smart home technology was defined as any ST (including but not limited to actuators, sensors, computer processors/software, and supporting structures) that creates an integrated home capable of monitoring and supporting residents in real-time. This study focused on ST that can assist elders with mobility impairments (MI) in their homes whether the technology was limited to the infrastructure of the home (fall detection system) or moves with the resident (powered smart walker/scooter). Therefore the terms smart technology and smart home technology were used interchangeably.

State of Smart Technology Development

We can expect commercial ventures in connection with smart home technology to extensively grow over the next few years and expand into mainstream population. This can already be seen in the private smart home residences constructed in Roanoke, Virginia (Lawson, 2003; Zurier, 2003) and Stockholm, Sweden (Electrolux, 2005; Giesecke et al., 2005) where residents can remotely control their home through the internet. Residents at the IT Condominiums, in Stockholm Sweden can utilize a terminal with a touch screen, or a personal computer for food management (including shopping and meal preparation); access a family calendar system for scheduling activities of all family members; and access the safety and security systems that detect and reports fires, water leakage, and intruder alarms (Electrolux, 2005; Giesecke et al., 2005). Commercial ventures by assisted living facilities have already

begun to incorporate ST into their care management, as seen in Miwaukie, Oregon (Elite Care, 2006). Residents and staff wear a small locator badge clipped onto their clothing to help record response time of staff-to-resident request to ensure timely responses. Resident's weight, sleep patterns, movements and interactions with other residents are collected and family members can monitor this data via secure web portal (Elite Care, 2006).

Commercial companies are joining together to develop and test smart home technologies and have built demonstration smart homes in Duisburg, Germany (inHaus, 2006), Eindhoven, The Netherlands (Philips, 2006), and Hunenberg, Switzerland (FutureLife, 2006). The largest of the three commercial smart home technology collaborations is in Hunenberg, Switzerland where over 60 companies have installed prototype and product smart technology in the FutureLife Smart Home (FutureLife, 2006). A family of four have been residents of this home and have been evaluating it for the last 5 years. The house includes: a smart refrigerator that is able to download recipes and cooking programs from the internet; a solar powered lawnmower that follows an underground induction loop that autonomously cuts the grass; an automatic door opening system that recognizes a chip in the resident's wrist watch and opens and locks the door automatically; sensors throughout the house where voice commands can prepare the room for TV viewing by lowering the blinds, closing the curtains, dimming the lights, and lowering a projector; and appliance sensors that can send messages to the residents when the washers spin cycle or dryer is done (FutureLife, 2006).

While the commercial ventures in smart home technology have been increasing, the majority of ST research has primarily been conducted by university-based institutions. At Georgia Institute of Technology's Aware Home researchers are developing prototype smart home technology systems to assist elders with impairments including: a Gesture Pendant with an

embedded wireless camera that can translate simple hand motions made to control house functions; Cook's Collage that utilizes cameras placed in specific locations to record steps performed when preparing a meal or doing laundry and, when prompted, displays the last few steps performed so the resident would be aware if the detergent was already been inserted or a cup of flour was already added; and Digital Family Portrait that displays daily activity performed by an elder resident in the form of various icons on a digital picture frame so family members at another location can check in on their family members by viewing this portrait in their home (Georgia Institute of Technology, 2006; Mynatt, Melenhorst, Fisk, & Rogers, 2004).

At University of Virginia Medical Automation Research Center's Smart House researchers are developing a sensor suite and data analysis system that can gather activity and health status of elder residents. Wireless sensors on stove-top, bed pad, shower, and a floor vibration sensor sends information to computer-based data manager where caregiver or family can monitor resident's behavior. Researchers have constructed a 3.5 lb. prototype fall detector that when placed on the floor can distinguish between a person falling and a 5-15 lb. object that has been dropped.

At University of Rochester's Smart Medical Home researchers are developing systems that can potentially detect resident's symptoms before the resident is aware, thereby providing support before a crisis arises (Medical Automation Research Center, 2006). By installing accelerometers, gyroscopes, and RFID sensors that monitor speech patterns, breathing patterns, computer mouse activity, body motion, and gait patterns, early detection of a health condition could be successful (Medical Automation Research Center, 2006).

At MIT's PlaceLab sensors are located throughout an apartment which can detect whether an object is moved, opened/closed, turned on/off, and also detect resident's limb motion with

wearable accelerometers (Massachusetts Institute of Technology, 2006). A resident's activities and behaviors can be recorded with one of the 9 infrared cameras, 9 color cameras, and/or 18 microphones distributed throughout. Researchers are working on a prototype system that promotes healthy lifestyles in the home. These prototype systems use social science and behavioral science techniques to motivate change in a resident's behavior (Massachusetts Institute of Technology, 2006).

At University of Colorado's Adaptive House researchers are developing a system that will 'program itself,' therefore no speech input, hand gesturing, gaze tracking, touch pad interfaces are used in the home (Mozer, 2005, 2006). Over 75 sensors monitor indoor/outdoor temperature, ambient light, audio level, movement in home, and door/window position. The house attempts to learn and anticipate the resident's needs and automatically sets the HVAC (heating, ventilation, and air conditioning), water heater, and interior lighting levels (Mozer, 2005, 2006).

The ST field is expanding and progressing rapidly both in the private and university-based sectors. Researchers are looking towards smart home technology as one of the solutions to the projected strains on the healthcare system during the future population shift (Eriksson & Timpka, 2002; Said, 2005). An important role of university-based research will be to address the need for further user research exploring the prototype ST needs of the elder population.

For this study ST development research has been divided into five component areas:

- Remote control technologies - (voice activated: lights, blinds, and temperature)
- Automation technologies - (automated: microwave, temperature, safety lighting)
- Monitoring technologies - (vital signs, falls, security, and activity/sleep patterns)
- Prompting/Reminding technologies - (physical exercise, medication management, and diet choices)

- Prediction technologies - (behavior learning and early detection of health conditions).

An extensive review of the state of smart technology development is summarized in Table 2-2. Table 2-2 categorizes each example of ST development research, by the five technology component areas listed above, in both the private sector and university settings around the world.

Prototype Smart Technology Development

In trying to provide a better technology-person match, developers typically conduct studies (interviews, surveys, focus groups, field trials, lab testing, live-in trials, etc.) to evaluate prototypes during the development process. Prototype trials have been conducted on: intelligent thermostats (Freudenthal & Mook, 2003), smart front door reminder systems (Kim, Kim, Park, Jin, & Choi, 2004), smart shirts (Shant, 2006), exoskeletons (Kawamoto, Lee, Kanbe, & Sankai, 2003), robotic home personal assistants (Carnegie Mellon University, 2004; Rotstein, 2004), infrared home health monitoring systems (Banerjee, Steenkeste, Couturier, Debray, & Franco, 2003; Ohta, Nakamoto, Shinagawa, & Tanikawa, 2002), tele-surveillance sensors in care rooms (Banerjee et al., 2003), tele-health home monitoring and educating devices (Kobb, Hoffman, Lodge, & Kline, 2003), a virtual health counselor (Kaplan, Farzanfar, & Friedman, 2003), and robotic home companion pets (Libin & Libin, 2003; Omron, 2001; Wada, Shibata, Saito, & Tanie, 2002, 2003). The majority of ST literature centers on prototype evaluations.

In 2004 consumers evaluated five prototype smart technology devices at Georgia Tech (Mynatt et al., 2004). Forty-four elder participants, who were ‘living independently’ (no demographics on disability status were reported) were given individual tours of Georgia Tech’s Broadband Institute Residential Laboratory-The Aware Home followed by a structured interview (Mynatt et al., 2004). While the tour showcased 5 prototype smart technology devices only 3 were discussed in the manuscript: 1) Gesture pendant - simple hand motions interpreted by a pendant that can control blinds, doors, lights, and a thermostat, 2) Cook’s Collage - cameras

placed in specific locations to record steps performed when preparing a meal or doing laundry and when needed could display the last few steps performed so the resident would be aware if the detergent was already placed or a cup of flour was already added, and 3) Digital Family Portrait - digital picture portrait displays daily activity performed by an elder resident in the form of various icons (up to 4 weeks of data can be displayed). A family member at another location could check in on their family member by viewing the digital portrait located in their home.

While the authors obtained data on the elder participants' perception of Georgia Tech's Aware Home prototype ST that have already been created, they did not specifically explore the participants' need for any further ST devices to be created. In fact the authors discovered that most of the elders felt the existing Gesture Pendant may be good for them in the future but not needed now. The authors acknowledge the complexity of the elder rationale when deciding if the existing prototypes at Georgia Tech were desirable. At times elders were willing to trade off privacy concerns for a device that would allow for more independence in their home, but at the same time they would easily reject a device due to concerns of over reliance on technology. Future research resources may be conserved if a thorough needs assessment study determines that elders are resistant to specific ST devices due to concerns of over reliance.

While the prototype evaluation phase can involve the consumer in the design process, typically it is only after the initial concept and working prototype has been established. Usually after the prototype has been created too many resources have been committed to scrap the overall concept (if needed) and to construct a ST application in a new direction (Dekker, Nyce, & Hoffman, 2003; Woods & Dekker, 2000). Therefore the prototype evaluation phase is typically limited to investigating the ergonomics or usability aspect of a prototype and not able to fully

reevaluate the overall concept of the ST. Woods (2000) reinforces the dilemma of involving the user at the later stages of prototype development when stating:

> Late testing studies are not able to tell developers how to use those degrees of freedom to create useful and desirable systems. The problem in design today is not can it be built but rather what would be useful to build given the wide array of possibilities new technology provides. (p. 275)

Baillie (2003) reports this has been a longstanding issue, stating:

> The call from the early 1980s to include users in design has still not been heeded. What we see in the household is exactly the problems we have seen and continue to see in the workplace. For that reason the home is likely to become a crucial proving ground for all those interested in developing a HCI (human computer interaction) that includes users as full partners in the design process. (p. 42)

Inadequate user involvement prior to the conception of the prototype creates an environment where technology is the principal guiding force in product development cycle, which can lead to countless person technology mismatches.

Mihailidis (2005) interviewed 15 baby boomers (born between 1946-1965) and 15 elders (aged 65 and older) to explore: their willingness to accept smart home technology, which types of smart home technology they preferred, and if there was difference between groups. An overall trend of higher acceptability/willingness scores were noted by the baby-boomer group. Their top five device areas were: health monitoring devices(100%), environmental control units(100%), personal emergency response system(85%), fall detection(78%), and lifestyle monitoring(62%) (Mihailidis et al., 2005). The top five device areas the elder group was willing to have in their home were: personal emergency response system(90%), health monitoring devices(80%), environmental control units(78%), fall detection(64%), and lifestyle monitoring(54%). These results suggest that baby boomers and elders most prefer to have environmental control units, personal emergency response systems, and health monitoring devices, which could be designed and built into smart homes. However Mihailidis points out further exploration is needed into the

rationale (perceived abilities, previous falls, loneliness/death) that was given for choosing one device over another (Mihailidis et al., 2005). Exploring the elder's attitudes and perceptions further would potentially help developers determine their ST needs and what device would match that need.

Mihailidis also relates suggestions for developers of future smart home technology:

- keep cost low
- keep devices small, discreet, and comfortable
- keep maintenance low
- allow user control
- follow principles of universal design
- protect privacy from outside intruders
- minimize false alarms and ensure technical support available
- have a back-up system in the event of power failure (Mihailidis et al., 2005).

However these concrete suggestions primarily focus on cost and usability and do not add to the needed literature on revealing which prototypes need to be created.

Demiris et al. (2004) used a focus group format when evaluating 15 elder participants' perceptions and expectations toward smart home technologies. Three focus group sessions (six, five, and four participants) each lasting 1-hour were conducted. The focus groups explored residents' (in a continuing care retirement facility) perspectives on future smart home applications (Demiris et al., 2004). Demiris (2004) reports potential elder smart home technology needs as:

- Emergency help
- Assistance with hearing and visual impairment
- Prevention and detection of falls
- Temperature monitoring
- Automatic lighting
- Monitoring of physiological parameters (e.g., blood pressure, glucose levels)
- Stove and oven safety control
- Property security
- Intruder alarm
- Reminder system announcing upcoming appointments or events

- Timely and accurate information on adverse drug events and contraindications. (p. 91)

Demiris reported five areas of concern expressed by elder participants on smart home technologies:

- Possible privacy violation resulting from the use of cameras
- Lack of human responders or possible replacement of human assistance by technology
- The user-friendliness of the devices, and
- The need for training tailored to older learners. (p. 91)

Participants also revealed privacy concerns regarding the use of cameras within their homes to detect falls or other accidents (Demiris et al., 2004). However elders felt that if the data being collected by the camera was in the form of a shadow or movement without identifying characteristics then privacy would not become an issue (Demiris et al., 2004). All participants had positive attitudes toward having smart technology enhance their lives (Demiris et al., 2004). The author noted that this sample may be more accepting of technology in their everyday lives due to 97% of participants currently used personal computers in their home and 66% regularly used their computers for surfing the Internet and sending emails. The elder group revealed that they might not be representative of their older friends; stating that some of their friends may not welcome technology into their homes as easily. The group suggested installing non-obtrusive devices that do not require users to operate or control them (such as automatic sensors).

Demiris was able to compile a list of smart technology areas elders perceive as important, such as providing for emergency help, detection of falls, automatic lighting, security, and oven control. However in agreement with previous research conclusions by Mynatt (2004) and Mihailidis (2005) further exploration of how the elder participants came to choose this list of ST is of most importance. The themes (surrounding the elder ST need decision process) that have been reported in this (prototype ST development) literature section have been integrated into the

ICF model and are illustrated in Figure 2-2 (Demiris et al., 2004; Mihailidis et al., 2005; Mynatt et al., 2004).

Summary

Scores of commercial companies are joining together to develop and test ST devices. Commercial ventures in connection with ST are expected to extensively grow and expand into mainstream population. Presently there are very few studies addressing the deficiency of needs analysis research on what ST prototypes should be created, particularly pertaining to the needs of the elder population. An important role of university-based research is to address the need for further user research exploring the prototype ST needs of the elder population. The existing elder needs analysis literature has made recommendations for further exploration into how elders perceive their ST need. At present the terminology cited in the literature is very limited. Terms such as ‘favorable’, ‘open to the idea’, ‘convenient’, ‘willingness to accept or have in home’ is frequently used to describe elder ST need. However these terms do not fully capture the elder ST need decision criteria. Constructing a preliminary decision tree model of how elders make ST need decisions may assist future designers in creating appropriately matched technological devices.

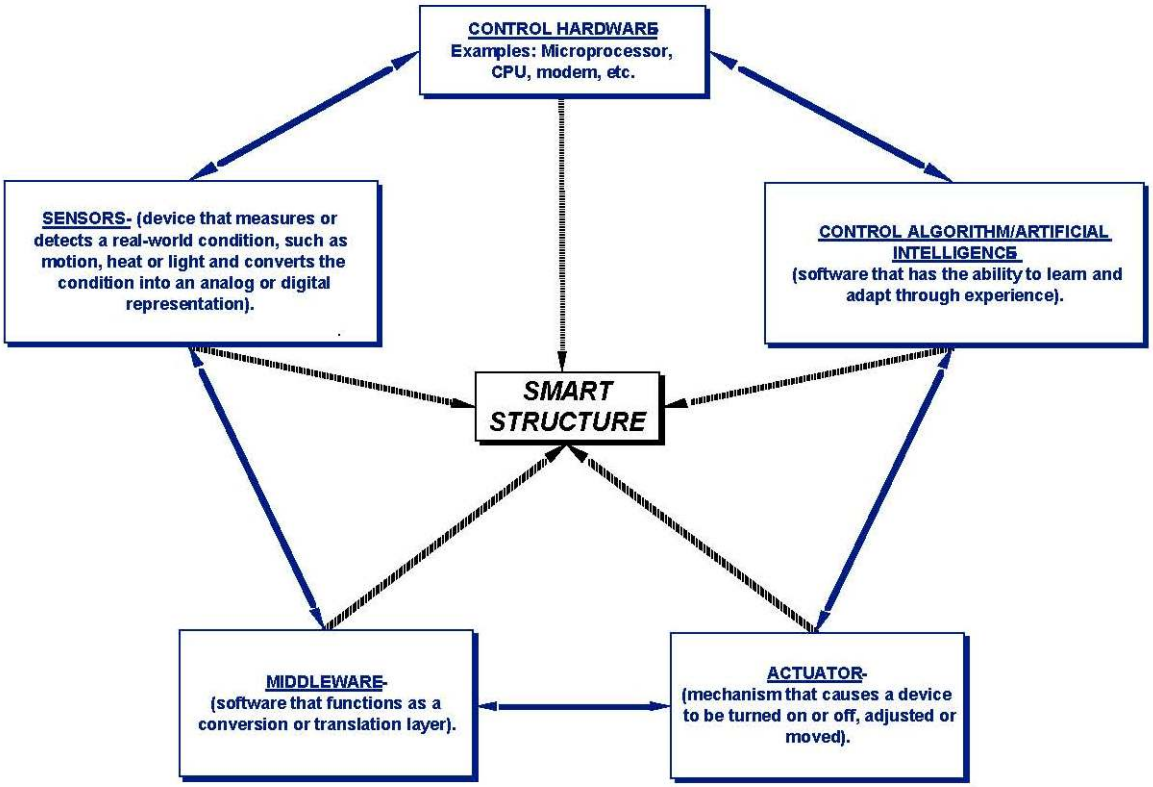

Figure 2-1. Example elements of smart technology that produce a smart structure. [Adapted from Goddard, N., Kemp, R., & Lane, R. (1997). An overview of smart technology. Packaging Technology and Science, 10, 129-143 (Page 132, Figure 1).]

Table 2-1. Smart home technology definitions

Source	Description/definition -smart home technology
Medical engineering and physics journal	The term 'Smart House' is commonly used to refer to a living or working environment, carefully constructed to assist people in carrying out required activities, using various technical assistive systems. This idea can be applied to the needs of a wide range of people, but presents particular potential benefits to elderly, or handicapped people. (Allen, 1996, p. 203)
Scottish government publication	In most homes, heating, lighting, security and entertainment systems all operate independently. Smart technology brings these systems together through a communication network providing new ways of managing and living in the home. Such inter-linked command and control systems have been extensively used in commercial buildings for years but have only recently started appearing in the home. (Scottish Executive, 2005, p. 54)
Information technology online resource	"A home that is highly automated. It uses a common network infrastructure for lights, appliances and other devices" (TechWeb, 2006).
Scottish environmental design research center paper	Homes that contain devices that are able to operate complex tasks that are pre-programmed either into the devices themselves (via a bus line) or through a computerized operating system (X10). (Dewsbury, 2001, p. 4)
Artificial intelligence conference workshop	Systems that have sensors and actuators that monitor the occupants, communicate with each other, and intelligently support the occupants in their daily activities. For elders, tasks can range in complexity from reminders to take medication to monitoring the general deterioration in functional capacity. (Haigh, 2002, p. 40)

Table 2-2. Smart technology development around the world categorized by the five technology component areas

Name/location	Structure description	Technology component	Description of smart technology development
Commercial ventures			
Blueroof Technologies, McKeesport, Pennsylvania (Blueroof Technologies, 2006; Carnegie Mellon University, 2005).	3 free standing single-storied model smart homes completed. Buyers have 4 styles of smart cottages to choose.	Remote control:	Handheld remote control interface, personal computer (PC) interface, and remotely control home via internet portal.
		Automation:	Appliances, lighting, keyless entry, heating ventilation air conditioning (HVAC), backup natural gas generator, and, security.
		Monitoring:	Security, water leaks, and personal emergency response system (PERS). Internet capable cameras in home and at front door.
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.
e2-home ITcondominiums, Ringblomman, Stockholm, Sweden(Electrolux, 2005; Giesecke et al., 2005).	59 private residence condominiums.	Remote control:	Touch screen, personal computer (PC), and remotely control home via internet portal.
		Automation:	Lighting, heat, and, security.
		Monitoring:	Security front door camera and smoke/fire.
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.
Oatfield Estates, Miwaukie, Oregon (Elite Care, 2006).	Six assisted living smart homes housing 68 elder residents.	Remote control:	Touch screen utilized by resident to check daily weather, facility activities, email, and call for assistance.
		Automation:	Doors auto open (via verification by infrared/RFID pendant)
		Monitoring:	Staff utilizes touch screen to monitor weight/sleep pattern (recorded via bed sensors). Tracks resident's activity in room and on grounds (via bracelet). Family members remotely monitor resident activity patterns, vital signs, and track response time of staff via internet portal.
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.

Table 2-2. Continued

Name/location	Structure description	Technology component	Description of smart technology development
Commercial ventures			
Blueroof Technologies, McKeesport, Pennsylvania (Blueroof Technologies, 2006; Carnegie Mellon University, 2005).	3 free standing single-storied model smart homes completed. Buyers have 4 styles of smart cottages to choose.	Remote control:	Handheld remote control interface, personal computer (PC) interface, and remotely control home via internet portal.
		Automation:	Appliances, lighting, keyless entry, heating ventilation air conditioning (HVAC), backup natural gas generator, and, security.
		Monitoring:	Security, water leaks, and personal emergency response system (PERS). Internet capable cameras in home and at front door.
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.
e2-home ITcondominiums, Ringblomman, Stockholm, Sweden(Electrolux, 2005; Giesecke et al., 2005).	59 private residence condominiums.	Remote control:	Touch screen, personal computer (PC), and remotely control home via internet portal.
		Automation:	Lighting, heat, and, security.
		Monitoring:	Security front door camera and smoke/fire.
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.
Oatfield Estates, Miwaukie, Oregon (Elite Care, 2006).	Six assisted living smart homes housing 68 elder residents.	Remote control:	Touch screen utilized by resident to check daily weather, facility activities, email, and call for assistance.
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		Monitoring:	Staff utilizes touch screen to monitor weight/sleep pattern (recorded via bed sensors). Tracks resident's activity in room and on grounds (via bracelet). Family members remotely monitor resident activity patterns, vital signs, and track response time of staff via internet portal.

Table 2-2. Continued

Name/location	Structure description	Technology component	Description of smart technology development
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.
Village at Tinker Creek in Roanoke, Virginia (Lawson, 2003; Village at Tinker Creek, 2006; Zurier, 2003).	20 free standing private residence smart homes in a 170-unit development.	Remote control:	Remotely control home via internet portal.
		Automation:	Lighting, heating ventilation air conditioning (HVAC), and security.
		Monitoring:	Appliance, gas meter, panic button, and indoor web cameras.
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.
Demonstration/ Model Homes Non-University-Based			
FutureLife Smart House, Hunenberg, Switzerland (FutureLife, 2006).	Live-in/ development/ demonstration 3-story smart home *Past 5-years have had a family of four permanently residing in the smart home.	Remote control:	Voice interface, touch screen, smart phone, and smart car remotely control the house.
		Automation:	Lighting, blinds, curtains, auto open/close windows, keyless auto front door, saves preferred shower water-temperature, smart refrigerator that is able to download recipes and cooking programs from the internet, and a solar powered lawnmower that follows an underground induction loop.
		Monitoring:	Washing machine that notifies resident when washer spin cycle is done.
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.
HomeLab, Philips, Eindhoven, The Netherlands (Philips, 2006).	Live-in/ development/ demonstration smart home.	Remote control:	Voice interface, gesture recognition, interactive mirror (allows you to check the traffic/weather condition, examine your weight, try different hairstyles, and both show your backside or magnify).
		Automation:	Lighting and blinds.

Table 2-2. Continued

Name/location	Structure description	Technology component	Description of smart technology development
		Monitoring:	Resident tracking via sensors in carpet, participants live in the house between 1-14 days to test prototype smart home technology. Researchers observe participants through two-way mirrors, cameras, and with microphones.
		Prompting/ reminding:	A virtual fitness coach that monitors physiological data while calculating intensity and provides encouragement to meet exercise goals. A robot cat assistant in kitchen that monitors resident's weight, daily activity, personal preferences and gives exercise and diet suggestions.
		Prediction:	None reported on home website.
Independent LifeStyle Assistant, Honeywell Laboratories, Minneapolis, Minnesota (Honeywell, 2006).	Development -of smart home automation systems.	Remote control:	Touch screen, web pad, and remotely control home via internet portal.
		Automation:	Door lock, lighting, thermostat, water flow, and prepare grocery list.
		Monitoring:	Mobility, falls, toileting patterns, temperature, camera, infrared, blood pressure, heart rate, glucose level, medication use, eating patterns, pressure pads, microphone, monitor cognitive decline, fires, burns, and poisoning.
		Prompting/ reminding:	Medication use, health care appointments, plan nutritionally balanced meals.
		Prediction:	An alert is sent when elder is behaving in an unusual way (not taking medications, wandering, not moving).
The Intelligent House Duisburg Innovation Center - (inHaus), Duisburg, Germany (2006).	Development/ demonstration smart home - includes a residential home, with a workshop, and networked	Remote control:	Touch screen, PC, smart car, and remotely control home via internet portal.
		Automation:	None reported on home website.
		Monitoring:	Appliances (including pantry/refrigerator tracking contents/expiration dates), fire, water leaks, and humidity.
		Prompting/ reminding:	None reported on home website.

Table 2-2. Continued

Name/location	Structure description	Technology component	Description of smart technology development
	car/garden.	Prediction:	None reported on home website.
Demonstration/ model homes university-based			
Adaptive House, University of Colorado, Boulder, Colorado (Mozer, 2005, 2006).	Live-in(principle investigator's residence) /Development/ demonstration 4 room smart home.	Remote control:	Opposes any alternative interface (including voice, gesture, and touch screen).
		Automation:	Lighting, ceiling fans, furnace, space heaters, water heater.
		Monitoring:	Over 75 sensors monitor indoor/outdoor temperature, ambient light, audio level, movement in home, and door/window position.
		Prompting/ reminding:	None reported on home website.
		Prediction:	The house attempts to learn and anticipate the resident's needs and automatically sets the HVAC, water heater, and interior lighting levels.
Aware Home, Georgia Institute of Technology, Atlanta, Georgia (Georgia Institute of Technology, 2006; 2004).	Development/ demonstration three-story, 5040-square-foot smart home.	Remote control:	Gesture and touch screen.
		Automation:	Lighting, blinds, keyless entry/automatic front door, and HVAC.
		Monitoring:	Family members remotely monitor resident activity patterns, vital signs via internet portal picture frame. Cameras placed in specific locations to record steps performed when preparing a meal or doing laundry.
		Prompting/ reminding:	When prompted, displays the last few steps of select tasks performed so the resident would be aware (i.e., if the detergent was already placed or a cup of flour was already added).
		Prediction:	Monitoring hand gestures possible prediction of Parkinson's disease.
GatorTech Smart House, University of Florida, Gainesville, Florida (RERC on	Live-in/ development/ demonstration one-story, 2,400-	Remote control:	Voice, touch screen, PDA, and remotely control home via internet portal/smart phone.
		Automation:	Lighting, blinds, keyless entry/automatic front door, and auto-program microwave.

Table 2-2. Continued

Name/location	Structure description	Technology component	Description of smart technology development
Technology for Successful Aging, 2006).	square-foot, 3-bedroom smart home.	Monitoring:	Tracking resident's movement and falls (via floor sensors), mailbox, microphone/camera at front door, body weight, temperature, water leak, toilet paper, water temperature, soap dispenser, and bed sensors monitor sleep patterns.
		Prompting/ reminding:	Microwave prompts food preparation steps, and reminders in home provided to take medications and upcoming appointments.
		Prediction:	None reported on home website.
MavHome, University of Texas at Arlington, Arlington, Texas(2006).	Development/ demonstration two-story, 5,500-square-foot smart home/banquet hall/meeting-classroom complex.	Remote control:	Voice, touch screen and remotely control home via internet portal.
		Automation:	Lighting, kitchen automatically retrieves recipes online, robot cuts grass and vacuums, and auto bath water temperature/filling.
		Monitoring:	Weight, appliances (including refrigerator tracking contents and automatically ordering food online).
		Prompting/ reminding:	Dietary recommendations based on resident ideal weight.
		Prediction:	Emphasis is on developing computer prediction algorithms to assist in adjusting the home environment (i.e. temp) and predicting health needs of residents (monitoring short and long term changes in health).
PlaceLab, MIT, Cambridge, Massachusetts (Massachusetts Institute of Technology, 2006).	Live-in/development/ demonstration 1,000-square-foot smart apartment.	Remote control:	None reported on home website.
		Automation:	None reported on home website.
		Monitoring:	Sensors are located throughout the apartment which can detect whether an object is moved, opened/closed, turned on/off, and also detect resident's limb motion with wearable accelerometers. A resident's activities and behaviors can be recorded with one of the 9 infrared cameras, 9 color cameras, and/or 18 microphones.

Table 2-2. Continued

Name/location	Structure description	Technology component	Description of smart technology development
		Prompting/ reminding:	Prototype system that promotes healthy lifestyles in the home. These prototype systems use social science and behavioral science techniques to motivate change in a resident's behavior. Examples promoting healthy eating, energy conservation, increase physical activity, and safety practices.
		Prediction:	None reported on home website.
Point of Care Laboratory, Oregon Health & Science University, Portland, Oregon (2006).	Development of smart technologies.	Remote control:	None reported on home website.
		Automation:	None reported on home website.
		Monitoring:	Bed pads/loading cells to assess quality of sleep (restless leg syndrome, COPD), and development of algorithms to detect when medication regimens are not adhered.
		Prompting/ reminding:	Developing interactive computer games as cognitive exercises. Reminding of medication administration times.
		Prediction:	Developing technology systems that through monitoring elder movements may detect early onset of cognitive impairments.
Smart House, Duke University, Durham, North Carolina (2006).	Live-in/development/ demonstration 4,500-square-foot smart home.	Remote control:	Voice.
		Automation:	Lighting, temperature, music, television, and security.
		Monitoring:	Facial recognition security cameras.
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.
Smart House, University of Virginia Medical	Development/ demonstration smart home.	Remote control:	Family members remotely monitor resident health status and sleep conditions.
		Automation:	None reported on home website.

Table 2-2. Continued

Name/location	Structure description	Technology component	Description of smart technology development
Automation Research Center, Charlottesville, Virginia (2006).		Monitoring:	Stove-top, bed mattress pad (breathing, pulse, room light level, and body temp/position). Gait pattern sensor and a fall detector (floor vibration sensor).
		Prompting/ reminding:	None reported on home website.
		Prediction:	None reported on home website.
Smart Medical Home, University of Rochester, Rochester, New York (2006).	Development/ demonstration 5 room smart home.	Remote Control:	None reported on home website.
		Automation:	None reported on home website.
		Monitoring:	Vital signs (blood pressure, pulse, and respiration), speech patterns, breathing patterns, computer mouse activity, body motion, and gait patterns are monitored.
		Prompting/ reminding:	None reported on home website.
		Prediction:	Developing a smart home system that potentially could detect various health problems before the resident is aware.

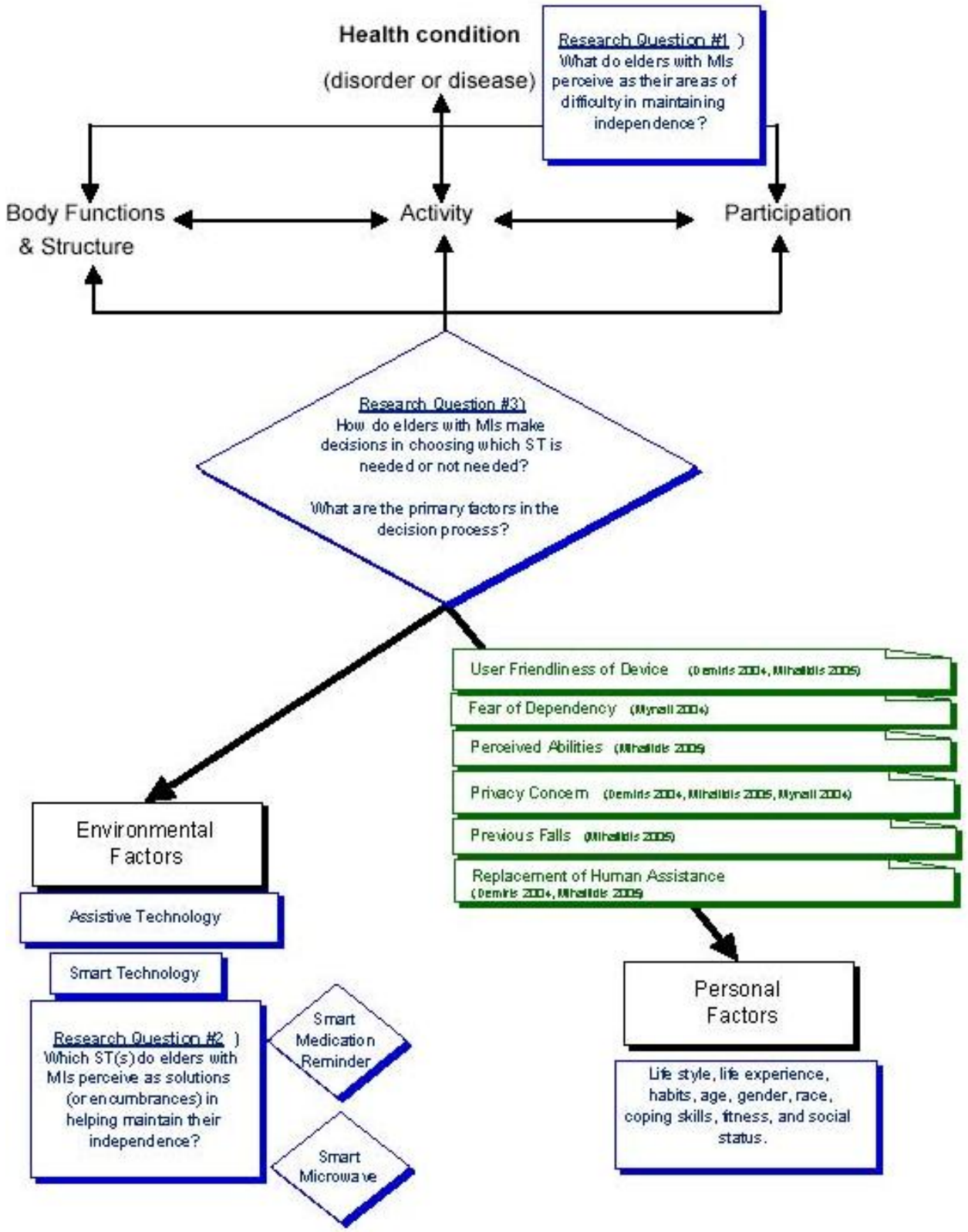

Figure 2-2. Six primary themes reported in literature incorporated into ICF model

CHAPTER 3
METHODOLOGY

Introduction

In this chapter the methodology for this study is presented in detail. The rationale for the research approach, a review of the ethnographic decision tree modeling method, role of the researcher, sampling criteria, participant recruitment, are presented. Data collection techniques and analysis process are also described. Finally, an exemplar of the analysis process conducted for participant three is described in detail to illustrate the process of analysis completed with each study participant.

Research Approach

Few studies have explored elder perceptions of needs in smart technology (ST). Therefore an ethnographic research approach was utilized to explore elders' perceptions of ST solutions. This study was designed to address the following questions:

1. What do elders with mobility impairments (MIs) perceive as their areas of difficulty in maintaining independence?
2. Which ST(s) do elders with MIs perceive as solutions (or encumbrances) in helping maintain their independence?
3. How do elders with MIs make decisions in choosing which ST is needed or not needed?

Rationale for Research Approach

A practical means of exploring end-users' needs is to involve the elder in the design process. User participation can be performed early or late in the product development cycle and can be studied in a controlled lab setting and/or in a naturalistic environment. Figure 3-1 illustrates techniques involving user participation along the development cycle (Muller, Wildman, & White, 1993). The horizontal axis of Figure 3-1 provides an approximate guide to

when a technique might be most useful during the development cycle (early or late). The vertical axis illustrates when the designer participates more directly in the users' world and vice versa. Suitable group sizes for each technique are indicated in the figure with superscript letters (Muller et al., 1993). Customization technique, collaborative prototyping for design technique, and participatory analysis of usability data technique are typically employed later in the product development cycle. In contrast, co-development technique, envisioning future solutions technique, and ethnography technique are approaches that would allow designers to get a better understanding early in the development cycle (which helps guide early prototype creation). Co-development technique, mock-up technique, and participatory ergonomics technique typically have users participate in a lab setting. While envisioning future solutions technique, contextual inquiry technique, and ethnography technique generally have the designers participate more in the user's world (which provides a richer dialogic context of their world). A rich dialogic context is important because it helps categorize the end-user's perspective of their situation in terms that are meaningful to the participant (Blomberg, Burrell, & Guest, 2003). Understanding the terms and categories utilized by the end-user can improve upon the validity of future quantitative studies (i.e., survey design) where the terms and categories have to be known in advance (Blomberg et al., 2003).

Ethnographic Decision Tree Modeling

Data analysis related to ethnographic product design should go beyond simple structured reporting of the interviews and observations (Mariampolski, 2006). They should produce interpretations of the data that potentially help developers in the design of products (Mariampolski, 2006). Developers would find it useful to know the types of ST devices perceived as needed by elders and how these need decisions are made. The goal of ethnographic decision tree studies is to predict decisions that will be made by modeling and identifying the

specific decision criteria used by most individuals in a group (Gladwin, 1989). Ethnographic decision tree modeling elicits “why people in a certain group do what they do” (Gladwin, 1989, p.7). Knowing a groups’ decision making process may enhance the success of the (ST) intervention being implemented (Gladwin, 1989).

There are two phases in building ethnographic decision tree models. Phase one, the model building phase, is an inductive process consisting of a series of ethnographic interviews and participant observations. Through these ethnographic field techniques decision criteria are elicited from each decision maker (i.e., elder consumer) and then combined to form a diagram (i.e., decision tree) of their choices. A composite decision model of all the individual decision trees is then constructed to represent a group model. Phase two, the model testing phase, utilizes a formal questionnaire to test the predictive accuracy of the composite model (created during phase one) on a separate group of decision makers from the same population. In this study, the initial stages of phase one were carried out which resulted in a preliminary ethnographic decision model of the elder ST decision process. This preliminary model could be utilized by future researchers to more thoroughly explore the decision criteria surrounding the elder ST need decision process. In summary an ethnographic research approach, with a decision tree modeling component, was chosen to explore the complex variables surrounding the criteria elders utilize when selecting ST prototypes early in the development cycle.

Ethnography and Technology Development

While ethnographic research comes from the discipline of cultural anthropology beginning in the early 1900’s (Creswell, 1998), it was not until the 1960’s that companies utilized ethnographers to understand their customers (Ante & Edwards, 2006), and early 1980’s that ethnographers were utilized to assist in examining human-computer interactions (Blomberg et al., 2003). The impetus for utilizing an ethnographic approach was due to technology moving

from engineering and research labs into the mainstream workplace environments (Blomberg et al., 2003). Designers realized that they could not solely rely on their own expertise as a guide for user requirements, they immersed themselves in real work situations to learn as much as possible from the user's point of view (Blomberg et al., 2003; Preece et al., 1994). Today large corporations are frequently utilizing ethnographers to help reveal consumer needs, for example: Sirius Satellite Radio had consulting ethnographers shadow 45 participants for four weeks studying how they interacted with entertainment technology prior to designing a new portable satellite-radio player; General Electric Company consulted ethnographers who conducted interviews over a period of four months to break into the plastic fiber industry; Intel Corporation had consulting ethnographers help devise a $500 community computer that would operate on a truck battery in 113 degree temperatures. Furthermore Intel is currently utilizing ethnographers to perform a needs assessment to prepare for the wave of aging baby boomers (Ante & Edwards, 2006; Berner, 2006; Loudon, 2005).

Advantages and Disadvantages of Ethnography

An advantage of using an ethnographic methodology to initially explore elder's perception of ST is its underlying assumption that in order to understand a world that you know little about, you must explore elders' everyday realities firsthand (Blomberg et al., 2003). The advantage of the holistic empirical nature of the ethnographic method will assist in understanding the cultural forces that shape the elder participants' everyday realities (attitudes, beliefs, and perceptions) in regards to ST needs (Portney & Watkins, 2000). Table 3-1 describes various advantages and disadvantages of utilizing an ethnographic approach.

An additional advantage of the ethnographic method in this study is that context rich data may potentially provide an initial framework that describes the elders' perceptions of their ST needs. Disadvantages of using the ethnographic method are the disruption caused by the

researcher's presence in the home and poor generalizability of results. However the emphasis on discovery and context rich data made ethnography best suited method for exploring any unmet ST user needs (Martin, Murphy, Crowe, & Norris, 2006).

Role of Researcher

Prior to data collection the ethnographic researcher determined which researcher role (observer-participant, participant-observer, insider-observer, and interviewer) was appropriate during the study (Table 3-2) (Blomberg et al., 2003; McMillan & Schumacher, 1997). The effect on the participant, researcher and event varies with each role (Blomberg et al., 2003; McMillan & Schumacher, 1997). As Table 3-2 illustrates both pure participant or observer roles were inappropriate as neither were interactive (McMillan & Schumacher, 1997). Participant-observer role (i.e. spouse-assistant) and insider-observer role (i.e. therapist, nurse) would both require time and resources to assimilate into the home and would take from the ability to interact with the elder participant. However both observer-participant and interviewer role were found to be appropriate for this study. An observer-participant role provided rich context specific data on how elder participants performed activities in their home environment. Interviewer role produced an in-depth understanding of any unmet elder needs and perceptions of ST solutions.

Sample

Inclusion and Exclusion Criteria

Inclusion criteria for this study included age $\geq$ 60 years, self-report of mobility impairment, and English-speaking. Exclusion criteria included participants who were unable to complete the interview session (d/t marked communication or cognitive deficits), reside in a skilled nursing facility, or nursing home. For this study mobility impairment was defined as a limitation in the execution of: carrying/manipulating objects, changing body position, or transferring from one place to another by walking or climbing stairs due to a physiologic abnormality or loss. The

definition of mobility impairment was composed from the World Health Organization ICF (2001) definition in which *mobility* is defined as, "moving by changing body position or location or by transferring from one place to another, by carrying, moving or manipulating objects, by walking, running or climbing, and by using various forms of transportation" (p. 138) and *impairment* is defined as, "a loss or abnormality in body structure or physiological function" (p. 213).

Recruitment

Subjects were recruited from the Rehabilitation Engineering Research Center on Technology for Successful Aging (RERC-Tech) research sample pool. Participants' demographics, health, and functional status information were screened for inclusion and exclusion criteria prior to being recruited via phone call. A total of 11 elders were recruited through purposive sampling method.

Data Collection Techniques Used

Interviewing

Interviewing is the most important data gathering technique for the ethnographer (Fetterman, 1998a) and is essential in understanding the participant's perspective (Blomberg et al., 2003). Ethnographic interviews were the primary data collection stratagem during the study and were a secondary outgrowth from participant observation sessions (McMillan & Schumacher, 1997). Interviewing was vital for this study due to the limited access this researcher had to observe participants performing their ADLs/IADLs and the conceptual nature of the study. This researcher conducted all in-depth interviews.

Structured and semi-structured interview approaches with open and closed-ended questions were utilized to obtain background information, descriptions of daily activity levels,

and participant perceptions of ST component areas (Figure 3-2). Figure 3-2 illustrates data that was collected by topic and subtopic areas.

The ‘Initial Interview Guide’ (Appendix A) was used to compile information such as basic demographic, health activity, aging in place, and technology experience information. This background information provided contextual information that assisted in describing the participants’ views on smart technology.

The ‘Current Activity Performance Guide’ (Appendix B) was utilized to document the participant’s description of their daily task (e.g. bathing, grooming, dressing, sleeping, and health management) execution. These activities are adapted from the Occupational Therapy Practice Framework’s categorization of the Areas of Occupation (ADLs, IADLs, work, play, leisure and social participation) (Youngstrom et al., 2002). This activity performance information assisted in describing the participants’ daily difficulty areas in maintaining independence (research question #1). Table 3-3 and Table 3-4 summarize all ADL and IADL activities assessed during the study.

The ‘In-depth Interview Guide’ (Appendix C) was utilized to probe participants’ perceptions of various component areas of ST (research question #2). The ST component areas are based on a ‘Smart Technology Development Framework’ (Appendix D) that was created for this study to illustrate the central ST component areas in development around the world. Eight visual display boards (Appendix E) were utilized to introduce smart technology and help participants visualize the differences between automating, monitoring, prompting/reminding, predicting, and remote controlling technologies in smart home design.

Participant Observation

Typically ethnographers utilize multiple methods and sources to collect and validate data (McMillan & Schumacher, 1997; Portney & Watkins, 2000). A fundamental assumption of anthropology is what people say they do may not always represent what they do in reality

(Blomberg et al., 2003). Therefore to verify and enhance the interpretation of the interview data participant observation technique were utilized. Participant observation helped capture behavior that participants were unaware of due to the habitual nature of tasks and relevant details that were missed due to dynamic nature of the home (Blomberg et al., 2003). A participant observation grid was utilized due to the limited observation time and the complex nature of the home environment (Appendix F). Utilizing a participant observation grid allowed the researcher to remain focused on descriptive details salient to the phenomena under study, which later led to more subtle information surrounding the phenomena (McMillan & Schumacher, 1997).

Use of Camera

Cameras enabled the ethnographer to document field observations, which acted as mnemonic devices during analysis phase (Fetterman, 1998a). Photographs captured during the beginning of the study were retroactively examined for themes (Fetterman, 1998a). Still camera photography was utilized to capture elder problem areas and success areas in their environment. Photographs of environmental modifications (i.e., ramps, grab bars, railing), homemade assistive devices (i.e., jar/soda can holder, yogurt cup holder), and problem areas (narrow door frames, uneven floor tiles, steep stairs) were recorded.

Field Notes

Ethnographic observations and interviews can be exhaustive (Fetterman, 1998b); therefore field notes were needed to capture the content rich data before subsequent events overshadowed the experience (Fetterman, 1998b). Field notes were indispensable in this study as they formed the building blocks necessary for the in-depth analysis process (Fetterman, 1998b). There are many styles of recording field notes in ethnography (Spradley, 1979). This study utilized three formats (condensed account, expanded account, and fieldwork journal) to record field notes (Spradley, 1979). A *condensed account* is comprised of field notes taken during the interview

and observation process (Spradley, 1979). Condensed field notes included short phrases, abbreviations, unconnected sentences, and mnemonics that later assisted the researcher in the reconstruction of events (Fetterman, 1998b; Spradley, 1979). After the field observation and interview session ended, the *expansion account* of recording field notes was initiated to expand upon the condensed field notes (Spradley, 1979). Expansion field notes included filling in all needed details surrounding the events not recorded on the location (Spradley, 1979). The final method of field note recording involved the researcher keeping an introspective *fieldwork journal*, which accounted for any biases or feelings that may have influenced the research process (Spradley, 1979). Fieldwork journal descriptions included recording problems, breakthroughs, confusion, mistakes, and ideas (Spradley, 1979).

Data Collection Protocol

Study sessions began with an initial interview phase to gather background information, including specific information on participants' current activity status. This was followed by an in-depth interview phase to explore participants' perceptions of smart technology. During the in-depth interview phase, visual display boards were utilized to introduce smart technology and help participants visualize the different technologies in smart home design. A brief participant observation phase followed to document the participant's use of space and integration of technology into their home. During the participant observation stage, still camera photography was utilized to help capture any problem or success areas in the home environment.

Outline and time that was allotted for each phase of data collection is listed below:

- Phase 1 - Initial interview (45-90min.)
- *Initial Interview Guide* - A structured interview approach with closed-ended questions were utilized to gather basic demographic, health activity, aging in place, and technology experience information (Appendix A).

- *Current Activity Performance* form (Appendix B) was utilized to document the status of participant's description of their daily task (e.g. bathing, grooming, dressing, sleeping, and health management) execution.

- Phase 2 - In-depth interview (45-90min.)

- *In-depth Interview Guide* - Semi-structured open-ended questions (Appendix C) along with eight visual display boards (Appendix E) were utilized to thoroughly explore participant's perceptions of various component areas of ST.

- Phase 3 - Participant observation (20-30min.)

- *Participant Observation Grid* (Appendix F) helped document observations while having the participant give a tour of their home and point out their success and problem areas. Utilizing the participant observation grid allowed the researcher to remain focused on descriptive details, which later led to more subtle information.

Interview and participant observation phases were audio recorded and transcribed verbatim. Field notes were written during interview sessions (condensed field note account), following interview (expanded field note account), and throughout the study (fieldwork journal account). Still camera photography was utilized during the participant observation phase (phase 3) to capture elder problem and success areas in their environment.

Data Analysis

Qualitative data analysis begins the moment a research problem is selected and builds on insights throughout the study (Fetterman, 1998a). Demographics, health, activity status, previous experience with technology, and views on aging in place were analyzed to help determine any trends in the study sample. Categorical variable (frequencies) and non-categorical variable (means, standard deviations, and range) background data were evaluated. All In-depth interviews were transcribed verbatim.

Bias

To help avoid researcher bias, during the analysis process multiple meetings with a qualitative advisor were conducted to analyze the researcher's interpretation of the findings. An

open coding process (as opposed to a preexisting list of codes) was utilized to capture all emerging decision criteria during the analysis process. Preliminary findings were also presented to a qualitative data analysis group, where the researcher's interpretations of the data were examined.

Data Saturation

In qualitative research the sample size varies due to the flexible nature of sampling. Data collection continues until data saturation (when no new themes emerge from the data) is achieved (Ploeg, 1999). Typically in ethnographic research themes begin to emerge within the first few interviews (Anderson, 2001; Muller et al., 1993) and data saturation almost completely occurs within the first 12 interviews (Guest, Bunce, & Johnson, 2006). For this study the majority of new themes emerged within the first four in-depth interviews. A couple of new themes were revealed during interview #7; however no new themes emerged in the last four interviews.

Ethnographic Decision Tree Modeling

As the goal of this study was to explore how participants made their decisions regarding ST, an ethnographic decision tree modeling approach was utilized (Gladwin, 1989). Interview transcripts, field notes, and field journal entries were analyzed based on this inductive approach geared toward eliciting contextual data about decision processes (Gladwin, 1989). Initial phases of data analysis involved many iterations of sorting, comparing, and identifying key phrases that both represented participant decision criteria, and reflected any contrasts in decision behavior (Gladwin, 1989). Decision criteria themes were then combined in the form of a decision tree to build decision models (Gladwin, 1989). Transcripts were read multiple times and expansively converted into decision models illustrating each participant's conceptual perceptions of their activity and ST needs. The final phase of analysis involved combining all participant conceptual

decision models into a broad composite conceptual model illustrating the issues surrounding the elder groups' ST need decision process.

Data analysis process involved creating numerous drafts to reflect the participant's decision process. For example early versions of participant-1's activity limitation decision models were basic and only illustrated contrasts between the types of assistance (person, equipment, no assistance) utilized (Figure 3-3). Later versions of this activity limitation decision model were more comprehensive and differentiated between types of assistance (AT, family, AT and family, no assistance) and status of the activities (satisfied with activity, problem with task completion and would like a solution, problem with task completion but not concerned)(Figure3-4). Early versions of the ST need decision models were often too complex. For example during initial phases many attempts were made to illustrate contrasts between all 44 ST devices in a single decision tree. Figure 3-5 documents an attempt to illustrate contrasts made by participant-1 between 26 ST devices.

Example Analysis Process for Participant Three

Background information

An exemplar of the analysis process completed with each study participant is reviewed in the following section. Each transcript was read multiple times and information regarding health condition, living arrangements, description of AT utilized, experiences with technology, and views on aging in place were synthesized and consolidated into a single coversheet (Figure 3-6). This participant background information sheet provided quick access to contextual information which assisted during the analysis process. For example a quick glance at participant-3's background information sheet illustrates that he is a 74 year old, Caucasian male, with a history of multiple strokes, who wears an orthotic brace on his left leg, owns a cell phone (and uses it

daily), lives with his daughter in a rented condo, and utilizes a powered wheelchair for ambulation.

Activity need decision model

As discussed in the previous section, later versions of activity-need decision models were able to differentiate between types of assistance (AT, family, AT and family, no assistance) as well as perceived status of activity performance levels (satisfied with activity, problem with task completion and would like a solution, problem with task completion but not concerned)(Figure 3-4). Utilizing a decision modeling approach, a key barrier theme of being satisfied with an activity performance was revealed. For example participant-3 cited being satisfied with his current activity performance level with regards to his assistive technology assisting him in his showering and walking activities. This is illustrated in his decision process: activity limitation, assistance utilized, assistive device utilized, satisfied with current performance level of activity (with assistive device) (Figure 3-4). A key facilitator theme of wanting to decrease imposition on family was revealed by participant-3 as well, who cited not being satisfied with his dressing activity. This is illustrated in his decision process: activity limitation, assistance utilized, family/person assistance utilized, problems with task completion (with family assistance), and would like solution to problems of completing activity. Where participant-3 cites,

> Oh I am not comfortable, because it [donning slacks] is awful difficult, and sometimes she [daughter] is doing something else and gets all ticked off….I don't like to have to depend on my family because they got their own lives and everything. (Transcribed Interview, pages 21, participant 3).

Smart technology need decision models

As discussed in the previous section, early versions of the ST need-decision process were found to be too complex when attempting to illustrate contrasts between all 44 ST devices in a single participant's decision model (Figure 3-5). Therefore separate decision models were

constructed for each of the ST component areas (remote control-voice, remote control-touchscreen, household automation, personal robotic assistance, monitoring technologies, reminding technologies, and prediction technologies) for each participant (Figures 3-7 to 3-14). Several of the smart technology decision models constructed for participant-3 are discussed in the next section.

Remote control-voice decision model

Utilizing a decision modeling approach, a key barrier theme of being concerned about the reliability of ST was revealed by participant-3. Participant-3 cited being concerned about the reliability of a remote voice controlled device. This is illustrated in his decision process of: remote-voice control (VC), no need, additional problems arise with the incorporation of technology (i.e., reliability a concern), VC-TV set (Figure 3-7). Where participant-3 cites,

> They [voice recognition] act up an awful lot. And I don't think you really need it, hell if you can't mash the button on the remote control what's the use, I mean, it would be nice to have it [voice recognition] but I don't think it's very important. (Transcribed Interview, pages 39, participant 3).

Household automation decision model

Utilizing a decision modeling approach, key ST facilitator themes were also revealed during the analysis. For example a key facilitator theme (diagrammed as a red cloud icon in the decision model) of desiring additional assistance with a difficult task was revealed (Figure 3-9). Participant-3 cited desiring further assistance in performing the difficult activity of opening/closing his front door. This is illustrated in his decision process: household automation, need, slight need, automatic front door (Figure 3-9). Where participant-3 cites,

> Well that [automated front door] would be nice, I could push the button and tell them to come in the front door and that would be nice. (Transcribed Interview, pages 42, participant 3).

Personal robotic assistance decision model

The decision modeling approach was able to reveal complex decision criteria. For example participant-3 cited needing assistance with transferring in/out of his bathtub; however he was concerned about the size of the technology and the heat generated by the technology. This is illustrated in his decision process: personal robotic assistance, need, strong need, transfer aid, concerned about, size of technology, and heat generated by the technology (Figure 3-10).

Participant smart technology overall decision model

An overall participant ST decision model, which represented all ST component areas, was built for each participant (Figure 3-14). This overall ST decision model illustrated all primary barrier themes (cost, fear of dependency, additional problems, no gain, stigma, donning difficulty, reliability concerns), facilitator themes (decrease imposition, replace unsafe activity, assist with activity that is difficult to perform, enhance ability to monitor health), as well as all ST devices (automatic front door, early detection of changes in activity level, voice control dialing of phone numbers, dressing aid, carrying aid, transfer aid) cited as needed by participant-three.

Elder smart technology decision tree model

The final phase of analysis involved combining all participant ST decision models into one broad composite conceptual model that represents the groups' decision process (Figure 3-15). Barrier and facilitator decision criteria cited in participants' ST decision models were utilized to build the final composite model. This final composite model illustrates the criteria surrounding ST need decision process and is discussed thoroughly in chapter 4.

Summary

Potential participants were pre-screened for inclusion criteria (65 or older, self report of mobility impairment) and exclusion criteria (reside in skilled nursing facility, or nursing home)

prior to being recruited via phone call. The in-depth interview/in-home observation session took 2.5 – 4 hours to be completed. Firstly participants were asked demographic and functional status questions. This was followed by exploring participants' perceptions of various smart technology component areas. During this stage, visual display boards were utilized to introduce smart technology and help participants visualize the different technologies in smart home design. The final stage involved the participant giving a tour of their home where still camera photography was utilized to capture any problem or success areas in their home environment. The interviews were transcribed verbatim and analyzed for key phrases that both represented participant decision criteria, and reflected any contrasts in decision behavior. Decision criteria themes were then combined in the form of a decision tree to build decision models.

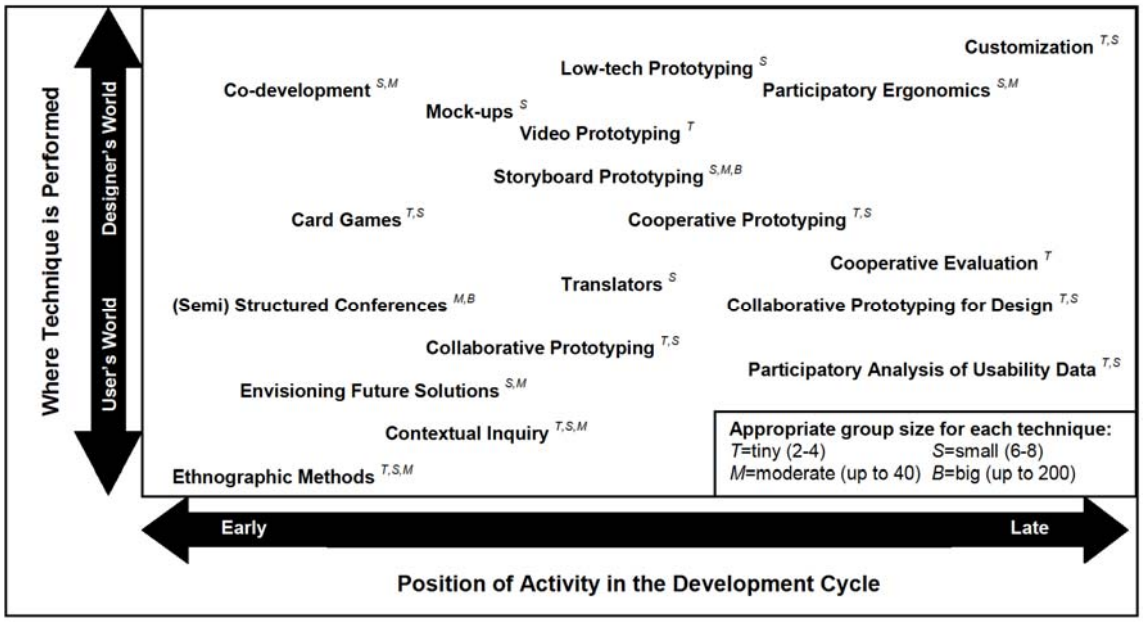

Figure 3-1. Techniques in user participatory design. [Adapted from Muller, M., Wildman, D., & White, E. (1993). Taxonomy of PD practices: A brief practitioner's guide. *Communications of the ACM, 36*(4), 24-28 (Page 27, Figure 1).]

Table 3-1. Advantages and disadvantages of ethnography. [Adapted from Denscombe, M. (2003). *The good research guide: For small-scale social research projects* (2nd ed.). Philadelphia: Open University Press. (Page 92-94).]

Advantages:	Disadvantages:
Direct observation- Have direct observation via fieldwork, rather than using only second-hand data.	Stand-alone descriptions- Potential to generate depictions of isolated stories that are not linked together.
Empirical- Grounded in empirical research by direct contact with pertinent people and places.	Story-telling- can become the exclusive purpose, leaving research product which is atheoretical, unempirical and non-critical.
Links with theory- Can be used as a process for developing and testing theory.	Reliability- Potential limitation of poor reliability and diminutive prospect of generalizing.
Detailed data- Rich data can deal with complex and subtle realties.	Ethics- Greater potential of problems linked with infringement upon privacy.
Holistic- Focuses on processes and associations that lie below the surface events.	Access- Acute complications in gaining access to settings that would avoid unsettling the naturalness of the setting.
Actors' perception- deals with the way participants perceive events - as seen through their eyes.	Insider knowledge- can potentially overlook habitual phenomena.

Table 3-2. Description of research roles. [Adapted from McMillan, J., & Schumacher, S. (1997). *Research in education: A conceptual introduction* (4th ed.). New York: Addison-Wesley Educational Publishers Inc. (Page 437, Table-12-1).]

Role	Description	Use
Observer	Researcher is physically absent (observer looking through a one-way mirror).	Inappropriate for ethnographic study; may be used for other forms of qualitative research.
Observer-participant	Observing events and interacting with participants from a subtle position. Does not experience the activity first hand.	A typical role in ethnographic study.
Participant	Researcher lives through an experience and recollects personal insight.	Inappropriate for ethnographic research.
Participant-observer	Actively involved in the events being observed. Researcher creates role (i.e. caregiver-assistant) for purpose of study.	A typical role in ethnographic study.
Insider-observer	Researcher has an existing formal position (i.e. superintendent, teacher, and counselor) in organization.	Used in special circumstances.
Interviewer	Establishes role (i.e., graduate student) with each person interviewed.	Primarily used in ethnographic interview studies.

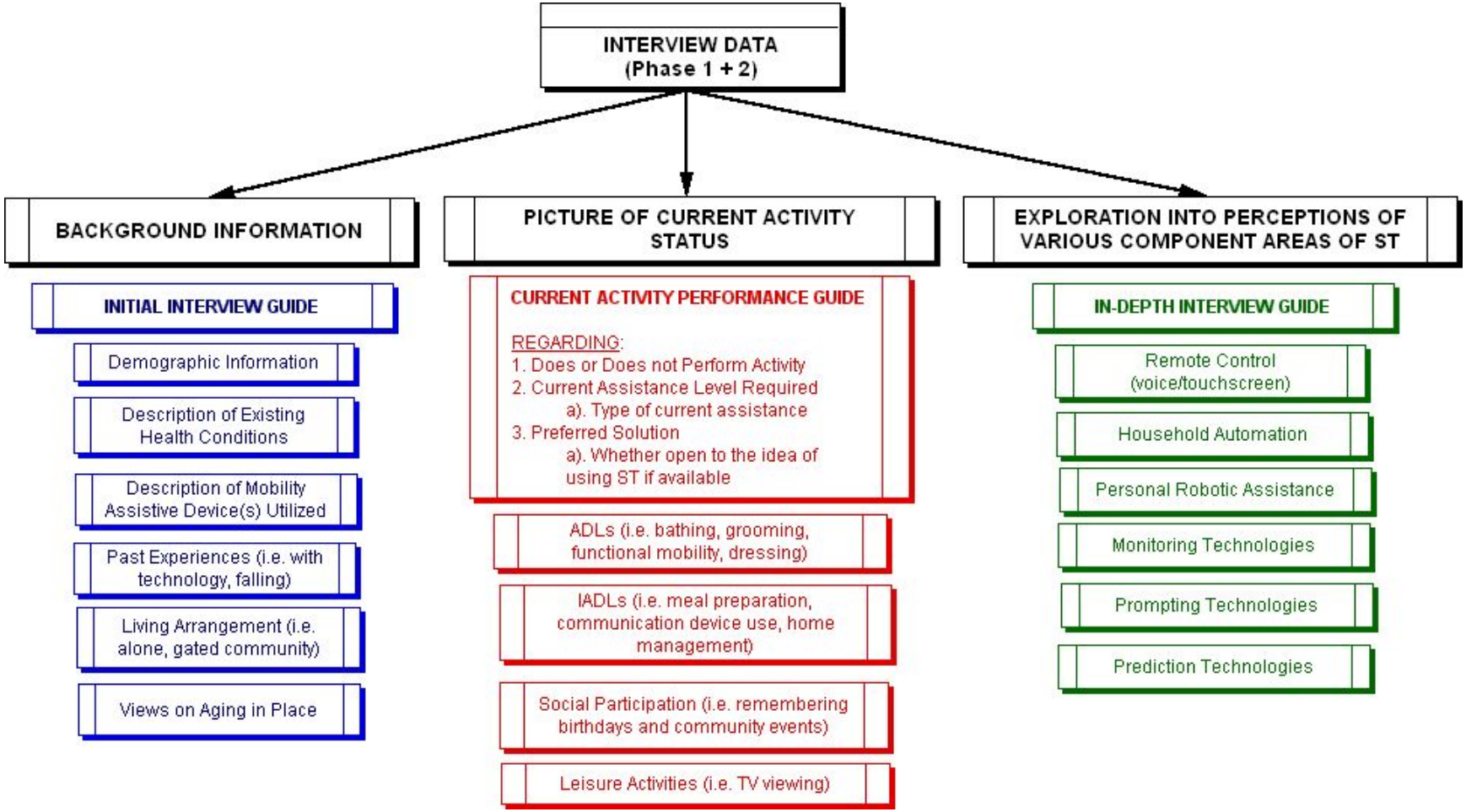

Figure 3-2. Interview data collected by topic and subtopic question areas.

Table 3-3. List of Activities of Daily Living (ADL) assessed

ADL (taking care of one's own body)
Bathing and Showering
Physically bathing/showering
Turning on/off shower/sink faucets
Adjusting water temperature of shower/sink
Bowel and Bladder Management (intentional control bowel/bladder)
Dressing
Lower body dressing (including shoes)
Upper body dressing
Eating
Functional Mobility
Functional ambulation
Getting in/out of bed
Getting in/out of shower
Getting in/out of tub
Carrying items around the house
Personal Hygiene and Grooming
Brushing teeth/combing hair
Toilet Hygiene
Transferring to/from and maintaining toilet position

Table 3-4. List of Instrumental Activities of Daily Living (IADL) assessed

IADL (oriented toward interacting with the environment)	
Communication Device Use:	Home Establishment and Management (home, yard, garden):
Cell phone/telephone	Adjusting the thermostat in home
Computer	Checking the mail
Community Mobility:	Preventing food from expiring before use
Driving and using public transportation -taxi, bus	Keeping track of food in kitchen
Financial Management	Doing laundry
Health Management/Maintenance:	Vacuuming
Monitoring vital signs (blood pressure, temp., resp. rate)	Remembering appliance maintenance
Monitoring sleep patterns	Mowing the yard
Tracking the frequency of trips to the bathroom at night	Turning on/off lights in home
Physical fitness activity/routines	Seeing who is at the front door
Mental fitness activity/routines	Opening/closing all doors/windows/blinds in home
Maintaining well balanced nutritional meal choices	Unlocking/locking all the doors/windows in home
Decreasing health risk behaviors	Setting the home security alarm
Medication management/routines	Seeing which stove top burner is on/off
Remembering physician appointments	Safety Procedures and Emergency Responses:
Meal Preparation and Cleanup:	Remembering to check in with designated family/friend
Planning/preparing meals	Remembering to turn off all appliances
Using a microwave to reheat items	Shopping:
Using a microwave to cook a prepackaged frozen meal	Preparing grocery shopping list
Cleaning up food and utensils	Purchasing items at a store

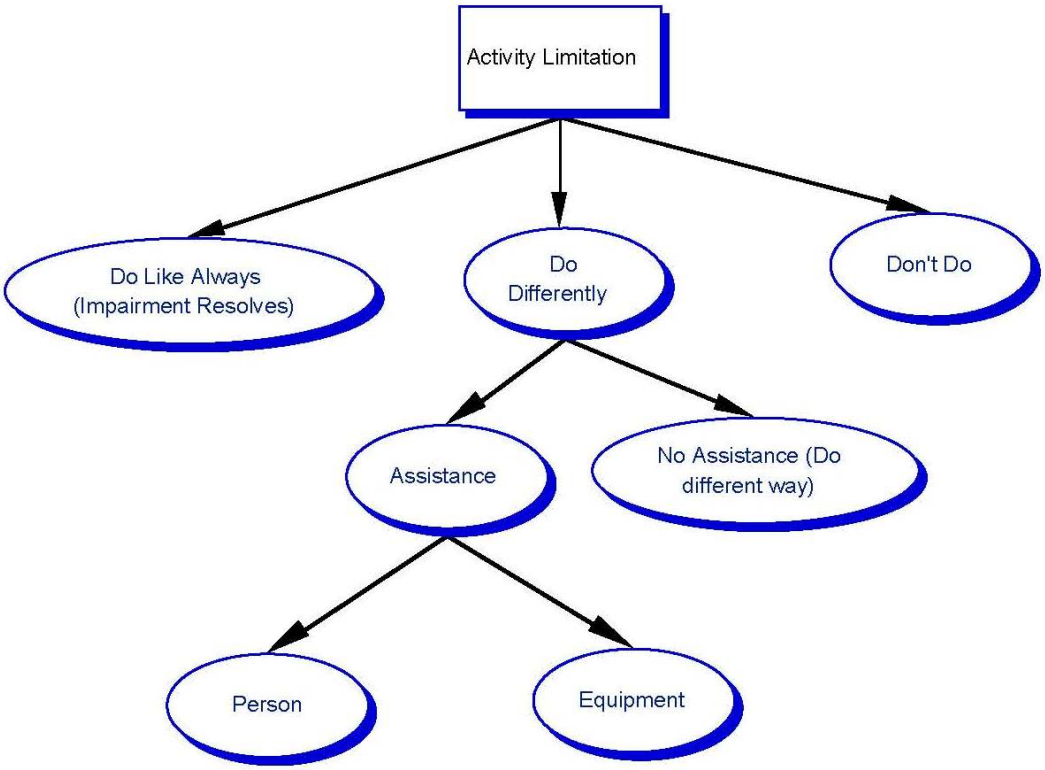

Figure 3-3. Early decision model regarding activity limitation.

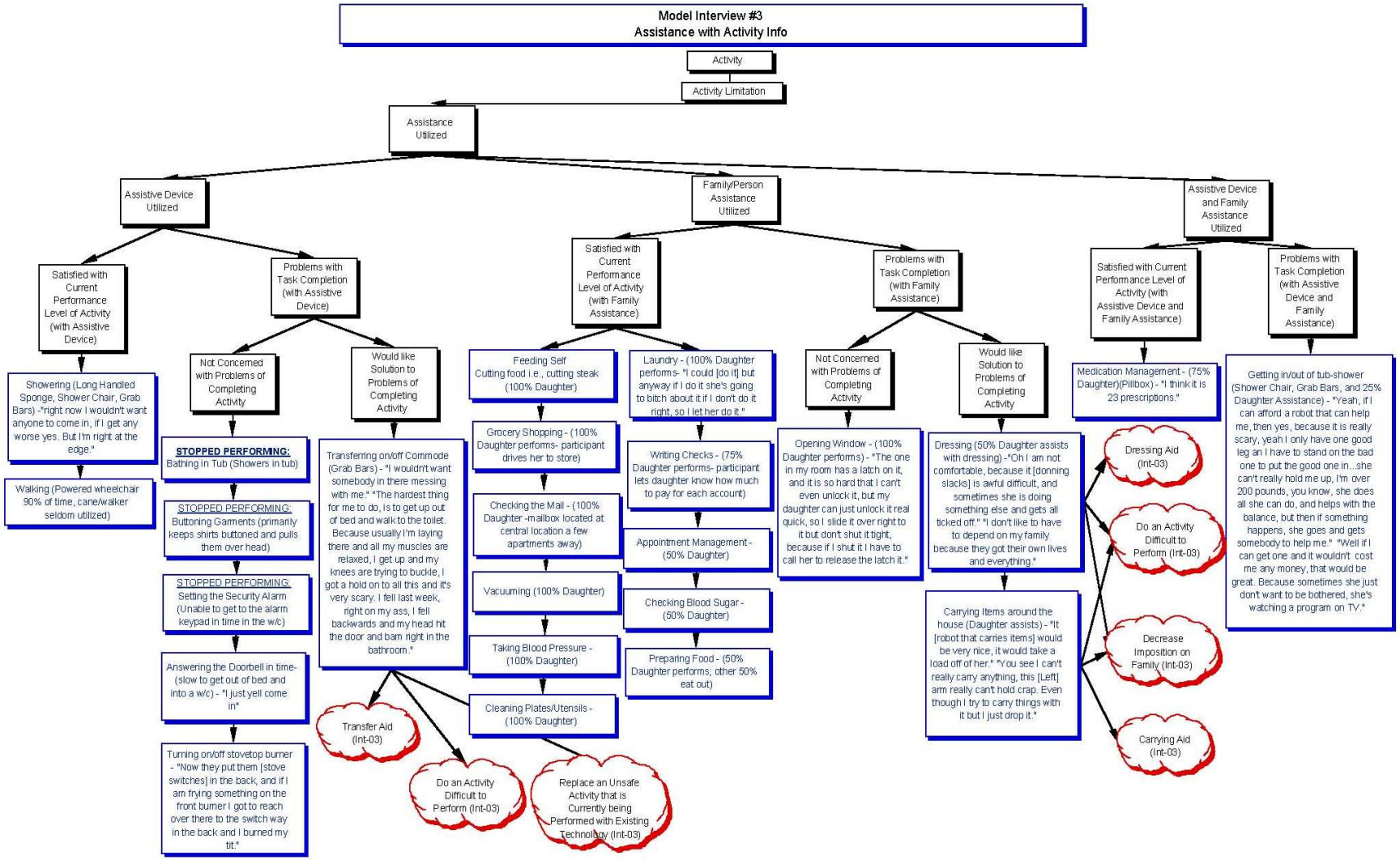

Figure 3-4. Participant 3's assistance with activity decision model.

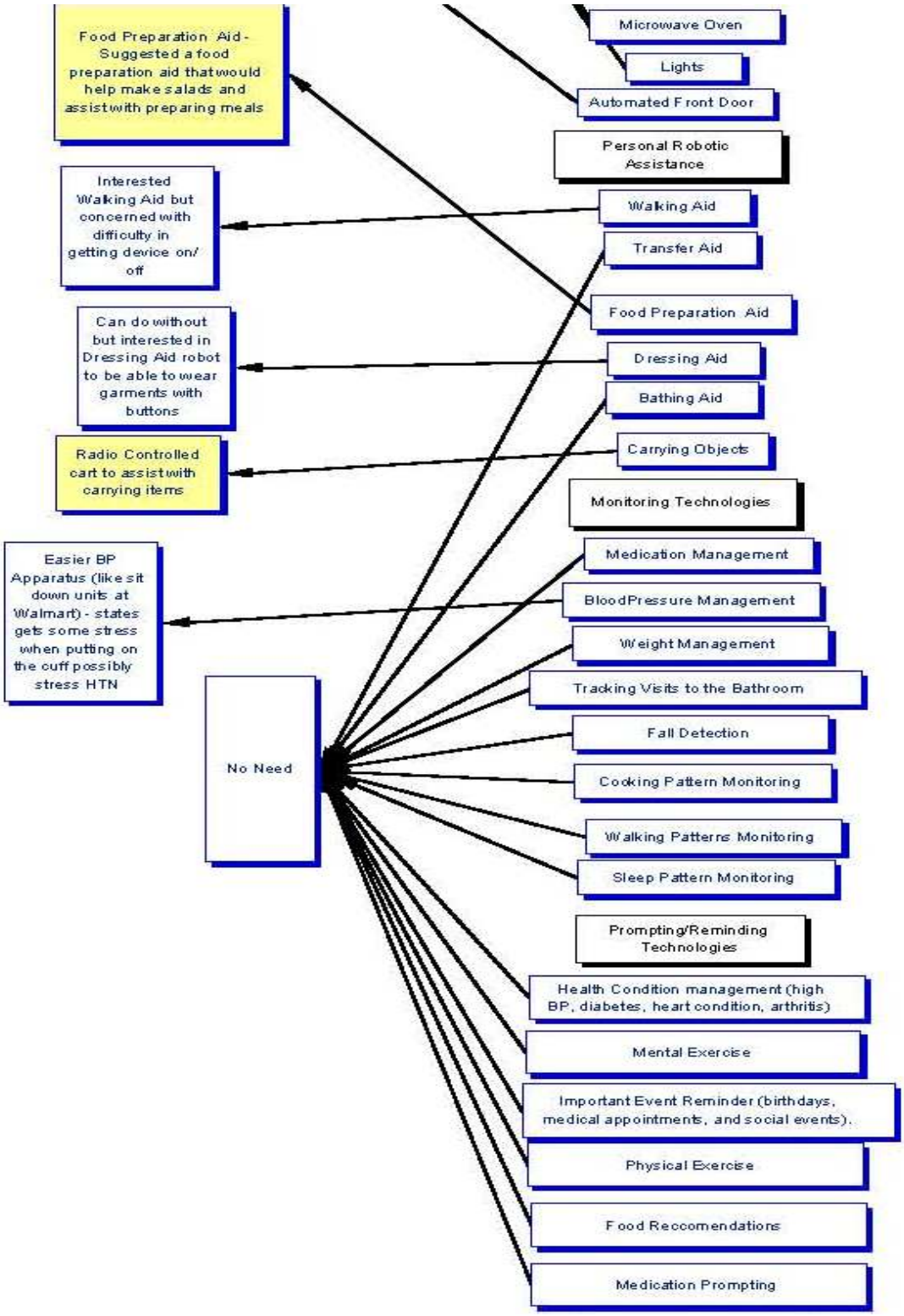

Figure 3-5. Early decision model attempt at categorizing 26 ST devices within one decision model.

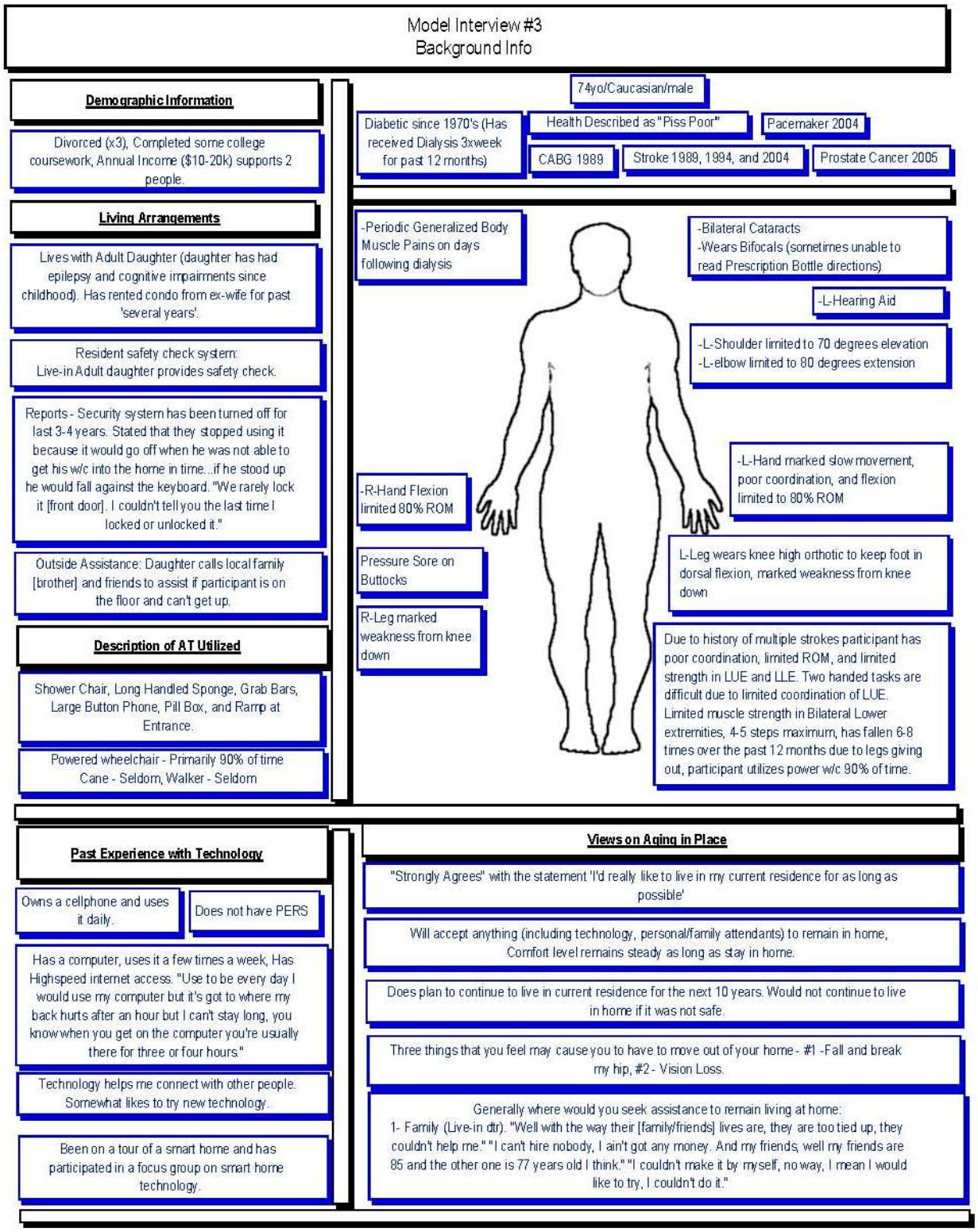

Figure 3-6. Participant 3's background information sheet.

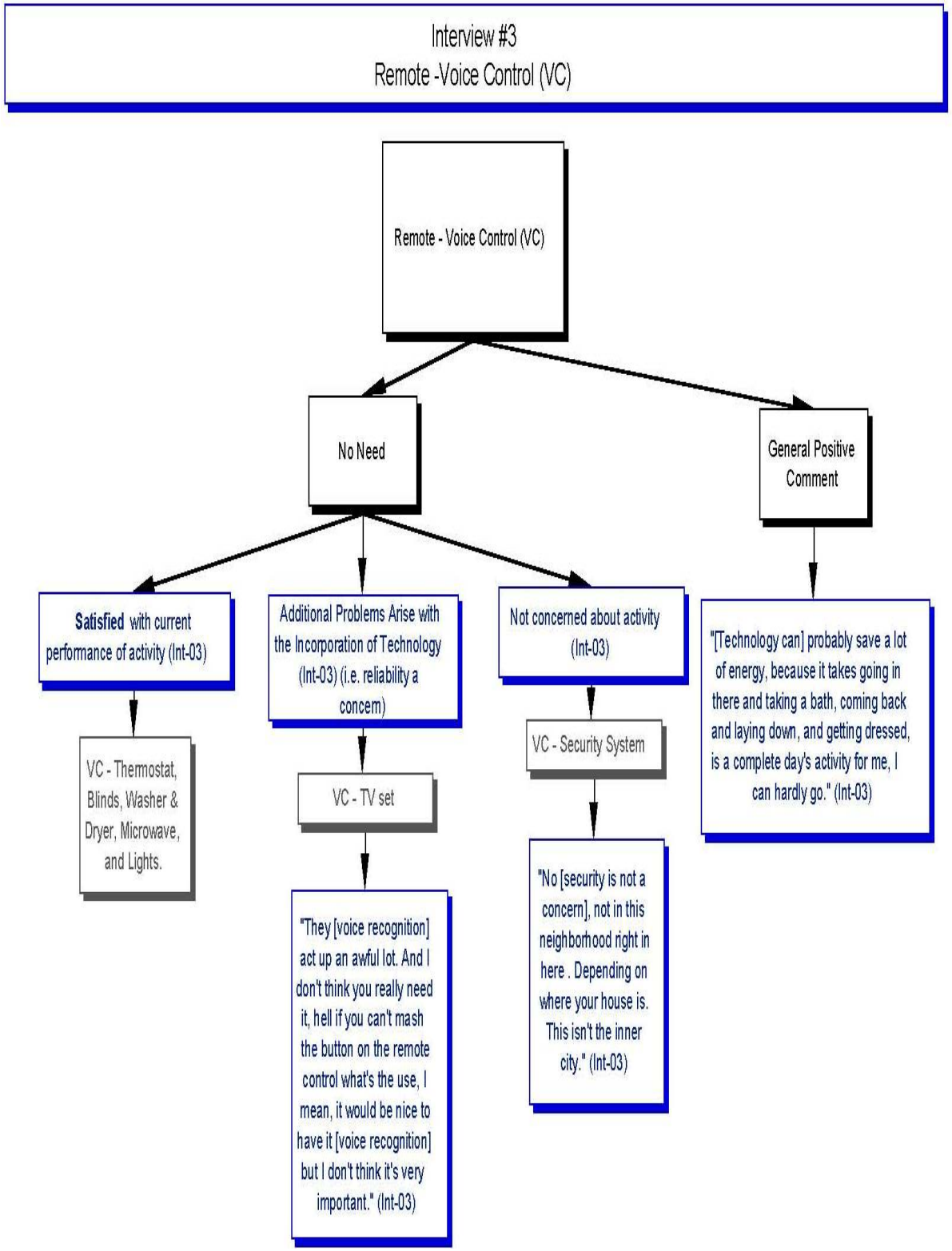

Figure 3-7. Participant 3's smart technology remote control voice recognition need analysis information sheet.

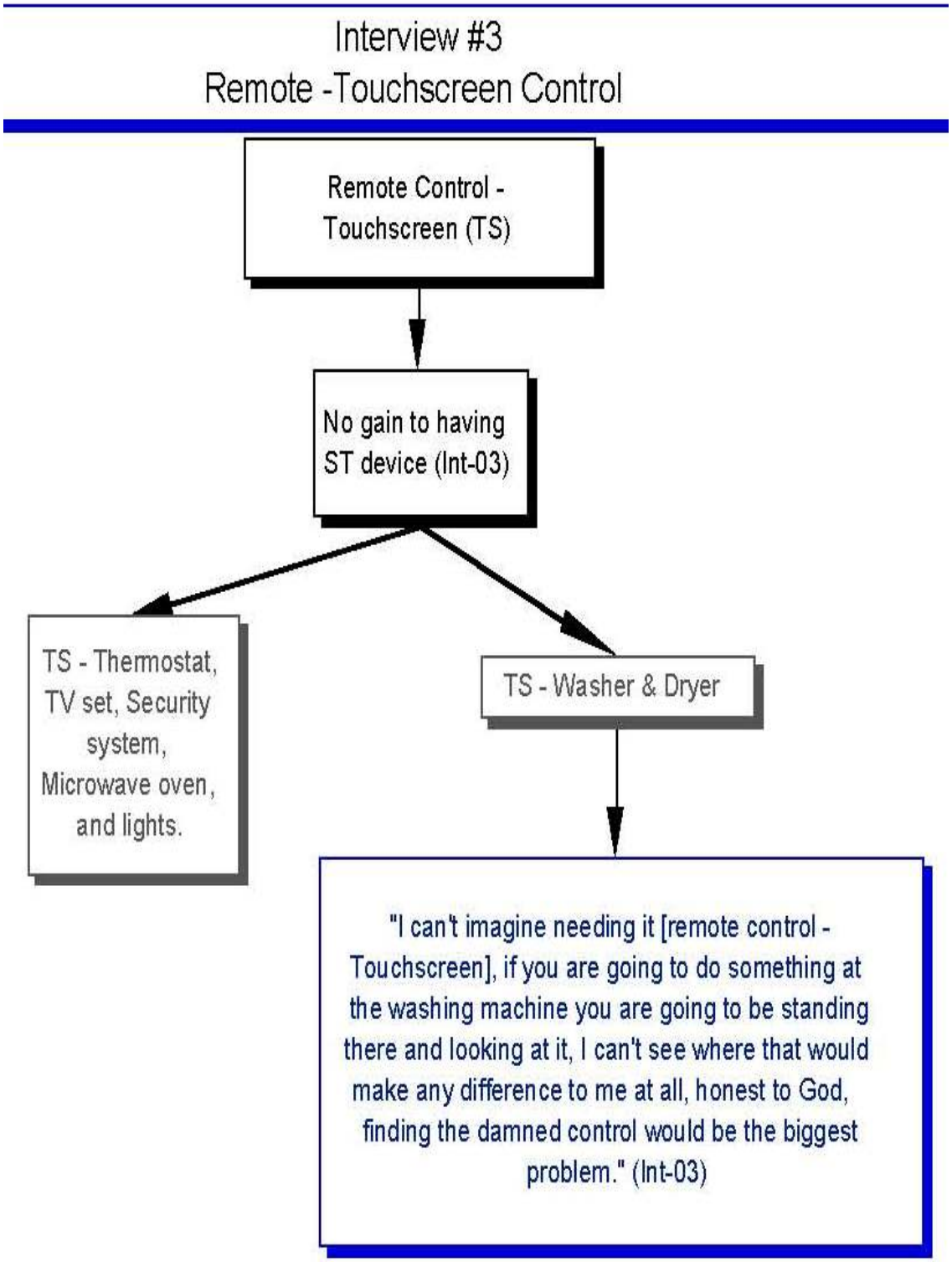

Figure 3-8. Participant 3's smart technology remote control touchscreen need analysis information sheet.

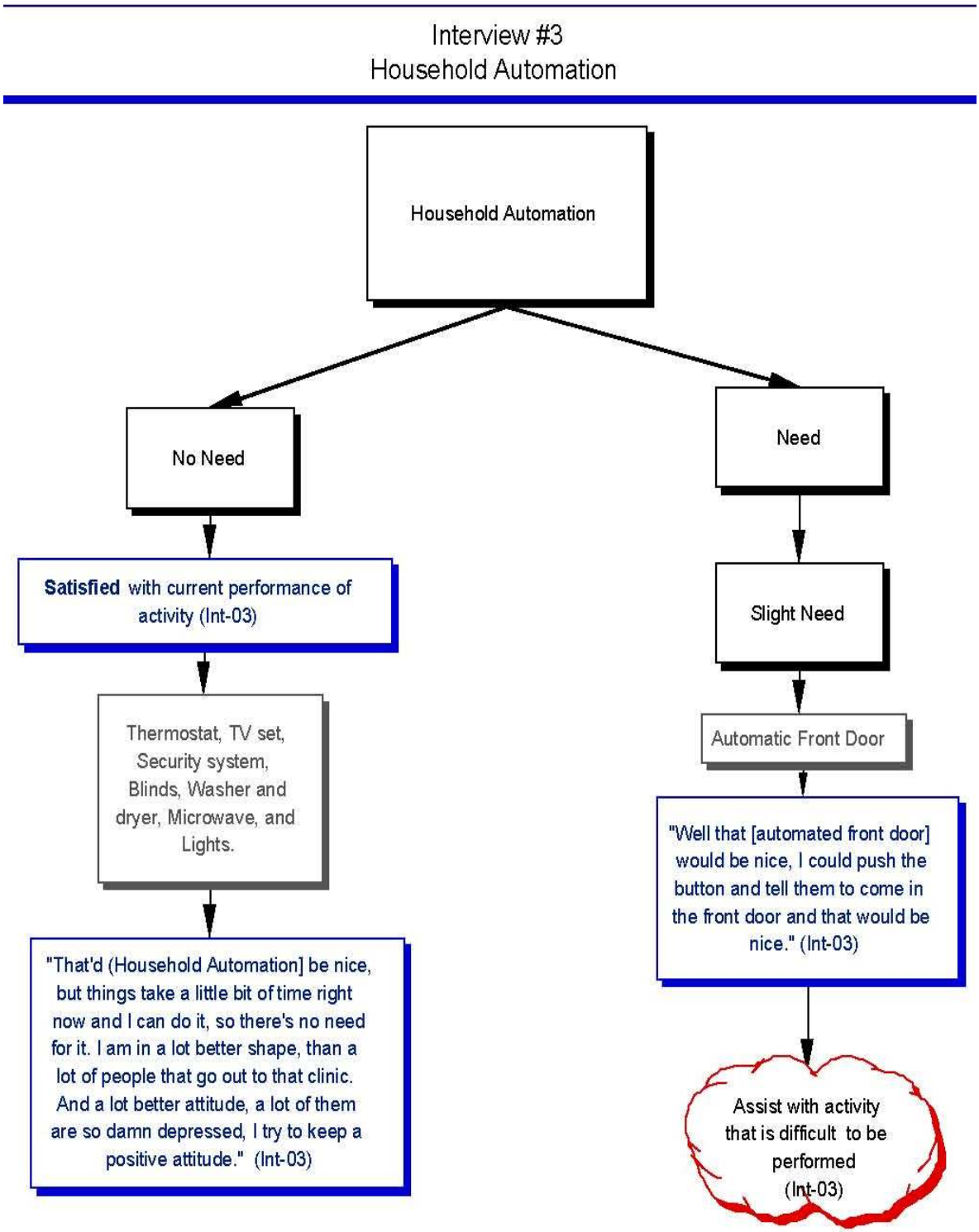

Figure 3-9. Participant 3's smart technology household automation need analysis information sheet.

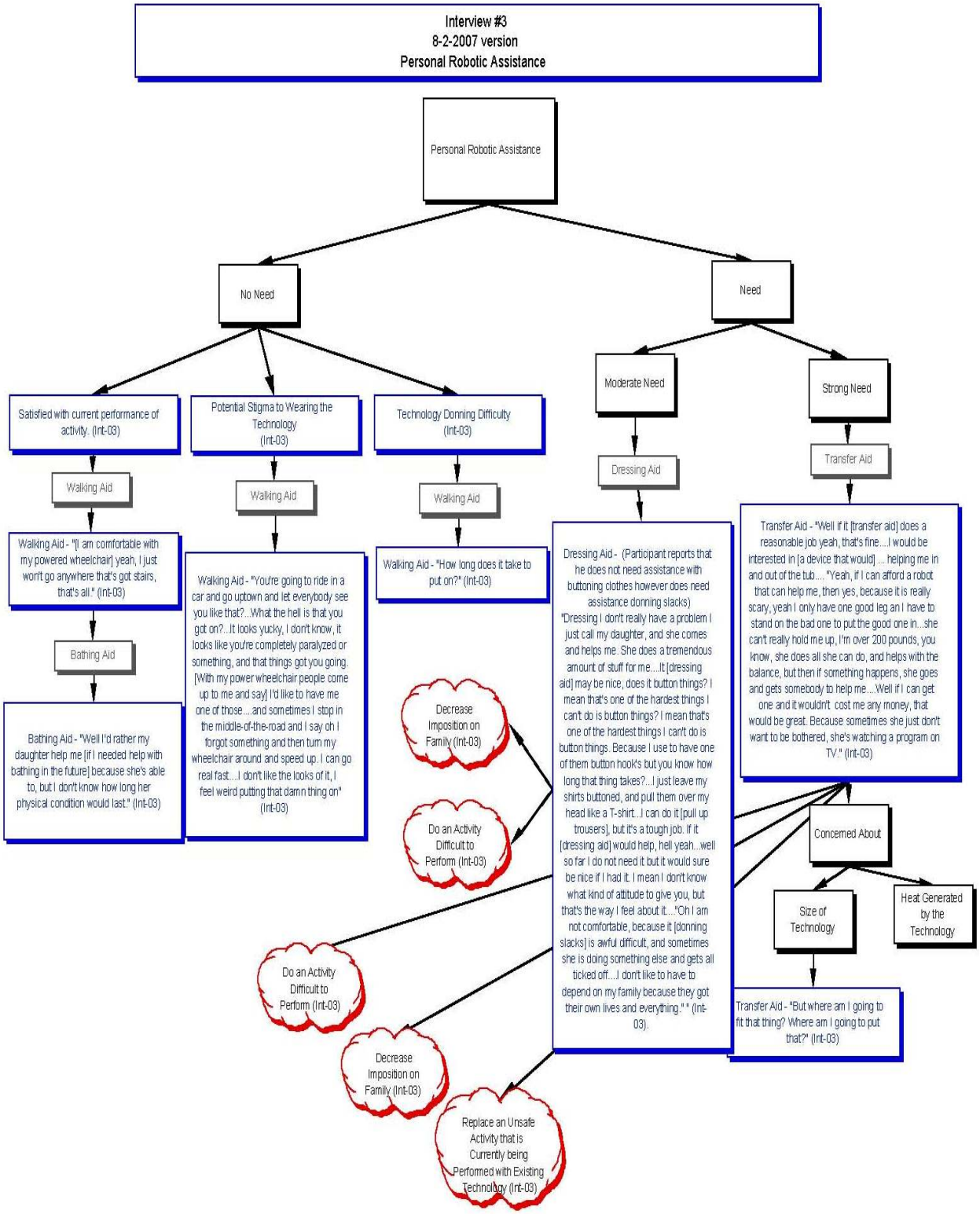

Figure 3-10. Participant 3's smart technology personal robotic assistance need analysis information sheet.

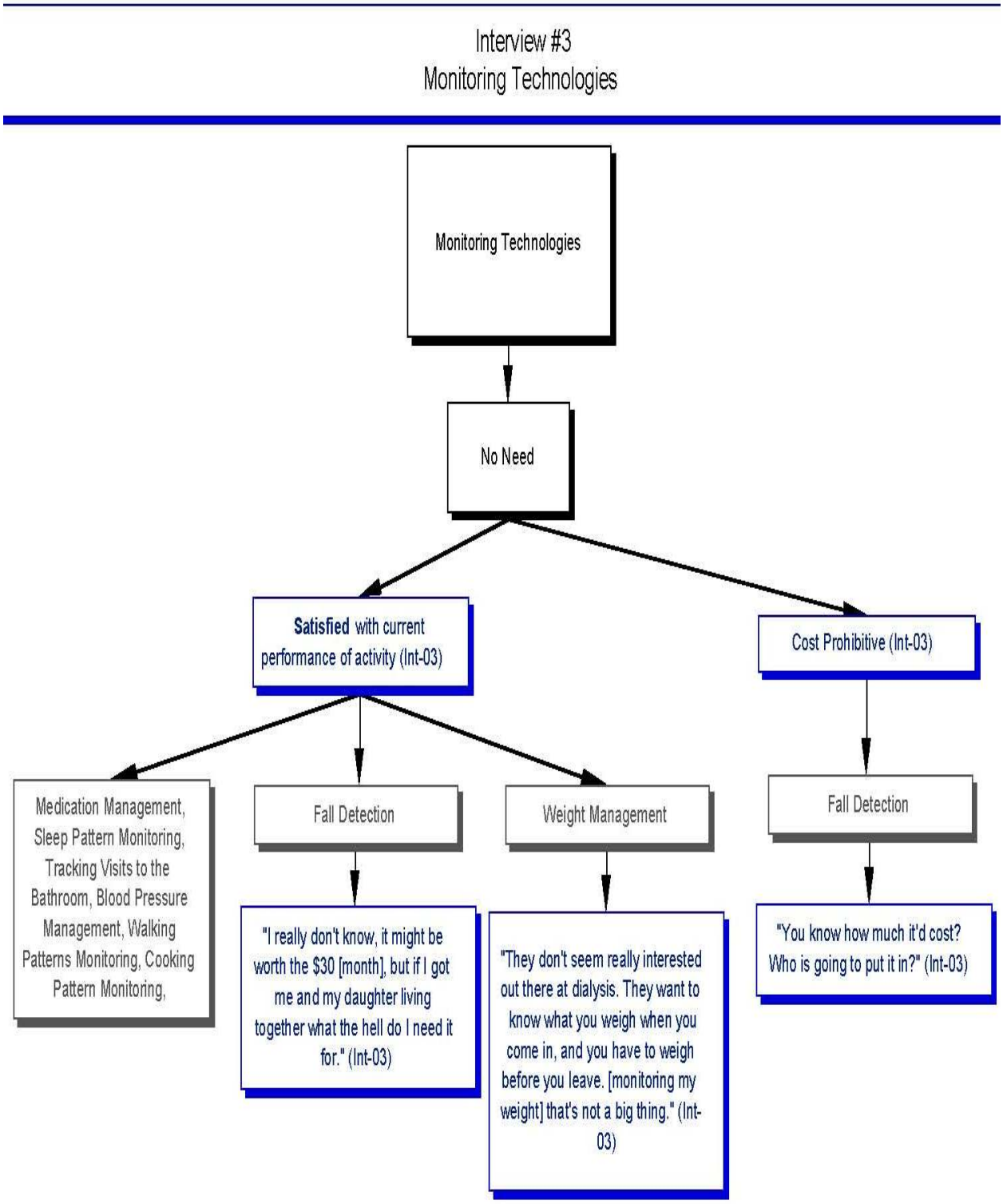

Figure 3-11. Participant 3's smart technology monitoring technologies need analysis information sheet.

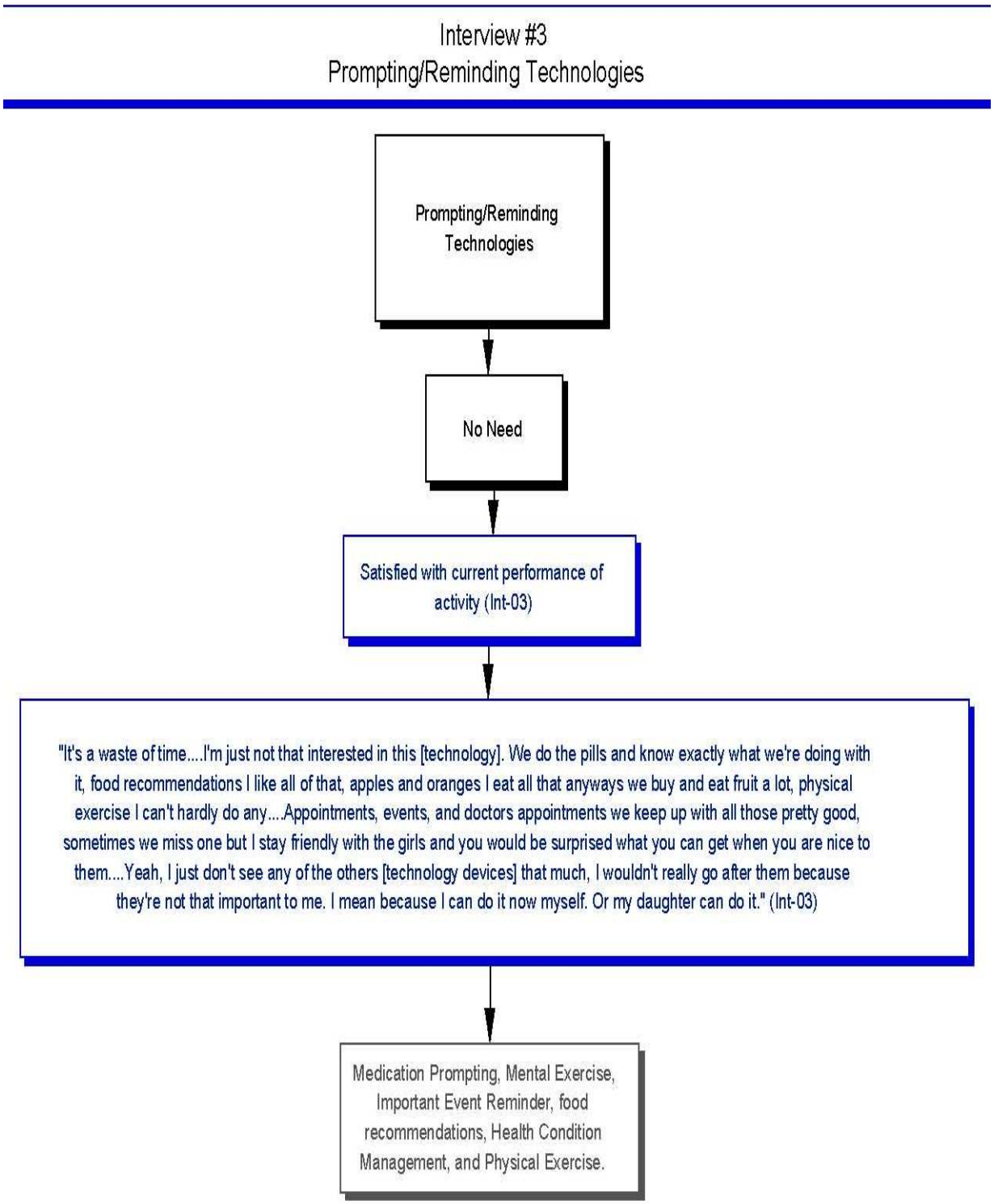

Figure 3-12. Participant 3's smart technology prompting/reminding technologies need analysis information sheet.

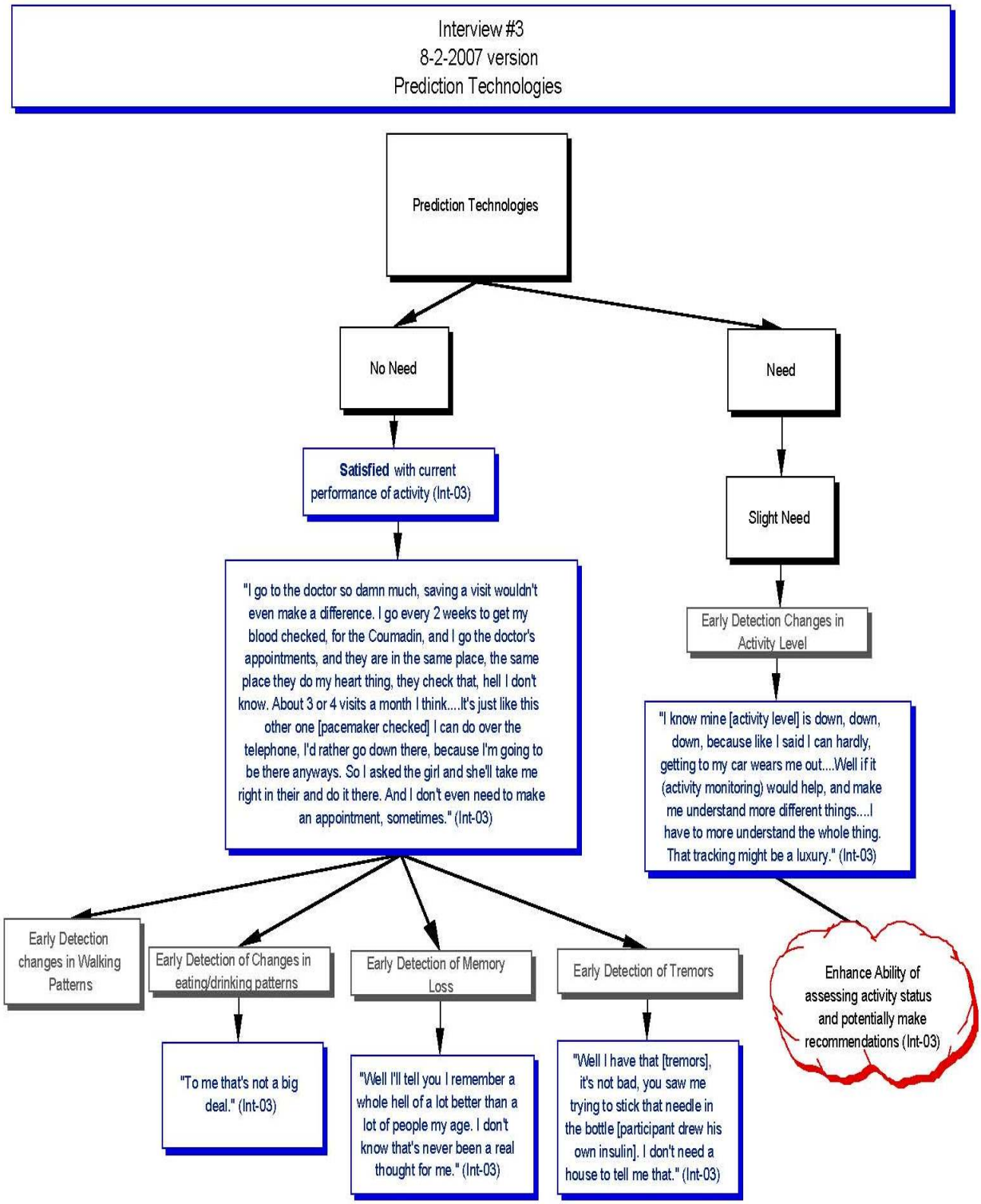

Figure 3-13. Participant 3's smart technology prediction technologies need analysis information sheet.

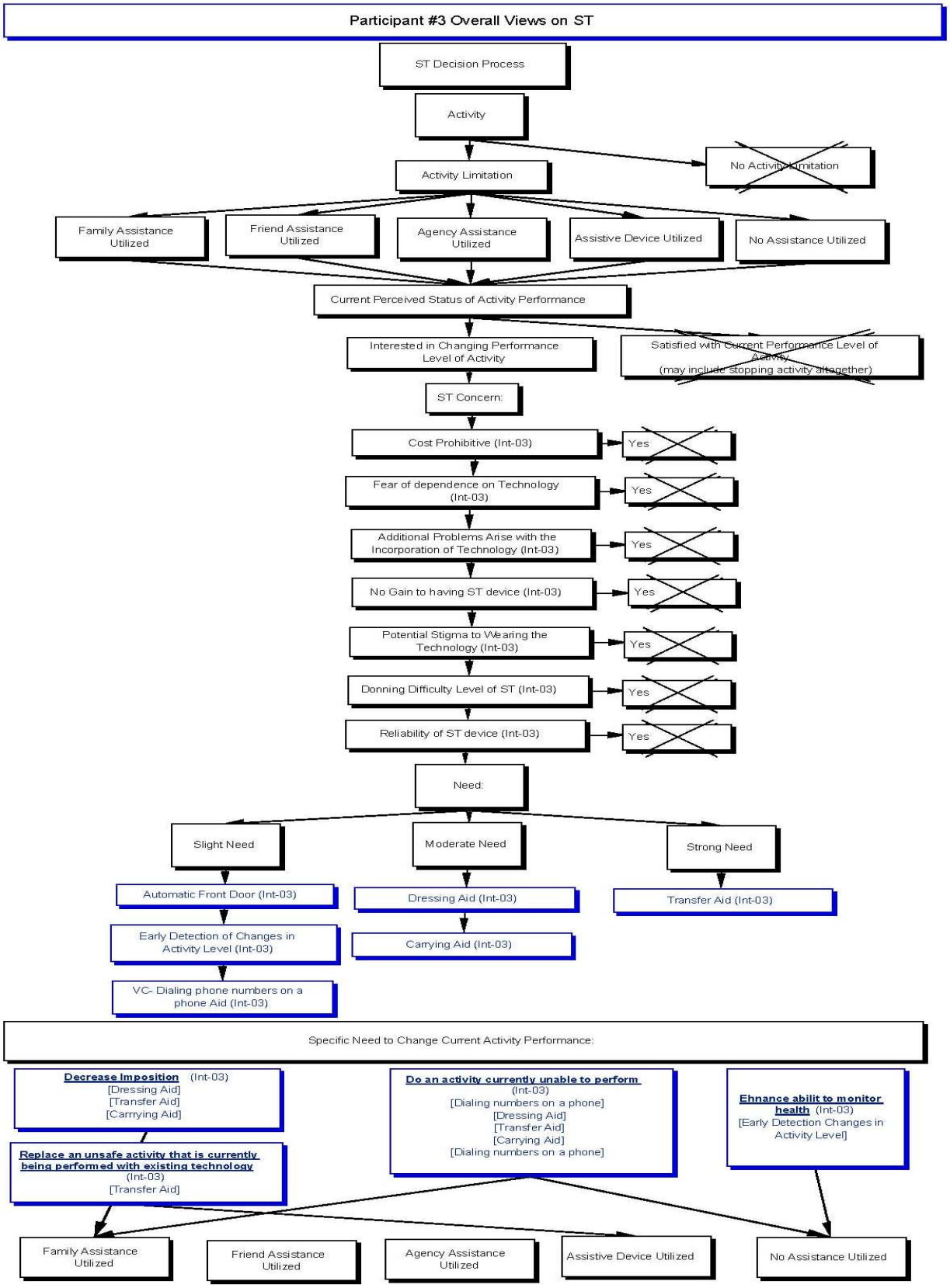

Figure 3-14. Participant 3's smart technology overall views need analysis information sheet.

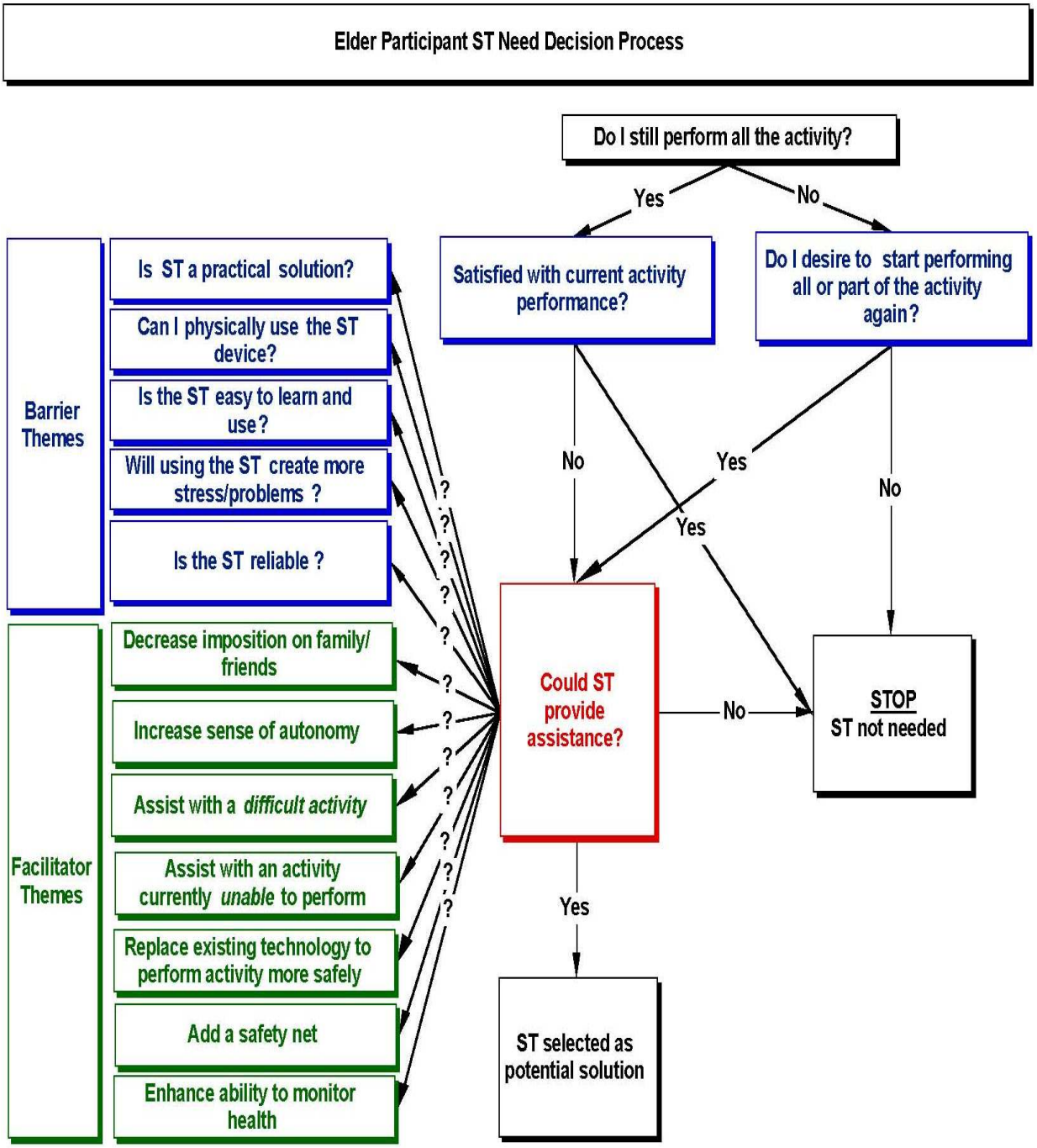

Figure 3-15. Composite elder smart technology decision tree model.

CHAPTER 4
FINDINGS

Introduction

The purpose of this study was to explore the perceived smart technology needs of elders with mobility impairments while constructing a preliminary decision tree model of how these decisions are made. To accomplish this task, the following research questions were addressed: 1) What do elders with mobility impairments perceive as their areas of difficulty in maintaining independence? 2) Which smart technology do elders with mobility impairments perceive as solutions (or encumbrances) in helping maintain their independence? 3) How do elders with mobility impairment make decisions in choosing which smart technology is needed or not needed? As characteristic with qualitative research *description* as well as *discussion* of the findings from the data will be integrated throughout this chapter.

This chapter includes four sections. The first section presents the demographic information of the sample. The next three sections correspond to the three research questions identified for this study. The next section examines participants' current activity performance status, thus determining the difficult areas participants had in maintaining independence. The third section focuses on categorizing the ST selected by study participants. The fourth section examines how study participants made their decisions regarding ST need. In this section themes are identified and quotes are used to provide greater understanding of each theme. Specifically an ethnographic decision tree modeling approach was utilized in this section to create a preliminary elder smart technology decision tree model.

Description of Participants

Participants ranged in age from 69 to 88 years, with a mean of 76(6.2). Sixty-three percent were female, and all were Caucasian. Fifty-five percent completed some college, and 27%

achieved at least an undergraduate degree. Demographic, health, and activity characteristics of the sample are summarized in Table 4-1. Thirty-six percent of participants lived alone, while 45% lived with a spouse, and 18% lived with an adult-child. Eighteen-percent of the sample had incomes under $15,000 per year, while 18% had incomes above $50,000 per year. Sixty-three percent of participants described their health as 'Good'. Fifty-five percent of participants could walk greater than 100-yards, and 27% had not fallen in the last year. Sixty-three percent of participants had less than five chronic conditions, and 18% utilized less than six assistive devices.

While sample findings are not generalizable due to the qualitative nature of the study, a comparison of the study sample parameters to the national elder population parameters is described below. The study sample ratio of male (36%) to female (63%) closely resembled the national parameter of male (41%) to female (59%)(He, Sengupta, Velkoff, & DeBarros, 2005). The study sample ratio of elders who lived alone (36%) to elders who lived with someone (63%) also closely resembled the national parameter of 28% to 66% respectively (Gist & Hetzel, 2004). In terms of education the study sample had a higher level of education with 18% receiving HS diplomas, 55% attending college, and 27% achieving a bachelor's degree as compared to national parameter of 32%, 18%, and 15% respectively(Gist & Hetzel, 2004). In terms of functional status the study sample had a much higher frequency of reported ADL difficulties with 18% of participants having difficulty with 1-2 ADLs, 55% of participants having difficulty with 3-4 ADLs, and 27% of participants having difficulty with 5-7 ADLs as compared to national parameter of 6%, 4%, and 3% respectively(He et al., 2005). However the study sample had a slightly lower prevalence of back problems (27%) as compared to the national parameter of 38%(Pfizer Global Pharmaceuticals, 2007). Lastly the study sample had a much higher

percentage of participants with a history of a stroke (36%) as compared to the national parameter of only 9%(Federal Interagency Forum on Aging-Related Statistics, 2004).

Research Question 1: What Do Elders with Mobility Impairments Perceive as Their Areas of Difficulty in Maintaining Independence?

The aim of the analysis in this section was to examine participants' current activity performance status, thereby determining the areas in which participants have difficulty maintaining independence. Documenting the status of the participants' daily activity needs is pivotal to the overall goal of this study, which is to explore how elders perceive the degree to which smart technology can meet these daily activity needs.

Activities of Daily Living

Within the seven major categories of activities of daily living (1-bathing/showering, 2-bowel and bladder management, 3-dressing, 4-eating, 5-functional mobility, 6-personal hygiene and grooming, and 7-toilet hygiene) assessed, the most frequently cited difficulties were functional mobility (100%), and bathing/showering (82%). The least frequently cited difficulties were bowel and bladder management (9%) and none of the participants had difficulty eating (Figure 4-1).

Out of the 154 ADL tasks assessed (14 ADL tasks assessed for each participant, refer to itemized list in Figure 3-3) participants cited having difficulty 47% of the time. These difficulties were met (via acquisition of AT, or family assistance) for 39% of the ADL tasks, however needs were reported unmet for 8% of the tasks (Figure 4-2).

Assistive technology (82%) and AT-family assistance (8%) were the most frequently cited method for resolving their ADL difficulties (Figure 4-3). The most commonly cited unmet-tasks were dressing (33%), getting in/out bathtub (17%), carrying items (17%), and climbing stairs

(17%) (Figure 4-4). Assistive technology (58%) and family assistance (25%) were the most frequently cited assistance methods that were not fully meeting their (unmet) need (Figure 4-5).

Instrumental Activities of Daily Living

Within the eight major categories of instrumental activities of daily living assessed (1-communication device use, 2-community mobility, 3-financial management, 4-health management and maintenance, 5-home establishment and management, 6-meal preparation and cleanup, 7-safety procedures and emergency responses, and 8-shopping), the most frequently cited difficulties were home establishment and management (i.e., vacuuming, yard care) (100%), meal preparation and cleanup (63%), and community mobility (63%). The least frequently cited difficulties were shopping (9%), and financial management (18%) (Figure 4-6).

Out of the 385 IADL tasks assessed (35 tasks assessed for each participant- refer to itemized list in Figure 3-4) participants cited having difficulty 19% of the time. These difficulties were met (via acquisition of AT, hiring assistance) for 16% of the IADL tasks, however needs were reported unmet for only 3% of the tasks (Figure 4-7). Family assistance (48%) and hiring assistance (20%) were the most frequently cited method for resolving IADL difficulties (Figure 4-8). The most commonly cited unmet-tasks were typing on a computer (23%), writing a message when on phone (15%), preparing meals (15%), and cleaning utensils (15%) (Figure 4-9). No assistance used (46%), AT (23%), and family assistance (23%) were the most frequently cited assistance method that were not fully meeting their (unmet) need (Figure 4-10).

Research Question 2: Which Smart Technology do Elders with Mobility Impairment Perceive as Solutions in Maintaining Their Independence?

The aim of the analysis in this section focused on categorizing ST selected by participants. Majority of participants (82%) cited at least one smart technology device as needed. Out of the seven major component areas of smart technology (1-remote control-voice, 2-remote control-

touchscreen, 3-household automation, 4-personal robotic assistance, 5-monitoring technologies, 6-reminding technologies, and 7-prediction technologies) assessed, the most frequently cited (as needed) component areas were personal robotic assistance (73%), and prediction technologies (64%)(Figure 4-11). The least frequently cited (as needed) component areas were household automation (18%), and remote control-touchscreen (0%).

Out of the 484 technology-decisions (44 smart technology devices assessed for each participant) participants regarded smart technology as needed only 11% of the time, (Figure 4-12). Eighty-nine percent of the time participants cited technology as not needed to maintain independence. Participants frequently cited ST as convenient or a novelty device. Of the 44 smart technology devices assessed (Table 4-2), only 16 devices (36%) were perceived as needed. Of the perceived needed devices the majority (89%) were cited as only slightly needed. The three ST devices that were cited as being moderately needed were the dressing-aid, blood pressure management-aid, and the carrying aid. The two ST devices that were cited as being strongly needed were the automatic front door, and the transfer-aid. Two of the ST main category groups had all of their ST devices selected at least one time. All the types of personal robotic assistance devices (walking aid, bathing aid, transfer aid, dressing aid, and carrying aid) were selected, as well as all of the types of prediction technologies (early detection: changes in activity level, memory loss, changes in walking pattern, and changes in eating/drinking pattern) were selected by at least one participant. When the participants were asked if their were any additional smart technology devices needed to assist in their daily activities, seven additional devices (voice-message aid, voice-typing aid, voice-dialing phone number aid on cellphone, food prep aid, utensil cleaning aid, monitor-appliance aid, and auto-checklist to remind when appropriate time for routine checkups) were cited (Table 4-2).

To further explore perceived smart technology need, participants were grouped by health condition, housing status, number of ADL deficits, and ambulation ability (Figure 4-13). Averaging the number of smart technology devices cited by members of in each group, revealed that participants with stroke cited more ST need than participants with back problems. The stroke participants selected more devices to assist with two-handed tasks (i.e., voice message aid, typing on a computer, and food preparation aid). Participants with additional deficits (ADL or ambulation) cited more ST need than participants with fewer deficits.

Research Question 3: How do Elders with Mobility Impairments Make Decisions in Choosing Which Smart Technology is Needed?

The aim of the analysis in this section was to explore how participants made their decisions regarding ST need; while constructing a preliminary decision tree model of how these decisions are made. The resultant elder smart technology decision tree model is discussed in this section. Themes are identified and excerpts from the interviews are used to provide greater understanding of the participants' perceptions of their ST need.

Elder Smart Technology Decision Tree Model

The elder smart technology decision tree model is presented in Figure 3-15. For these elders with mobility impairments, the model identifies that they began the process (of determining whether ST was needed) by ascertaining (if they were no longer performing all or part of the activity) if all or part of the activity should be restarted. If the participants were content with no longer performing all or part of the activity then the participants did not critically consider the ST device. If the participants desired to restart all or part of the activity then they would consider ST as a possible solution. If the participants were already performing the activity they would begin by ascertaining if they were satisfied with their current performance level. If the participants determined that they were satisfied with their current activity performance level

then they would not critically consider the ST device. If the participants determined that they were not satisfied with their current activity performance level they would then consider ST as a possible solution to assist with their activity performance. Dissatisfaction with current activity level was no assurance that the participants would necessarily desire ST to assist with their daily activity needs, due to the numerous other barrier criteria identified in the model. If any of the other barriers were a concern then the elders would not desire the ST device. Additional potential barrier decision themes that emerged when the participants were ascertaining if ST could assist with their activity performance were if the ST device was: practical, usable, easy to learn, reliable, or if it created more stress or problems. The model also identifies important facilitator criteria that could motivate elders to adopt ST assistance. These key decision criteria (i.e., barriers, facilitators) identified in the model are discussed in more detail in the subsequent sections.

Key Barrier Themes

Seven predominant barriers central to the participant ST need decision process emerged from the data (Table 4-3). The analysis revealed many complex sub-themes surrounding several of the predominant barrier themes that center on the participants' evaluation of the ST device itself. As illustrated in Figure 3-15 the first two predominant barrier themes initiate the ST decision process while the remaining five predominant barrier themes are not hierarchical. Each of the predominant barrier themes as well as their integrated sub-themes is presented below.

Do I desire to start performing all or part of the activity again?

In the following sections excerpts from the interviews are used to provide greater understanding of the participants' decision criteria. A primary barrier theme that emerged from the analysis of the data was that these elders with mobility impairments did not aspire to perform all (or part of all) 49 activities that were assessed. After their ability levels declined, activities

that were once performed in the past were no longer entirely performed. Participants were content with not performing all or part of certain activities. A common activity that was no longer performed was bathing in a bathtub (82%). Of those participants who no longer bathed in a tub, 78% did not miss the activity. An objective of ST is to provide compensation techniques to return an individual to functional status; however findings indicate that participants were content with not performing all or part of certain activities any longer. The point of being content with no longer performing all or part of certain activities is illustrated in the following quotes:

> Participant-5: No, I miss it [bathing in a bathtub], ah, sometimes.
> Interviewer: Now, if there was a relatively inexpensive technology that helps you get up and down from the tub, would you be interested in a device such as that?
> Participant-5: I don't miss it that much. (Transcribed Interview, pages 28, Participant 5).

> Interviewer: Do you get down [in your tub] and take a bath; do you get into the bathtub?
> Participant-11: I haven't; I haven't gotten in a bathtub in years.
> Interviewer: Is that something you miss, or is it--
> Participant-11: No.
> Interviewer: You're okay without that.
> Participant-11: Uh-huh. (Transcribed Interview, pages 47-48, Participant 11).

A subcomponent of the barrier theme of being content stopping all or part of an activity was that participants felt it was easier to adjust their actions or the activity itself rather than to incorporate external assistance as a solution to the difficult task. Participants felt it was easier to modify their behavior first over incorporating external devices. Rather than incorporating an assistive device (i.e., dressing stick, sock aid, button hook, robotic dressing aid) into their activity performance or asking for assistance (i.e., spouse, adult child) they would rather self-compensate or modify certain activities. This point is illustrated below,

> Well, you revise the way you're doing things, or you wear shoes that don't need to be tied (laughs) or whatever—uh—so that, I guess my feeling about this was--my overall feeling about the smart house was that it's easier to adjust a person rather than this over-the-top technology.(Transcribed Interview, pages 86, participant 8).

Another subcomponent of the barrier theme of being content with stopping all or part of an activity was that participants were found to be preplanning to stop or limit certain tasks. Rather than planning how they will maintain full functioning with tasks, the data analysis revealed participants were preplanning how they would be limiting future activities. Participants cited plans to stop certain parts of an activity (i.e., not having garments with buttons or zippers, not wearing socks or trousers) over planning how to fully perform an activity. Therefore a ST device that would allow them to wear garments with buttons and zippers would consequentially not be needed. This point is illustrated in the following quotes,

> Interviewer: Let's say it gets to the point where, you physically can't reach over anymore to put on your socks?
> Participant-4: I just wouldn't wear socks.
> Interviewer: What about for your trousers, you would resort to using a reacher?
> Participant-4: No, I'd wear skirts and tops. Of which I have a closet full, I just like wearing pants.
> Interviewer: So you would be able to modify your outfit so you wouldn't have to bother with,
> Participants-4: I would do that, before I went with those [assistive devices] other things.
> Interviewer: So with skirts you would just have to step into them?
> Participant-4: Well, you can pull it over your head, or you step into it, you see its not stepping in to, now the underpants you always got to do those, just have to do that, or
> Interviewer: So if it came to the underpants, you have to use some type of dressing stick?
> Participant-4: I suppose a person would, I have, but I don't feel like that's like socks, [participant laughs] I would just adjust my clothing, I wouldn't put on shoes and socks, I would put a robe on, I mean, I would just make compensations as I've always have. (Transcribed Interview, pages 20-21, participant 4).

This barrier may have several other subcomponents tied into the decision of stopping an activity, such as the length of time since stopping an activity or the pre-deficit gratification level of the activity. This barrier of being content with limiting all or part of an activity reveals a primary barrier central to the participant ST need decision process, if the elder consumer is content with not performing all or part of an activity then ST will not be needed to compensate

for the loss in activity performance. This barrier would limit the window of opportunity for ST to be needed by elders.

Satisfied with current activity performance?

The second primary barrier theme that emerged from the analysis was the most frequently cited barrier. Participants repeatedly cited being satisfied with their current activity performance level. 'No need' for smart technology emerged routinely during the study. This finding was reflected in data from research questions 1 and 2, where minimal overall reported unmet ADL (8%) and IADL (3%) need was found.

Satisfaction with doing activities in their own way was commonly alluded to by participants. Participants had adapted their method of activity performance and did not express a need to make a change in their behavior. Even if the task could be simplified and performed more easily with ST. Participants did not desire technology to help complete tasks more easily. Participants who would benefit from a robotic carrying aid frequently verbalized being satisfied with their method of activity completion and not desiring ST to assist. This point is illustrated by participant-2 who had balance difficulties, utilized a 4-wheeled walker for long distances, and had difficulty carrying items with both hands (contractured right-hand) below,

> Interviewer: What if he [robotic carrying aid] was able to grasp and carry items for you? What if he was able to grasp your basket that you use to carry items?
> Participant-2: I can carry the basket in my right hand; my left hand has to hold the cane. And I couldn't find a lot of use for him [robotic carrying aid]. Just to transfer a few books in and out of a room he would be totally worthless. I take my groceries out of the wagon, and put them on the counter….I think he would be too much trouble than he is worth. (Transcribed Interview, page 39, Participant 2).

Participants also commonly alluded to being satisfied with tasks taking more time than usual. If it took an extended amount of time to complete an activity (i.e., answering the door, turning on/off lights, walking across a room) participants were ok with it. Participants did not desire technology to help complete tasks faster. This point is illustrated by the quotes below,

Participant-5 who takes considerable time with her single-point cane (utilizes a 4-point cane at night) to ambulate across a room,

> Interviewer: Just getting around your home does take considerable time?
> Participant-5: Yeah,
> Interviewer: But giving you technology, it wouldn't be needed?
> Participant-5: Yeah,
> Interviewer: To save you time?
> Participant-5: yeah, yeah,
> Interviewer: Or do you feel that,
> Participant: Time, I have plenty of it,
> Interviewer: So you have plenty of time, you don't feel that, if you can only do things faster, you would be able to do more things each day?
> Participant-5: no,
> Interviewer: So you are okay with the balance of time and how long each activity you do takes?
> Participant: Yeah.

Participant-3 had a history of multiple strokes, limited left-hand functioning, could perform transfers only, and received dialysis three-times a week, stated,

> That'd [household automation] be nice, but things take a little bit of time right now and I can do it, so there's no need for it. I am in a lot better shape, than a lot of people that go out to that [dialysis] clinic. And a lot better attitude, a lot of them are so damn depressed; I try to keep a positive attitude. (Transcribed Interview, page 43, participant 3).

While household automation technology would have allowed participant-3 to more speedily turn on/off his lights and open/close his blinds he verbalized that he felt he could sufficiently perform the tasks (in his powered wheelchair). He cited 'things take a little bit of time right now and he can do it, so there's no need for it', expressing that he is content with how long it takes him to complete these activities.

Participants commonly alluded to being satisfied with their endurance level in performing tasks. If they could only walk household distances or only walk up a few steps at a time participants were generally satisfied with it. Participants did not have a strong desire for technology to improve their endurance level. For instance the majority of sample (82%) required AT to ambulate, however only 18% of participants cited a 'slight need' for the ST walking aid.

Even though participant-9 would benefit the most due to low endurance and difficulty walking household distances, he did not feel a strong need for desiring the robotic walking aid. Although the walking aid would allow participant-9 to potentially conserve his energy, and ambulate longer distances, he only felt the walking aid would be 'convenient' but not necessary. This point is illustrated in the below quotes,

Participant-9 able to ambulate household distances only.

> Interviewer: Let's say it [walking aid] did work, just like your lift chair worked. Let's say this thing worked and all the bugs were worked out of it and this thing would free up your hands—you wouldn't have to hold onto a walker any more—and they can say, "Well, you can use this and you wouldn't have to hold onto anything." What are your thoughts on that?
> Participant-9: It would be—be lovely.
> Interviewer: Would it be a necessity, or would it be just convenient?
> Participant-9: Convenient. (Transcribed Interview, pages 79, participant 9).

Participant-2 who has a history of a stroke, balance difficulties, utilizes a cane in home and a 4-wheeled walker for long distances, and has difficulty carrying items with both hands (contractured right-hand) cited that he considered the walking aid only appropriate for those who had a 'spinal cord injury'. Participant-2 who had trouble walking up steep ramps, up/down stairs without railing, and had problems carrying items while having to hold onto cane 'wouldn't bother with [walking aid]'. Even when the walking aid was presented as easy as a pair of slacks to don/doff the participant did not feel any need for the ST device. This point is illustrated in the below quotes,

> Interviewer: And now getting back to the robotic exoskeleton device, what are your thoughts on this? [pointing to the exoskeleton on the diagram]
> Participant-2: I, um, that's what I'm talking about I, I didn't see anybody, would this device be able to help someone walk down steps?
> Interviewer: Yes.
> Participant-2: I guess if a guy really had a lot of problems with his legs, it might be a good thing. I don't know, I would have to see a, the definite
> Interviewer: you would like to see it?

> Participant-2: no, I wouldn't want to see it, I would have to see the definite, it would have to be a person that would want to use this really bad. Who didn't walk very well, I don't walk very well, but rather than going to the trouble of putting this thing on, I would just use the stairs.
> Interviewer: so if this thing were to help you walk further, would be worth while to put it on? It would not only help you walk up and down stairs but it would help you walk further. It would be similar to putting on a pair of pants so once you got ready you would just put these on like a pair of pants and you just go about your day.
> Participant-2: I, um, today in my condition I wouldn't bother with it.
> Interviewer: is that because it would be too much trouble?
> Participant-2: too much trouble to put on.
> Interviewer: would you be concerned about becoming dependent on this device?
> Participant-2: that's not a concern. It is just too much trouble to put on. Now in all fairness if somebody was in a condition like Mr. Superman, who had spinal cord injury, I suppose it might be a good thing. (Transcribed Interview, pages 37, participant 2).

This barrier of being satisfied with their current activity performance level may have a subcomponent of length of time since onset of disability. Participants who have already adapted and established a daily routine for a long period of time may have become content with their activity performance level. Changing to a new assistance routine may be viewed as more arduous after having already modified or limited an activity. The analysis revealed that all participants were at least one or more years from initial onset of their chief condition. Therefore the participants may have become accustomed to their established daily routine for a long period of time. If ST was offered within the first few weeks of a loss of ability then potentially ST need would be greater, as the elder consumer may not have grown accustomed to their modified routine.

This barrier of being satisfied with their current activity performance level reveals a primary barrier central to the participant ST need decision process. If the elder consumers are satisfied, then ST will not be needed to only replace their existing activity performance method that they feel is being performed sufficiently. This barrier would limit the window of opportunity for ST to be needed by elders. Future researchers could further explore the issues surrounding

this barrier theme, which may have many more subcomponent tied into it (i.e., accepting of performance level, resisting change, established control issues).

Is ST a practical solution?

The third predominant barrier theme that emerged from the analysis centered on the issue of whether ST devices were a practical solution. All participants in this study indicated at one point concern that ST devices were not practical for their needs. When describing ST participants expressed that it was 'too costly', 'excessive', or had 'no gain'. Participants did not view ST as a practical solution to their daily activity needs.

Any gain to having ST device – (sub theme):

Forty-five percent of participants expressed that certain ST devices were not practical for their needs because they did not see any gains from the device. For example, participant-7 cited that she (or her family or friends) would know if she was losing her memory, or if her walking patterns changed. Therefore she did not need a ST device to tell her what she already knew. The point that ST is perceived as not being practical for their needs because no gain was seen with the device is illustrated in the following quote,

> I don't need this [prediction technologies], I mean—I don't need all those things 'cause I--I know—and people around me will notice—uh—that I'm losing my memory and my—I'm not walking, I know that. (Transcribed Interview, page 84, participant 7).

Cost prohibitive – (sub theme):

Ninety-one percent of participants expressed that certain ST devices were not practical because the technology would be too costly for their needs. Participants expressed that they only spent money on the necessities and that the minimal gain from technology was not worth the cost. For example even when the cost of retrofitting and home installation of a fall monitoring system was taken out of the equation, participant-3 did not feel a need to spend $30 a month for a

fall monitoring system. He felt that $30 a month would be too costly only to monitor him for falls when his daughter was out of the home. This point is illustrated by the below quote,

> Participant-3: You know how much it'd [fall monitoring system] costs?
> Interviewer: Let's say $30 a month,
> Participant-3: Who's going to pay to put it in?
> Interviewer: Let's say it comes with the house, let's say this is five years from now, and houses are being built with these technology devices preinstalled and can be available for activation.
> Participant-3: I know how it works, but I figured I couldn't afford it, and have it installed.
> Interviewer: Let's say its there in your home just has to be activated.
> Participant-3: I really don't know, it might be worth the $30, but if I got me and my daughter living together what the hell do I need it for. (Transcribed Interview, pages 49-50, participant-3).

Participant-7 initially expressed a desire to use a cell phone however changed her mind when she stated that she does not like to spend money on anything except necessities. She did not feel the added safety benefit of having a cell phone in her car was worth the expense. This point is illustrated below,

> Yeah; well (sighs), if I had one [cell phone], and somebody showed me how to use it, I probably would use it, but uh, I don't—all that expense—the reason I can live on nothing, which you know I do, uh is because I don't spend any money on anything except absolute necessities—and all that stuff takes—costs money—I'm a-a product of the Depression, that's what I am (laughs)—never gotten over it! (Transcribed Interview, page 27, participant 7).

Excessive technology – (sub theme):

Sixty-four percent of participants expressed that certain ST devices were not practical because they were too excessive for their needs. Participants frequently cited voice controlled, home automation, monitoring, reminding technologies as excessive. A few participants expressed that the only population that voice controlled and home automation technologies would be good for were paraplegics or quadriplegics. This point is illustrated in the below quotes,

> I don't need anything except for the remote control that I have for my TV. There isn't anything else that I would need to have done [to my home]. There is nothing there, I don't

> need a voice control thermostat or lights or blinds....I don't see, in my case anyway, any value in that [voice recognition]....I can't foresee that at all in my future unless I became a quadriplegic, that's who this would benefit, maybe a paraplegic. (Transcribed Interview, pages 33-34, participant 4).

> Some of the new technologies that I have seen, as in the smart house, are so far-fetched, I wouldn't waste my time on'em....The uh—opening and closing window shades, I think, is far-fetched. (Transcribed Interview, page 38, participant 9).

Participants' often cited that a simpler and less excessive solution could be developed that would be more practical for their needs. For example participants' often expressed a simpler solution would be to have a human assist over acquiring 'excessive' technology. Stating that when their needs became extensive they would need a human (personal caregiver) and it would be easier to have a human do the task (as opposed to the ST). This point is illustrated in the following quote,

> Well, I guess this was my thought somewhat, too, when I called the smart house "pie-in-the-sky," that I think somebody needs so much help would probably be better off in a place where—a group home, or something of the sort, where people are able to—to have various kinds of assistance, rather than having it from their house. I think some of those house things would be uh—more of a luxury or a convenience but not something for a real impairment. (laughs) (Transcribed Interview, page 76, participant 8).

This barrier of perceiving ST as not being a practical solution for their needs is central to the participant ST need decision process. If the elder consumer does not perceive ST devices as practical solutions to their needs then ST will not be needed to assist with their daily activities.

Can I physically use the ST device?

The fourth predominant barrier theme that emerged from the analysis was the least frequently cited (predominant) barrier. Twenty-seven percent of participants reported concerns of potentially not being able to adequately utilize the ST devices. For instance participants with limited use of an upper extremity expressed concerns of not being able to use touch screen devices as it requires the use of both hands. Concerns of not having adequate hand dexterity to don an exoskeleton walking aid were conveyed as well. Participants with visual impairment verbalized frequent problems utilizing ATM machines; therefore participants with visual

impairment would have difficulty utilizing the ST touchscreen devices. This barrier, being concerned that they would not be able to physically use the ST device, is central to the participant ST need decision process. If the elder consumer perceives that they can not physically use the device then ST will not be desired.

Is the ST easy to learn and use?

The fifth predominant barrier theme that emerged from the analysis centers on the ease in which the participants perceive ST as being utilized. Sixty-four percent of participants indicated concerns with both, how they were going to initially learn how to use the ST devices, and if their daily interactions with ST would be too complicated. Participants expressed previous experiences with not wanting to buy a new washer and dryer because they did not want to learn how to work the newer appliance. Therefore the idea of having to learn how to interact with a whole new (smart) home was overwhelming. This barrier is illustrated in the following quotes,

> Interviewer: And why would you say you wouldn't want to live in the smart house?
> Participant 9: It'd take too long to learn how to use it. (Transcribed Interview, pages 36-37, participant 9).

> Well, I don't like it when I get a new washing machine or dryer 'cause I don't want to have to learn the machine again. Uh—I don't have a lot of patience. I have less patience now that I've found out I've got Parkinson's (laughs) than I ever did…. I think I'd kill myself before I have to live like that [in a smart house]. (laughs) I think it would be one frustration after another, for me. (Transcribed Interview, pages 36-37, participant 11).

This barrier of being concerned with the ease in which the ST devices would be to learn how to use and how complicated the daily interaction would be is central to the participant ST need decision process. If the elder consumer perceives that the process of learning how to use the ST device or their daily interaction level as complicated then ST will not be desired.

Will using the ST create more stress/problems?

The sixth predominant barrier theme presented as the most complex theme with six sub-themes revealed during the analysis. This primary barrier theme centered on the concern that

utilizing the ST device would cause additional problems and stress. Fifty-five percent of participants expressed concerns that additional problems may accompany the utilization of ST. Any perceived value gained from utilizing the ST device would potentially be negated by the associated perceived new problem. Participants expressed that technology could potentially: cause physical dependency, bring unwanted stigma, replace needed human contact, and 'annoy' and 'stress' the participants with an overload of information. These potential new problems are discussed below.

Misinterpretation of information – (sub theme):

Eighteen percent of participants expressed that there may be more stress and problems created by the utilization of ST devices because the information output from the ST device may be misinterpreted. Participants expressed that they may become more anxious, and potentially would assume the 'worst-case scenario' when given so much information regarding their health. This point is reflected in the below quote,

> It [prediction technologies] sounds like a real stress inducer to me [participant laughs], this sounds like a potentially really troublesome, because of, it says okay, it gives you a symptom but it does not really interpret and the recipient's immediate response is the worst-case scenario, I have tremors oh my god I have Parkinson's now. (Transcribed Interview, page 31, participant 1).

Information overload – (sub theme):

Twenty-seven percent of participants expressed that there would be more stress and problems created by the utilization of ST devices because they may become irritated by technology telling or reminding them to do things. Participants expressed that having an inanimate object constantly telling them something would become annoying. This point is illustrated by the below quote,

> I know all these things [prediction technologies] when it happens, uh—I don't know the advantage—if you got sick enough that you didn't know these things, I don't the advantage of some inanimate object telling you. I—I—I don't respond favorably to this….I don't

> know that I would appreciate an inanimate object telling me, "Hey, you're not walking so good today" (laughs). (Transcribed Interview, page 79, participant 10).

Fear of dependency – (sub theme):

Twenty-seven percent of participants expressed that there would be more problems created by the utilization of ST devices because they have a fear of becoming dependent on the technology. One participant reported a fear of dependency, not on technology, but rather fear of dependency on having a personal assistant come in to help him bathe. His fear was that the less he physically does himself the weaker he will get and the more dependent he will become on the personal assistant. However the majority of participants who voiced fears of becoming dependent cited technology rather than human assistance as a concern. Participants expressed concerns such as having to use a wheelchair because they did not do enough for themselves. Or as, one participant stated, she would have to 'strap her lift chair on her back and take it with her' everywhere if she became dependent on her lift chair. The following quotes illustrate fear of becoming dependent on technology,

> Yeah; somebody thinks—somebody figures that out and thinks it up—they're smart, but some of the things aren't needed….I don't know—I think that we have too much help—I see my granddaughters, for instance, and they're both a little over—they're both overweight 'cause they don't do enough—they don't do enough, you know? And, I think we need to keep doing things for ourselves—I just—that's why this—all this stuff kind of turns me off, to tell you the truth….I mean, a wheelchair—you could do some things for yourself, and I'm not sure you don't end up in a wheelchair 'cause you don't do things for yourself, you know, I mean—(laughs). (Transcribed Interview, page 68, participant 7).

> Because I know that I'm not walking to get my exercise right now; and I know that pretty soon, I won't be able to do anything [due to progression of Parkinson's Disease]. If I use that damn lift chair to get out of the chair all the time, I'd have to strap it on my back and take it with me." And I'm not going to restrict myself like that. But I feel like my—my legs need the struggle that I go through to get out of that chair the way I get out of it. But I don't—I have never yet let it lift me up; I let it recline me. (Transcribed Interview, page 39, participant 11).

One caveat is that the analysis also revealed that a majority of participants (73%) were adamant about not being concerned about becoming dependent on technology. They verbalized

that they would basically be aware of becoming dependent on technology, however did not have a fear of it. Clarifying further if they were to start relying on technology (i.e., wheelchair) then they would automatically know that they should be sure to do exercises to keep up their strength.

Potential stigma – (sub theme):

The analysis revealed one participant that expressed a perceived stigma to technology. This participant was one of the few who would have benefited the most from the exoskeleton. Participant-3 utilized a powered wheelchair, could only perform transfers, fell 6-8 times in the last 12-months (due to his knees giving out), however he cited a strong stigma to needing the ST device. Specifically participant-3 felt the exoskeleton device was weird and he was concerned that people may think he was totally paralyzed when he was wearing it. This point is illustrated by the following quote,

> You're going to ride in a car and go uptown and let everybody see you like that…. It [robotic walking aid] looks yucky, I don't know, it looks like you're completely paralyzed or something, and that things got you going. That's what I would say…. I don't like the looks of it, I feel weird putting that damn thing on. (Transcribed Interview, page 44, participant 3).

Privacy concerns – (sub theme):

Eighteen-percent of participants expressed that there would be more stress and problems created because they would potentially have privacy concerns if they installed the ST device. Participants cited that they would not like having cameras monitoring their every move. This point is illustrated below,

> I wouldn't pay for that kind of [monitoring] agency. I could see myself paying for a person to be a companion, but that—that companion also would not have her eyes on me every instant of the time, uh—she would be there, but—it would also be a—uh normal relationship—now, I would—I would not go for the camera system under—well, I don't want to say "under any circumstances. (Transcribed Interview, page 72, participant 8).

One caveat was that when technology was presented in the form of monitoring with cameras and sensors, privacy became a concern, however when technology was presented in the

form of robotics and dressing aids the opposite effect occurred. Privacy was perceived as being enhanced by technology as participants did not want to have a human helping them with sensitive activities (i.e., dressing tasks). Participants stated that having a person help you dress may be too personal and a robot dressing aid would preserve some privacy.

Loss of human contact – (sub theme):

Twenty-seven percent of participants expressed that there would be more problems created by the utilization of ST devices because a few of the devices would limit human contact. Participants expressed a need for human contact because it provided a 'human element' of caring that a technological device was without. While participants expressed concerns of additional problems (i.e., trust) when having a hired care person in their home, these concerns where trumped by the potential of losing human contact. This point is illustrated below,

> I don't think I would like it [robotic assistance]. I would rather have human help or at pre—present, I don't need it. I can get up and down myself, but if I needed help, I think I would rather have human help than this….When you have someone come in your home and work, you don't immediately trust'em to help you get in and out of the bathtub. But, after they have become your friend and helped you in other areas, then I think you would, uh—you have to learn to trust'em—it doesn't come automatically, like—a robot—you don't care whether it trusts you or not (laughs)—it just does its job. The human—with a--with a human being, the human element comes into it…. and the fact that my husband helped me get dressed when I was sick—that—that warms your heart. (Transcribed Interview, page 68, participant 10).

This barrier centering on the concern that utilizing ST would cause additional problems and stress is central to the participant ST need decision process. If the elder consumer perceives that the utilization of ST would cause more stress and problems then any perceived value gained from utilizing the ST device would be negated. Therefore ST will not be desired. As this primary barrier theme was the most complex, further exploration of the issues surrounding the type of stress associated with type of problem would be beneficial. The study analysis process did not clearly differentiate between stress and problems that would be created.

Is the ST reliable?

The seventh predominant barrier theme that emerged from the analysis centered on the issue of perceived reliability of ST devices. Seventy-three percent of participants indicated concern that ST devices were not reliable. Participants with previous experience interacting with voice-recognition software expressed concerns that the technology was still not advanced enough for reliable use. Participants frequently expressed concerns that ST would frequently break. When evaluating ST need the participants frequently compared ST reliability with that of having a human caregiver. For example participants would cite that you do not have to worry about a human not understanding what you say. The concerns with ST reliability are illustrated by the following quotes,

> The reason—well, if, you know—if you have a good person that is reliable (laughs)—technology is not. (Transcribed Interview, page 77, participant 8).

> Right, because you wouldn't have those dirty, cords, I started to say that you wouldn't have to worry about them [voice controlled blinds] breaking, but the piece of machine is going to break first, (participant laughs). (Transcribed Interview, page 38, participant 4).

This barrier centering on the issue of perceived reliability of ST devices is central to the participant ST need decision process. If the elder consumer perceives the device as unreliable then the ST device will not be desired.

Key Facilitator Themes

Seven predominant facilitators central to the participant ST need decision process emerged from the data (Table 4-4). Facilitator themes were categorized by the type of assistance provided to the participant. For example ‘assist with an activity currently unable to perform’ was classified as providing physical assistance, ‘enhance ability to monitor health’ was classified as providing cognitive assistance, and ‘increase sense of autonomy’ was classified as providing psychosocial assistance. Elders with mobility impairments expressed more physical assistance facilitators (i.e.,

assisting with tasks that are difficult or are unable to be performed) than cognitive assistance facilitators (i.e., assisting with monitoring personal health status) or psychosocial assistance facilitators (i.e., decreasing imposition, increasing sense of autonomy) facilitators. Facilitator themes generally provided multiple types of assistance (physical, cognitive, or psychosocial) and as illustrated in Figure 3-15 they are not hierarchical in the elder ST need decision process. Each of these facilitator themes is discussed in detail below.

Decrease imposition on family/friends (psychosocial)

A primary facilitator theme that emerged from the analysis of the data centered on the issue of decreasing imposition on family/friends. Fifty-five percent of participants expressed a desire for ST to assist in lessening the burden of live-in family members (i.e., spouse, adult-child). Citing that at times family members would be burdened by having to stop doing what they were doing in order to assist the participant with a (dressing) task. Participants expressed that it would be 'more convenient' for ST to assist with their activity needs than imposing on their families. This point is illustrated by the following quotes,

> Dressing I don't really have a problem I just call my daughter, and she comes and helps me. She does a tremendous amount of stuff for me….it [robotic dressing aid] may be nice, does it button things? I mean that's one of the hardest things I can't do is button things. Because I use to have one of them button hooks, but you know how long that thing takes?.... I just leave my shirts buttoned, and pull them over my head like a T-shirt…. I can do it, but it's a tough job. If it would help, hell yeah….well so far I do not need it [robotic dressing aid], but it would sure be nice if I had it. I mean I don't know what kind of attitude to give you, but that's the way I feel about it….Oh I am not comfortable, because it [donning slacks] is awful difficult, and sometimes she [daughter] is doing something else and gets all ticked off. You know how that is so….I don't like to have to depend on my family because they got their own lives and everything. (Transcribed Interview, page 45-46, participant 3).

> The [dressing aid] robot's not as good-looking as she [spouse] is, but probably would be more—probably be more convenient. Just—just so she wouldn't be—one of the things she wouldn't have to do. (Transcribed Interview, page 51, participant 9).

> Yeah I would get the robot, over my husband….I don't want to interrupt him [spouse], because it's always more convenient to call a robot over a person. (Transcribed Interview, page 51, participant 5).

Findings also indicate that the facilitator theme of desiring to decrease burden of family extends beyond live-in spouses and adult-children. Participants in the study who did not currently live with any adult children indicated they felt that their children have lives of their own and they did not want to burden them. A few participants indicated that they would rather hire someone to assist with their needs rather than burdening a family member. This point is illustrated in the following quote,

> Yes; I would like to have somebody because I don't know if I would need something, you know. But, otherwise, they [neighbors in building] have told me that, "You do have a son." Well, thank goodness, I do, but I don't like the idea that I have to depend on my kids, and I don't want them to feel that they are obligated to have to run every time that I need something, you know, I don't like that dependent feeling. It makes me uneasy, to say the least…. I wouldn't mind having to pay somebody to, I don't know, whatever it is--- But, uh—Or the maintenance people, whatever, but the maintenance people are—he's actually doing double the amount of work that he would be, that person should be having to do, you know what I mean? They should really have two people for maintenance, but they just have this one, and he's really over-worked. And, so, I really would hesitate to call him, knowing that he's doing more than his share. (Transcribed Interview, page 16, participant 6).

> Uh-huh. I think that's [remaining in own home] key to my happiness and—and what I want for my daughter and her husband also. I don't want them to have to give up their lives to worry about me. I have a long-term care policy, but it's—(laughs) they're never long enough term, you know? (Transcribed Interview, page 16, participant 6).

A subcomponent of the facilitator theme desiring to decrease imposition on family members, that was revealed was those participants who have previous experience with care giving may be wary of burdening their family members. For example participant-10 expressed concerns of potentially losing her 'very good relationship' with her children by burdening them with her activity needs. Participant-10 cited the experience of losing the great relationship she had with her 'angel mother', when she had to start caring for her mother who became very

distrustful while the participant was her caregiver. An example of this is illustrated by a quote from participant-10 below,

> That's the main thing. We have a very good relationship with both of our [children]—they like us; we're friends; they enjoy being with us; we go out to eat for every birthday and every anniversary and every opportunity we get; we just were out last Saturday night's why I keep pointing at this (gestures)—uh—after my experience with my mother, I—I just don't think it would work; and I would not risk our relationship for that, uh—if I couldn't afford to hire somebody, one of our—we have some insurance policies that, when the CD rates went down, we bought….but one of the policies has a thing that if I get where I can't live alone and I need help, that I can borrow money from that to go into a nursing home. I would go into a nursing home before I would stay with my children. Now, the only way I could afford it would be either sell the house or somehow qualify for Medicaid. Uh—I think you can keep your house and qualify for Medicaid, and I could probably qualify for Medicaid money wise, uh—if they let me keep the house. If I had to sell the house, of course, I'd have that money. So, that would not be my first choice…. like I said, when we came here (laughs) from a very happy life of traveling in an RV to take care of my "angel mother," who had always been the world's greatest—my—my friends all called her "Mom"—she was just--she was just "Mom"—but the—the disease made her very uh—contrary—very suspicious. (Transcribed Interview, page 23, participant 10).

This facilitator theme centering on the issue of decreasing imposition on family/friends is central to the participant ST need decision process. If the elder consumer perceives the ST device as potentially relieving a family member's burden then ST device may be desired.

Increase sense of autonomy (psychosocial)

The second primary facilitator theme that emerged from the analysis of the data centered on the issue of increasing the participants sense of autonomy. Eighteen percent of participants expressed a desire for ST to assist in providing more autonomy. For example a few participants chose technology over hiring a caregiver due to perceiving that technology would provide a greater sense of autonomy. Also participants expressed that they would feel more in control of a robot than a hired caregiver. This point is illustrated by the following quotes,

> Interviewer: You can either have this robot stay with you and help you dress and do your morning routine, or have an agency care assistant come in and help you?
> Participant-6: I probably would prefer the robot.
> Interviewer: And that would be because? Privacy?

Participant-6: Um (long pause), possibly. I probably would feel that I was still independent.
Interviewer: Because you would be having the robot do something for you? Rather than relying on?
Participant-6: On a human being, yes.
Interviewer: Now, with the human being, you would have control of the human being; you know, you would pay them and stuff—but, that wouldn't necessarily be as much control as having the robot and telling the robot what to do?
Participant-6: Right.
Interviewer: Because you can tell the robot to put on your sock a lot easier than telling a person to put on your sock.
Participant-6: Well.
Interviewer: Depending on the relationship you had with that caregiver?
Participant-6: Yeah. (Transcribed Interview, pages 73-74, participant 6).

This facilitator theme centering on the issue of increasing sense of autonomy is central to the participant ST need decision process. If the elder consumer perceives the ST device as potentially increasing their sense of autonomy then the ST device may be desired.

Assist with a *difficult* activity (physical/cognitive assistance)

The third primary facilitator theme that emerged from the analysis of the data was the most frequently cited facilitator. This theme centered on the issue of assisting with activities that were currently difficult to perform. Eighty-two percent of participants expressed a desire for ST to assist in providing assistance (i.e., physical, cognitive) with activities that they were having difficulty performing. Participants frequently cited a desire for ST to assist with physical activities such as dressing or preparing meals, and with cognitive activities such as medication management or remembering to perform daily exercises.

A few participants who had difficulty with two-handed tasks frequently expressed a need for ST to assist with food preparation activities. For example, participant-1 cited he no longer utilized his stove or oven but rather only utilized his microwave to prepare his meals. He stated that prepackaged meals were all that he could make and that a ST device that would assist with preparing food would be readily accepted. Also, participants who had difficulty getting in and

out of their front door expressed a need for physical assistance in the form of an automatic door. The need for ST to provide physical assistance with difficult tasks is illustrated in the quotes below,

> Nah most of this [reminding technology] is stuff I'm so conscious of anyways that I really don't need any of this. Now on the other hand for the food recommendations, if it could just fix the food that would be great [participant laughs]. I know what I should be eating but I, I would like more salads but fixing them is not the easiest. (Transcribed Interview, page 30, participant 1).

> Yes I would like that [automatic front door] because I could buzz in and out with my scooter, I would be interested in that. Oh boy….The door would be nice because I would be able to zoom in and out with my scooter, because now I have to get up and prop the door. (Transcribed Interview, page 33, participant 1).

A few participants who had difficulty with their medication routine frequently expressed a need for ST to assist with reminding them when it was time to take their medications. For example participant-6 normally had a routine (i.e., keeping her medication bottle inverted) in place to remember if she took her medications. However on the days that she would do certain activities (i.e., paying bills) on her kitchen table she would move her pill bottles and subsequently forget to take her evening medications. Participants who had difficulty remembering to always perform exercises expressed a desire to have technology assist in reminding them to perform daily exercises. For example participant-9 who sometimes had his wife remind him to exercise, wanted more assistance as he felt that he was too often forgetting to exercise. The need for ST to provide cognitive assistance with difficult tasks is illustrated in the quotes below,

> Well, not actually necessary, but it probably is getting to that point because I occasionally have forgotten to take this [gestures to medication bottle]….Yes, I think that would be almost a necessity because I do occasionally forget to take the medications at night, you know. In the morning, I just automatically do that the first thing, see; I do that even before I get dressed, so—to make sure that I'm taking them, you know; but, occasionally, I forget to take this one here (gesturing) that I take only once a week, and, every now and then, I'll forget about that, even though I usually put it like this (gesturing) so that I don't forget it; and yet, in the evening, I'll take this here and I'll put it away like this here (gesturing) in

> order to have a space over here to do something else, uh, pay the bills or something, you know,--And, then I forget to put this back here so that I would remember, and then I'll forget-- (Transcribed Interview, page 67, participant 6).

> [Reminding technologies – physical exercise] Well, I hate to say this because it opens the door for her [spouse]—but I need help being reminded to do more physical [exercises]. (Transcribed Interview, page 85, participant 9).

A subcomponent of the facilitator theme assisting with activities that are currently difficult to perform, that was revealed was that participants had certain expectations of how long an activity should take. While some participants were comfortable (as cited in earlier examples) with activities taking a long duration of time, other participants cited a need to lessen the time required to complete certain activities. Difficult activities that take longer than a participant expects potentially may be an area for ST assistance. For example participant-7 expressed a desire for ST to assist with donning her support stocking due to the fact that it takes her a long time to put them on. Tasks that are difficult but are quickly performed may not necessarily need ST to assist, however if a task is difficult and takes too long (per participant's expectations) then ST potentially may be desired. This point is illustrated in the below quote by participant-7,

> Interviewer: So, if there were a device that could help you put on your support stockings or hose, you'd be open to that idea?
> Participant-7: Yeah, right.
> Interviewer: Would it be necessary, convenient, or not needed, as far as that technology is concerned?
> Participant-7: Well, I'd say, necessary—I guess, except that, since I don't use it now, it's obviously not necessary 'cause I get along without now (laughs)—but, it could be necessary, yeah—if it was available.
> Interviewer: So, you're not able to put on the stockings yourself at this point--?
> Participant-7: Yeah, I put'em on; but it's time-consuming and not easy--
> Interviewer: So the reason that shifted to necessary is because it's something that you're able to do, but you're not able to do it at the speed
> Participant-7: Yeah
> Interviewer: Or at the comfort level that you want, so that's why it became necessary--?
> Participant-7: Yeah, yeah—exactly—

This facilitator theme centering on the issue of assisting with an activity that is difficult to perform is central to the participant ST need decision process. If the elder consumer perceives

the ST as assisting with activities that are physically or cognitively difficult to perform then ST device may be desired.

Assist with an activity currently *unable* to perform (physical assistance)

The fourth primary facilitator theme that emerged from the analysis of the data centered on the issue of assisting with activities that were currently unable to be performed. Fifty-five percent of participants expressed a desire for ST to assist in providing physical assistance with activities that they were no longer able to perform. The findings indicated that participants were the most open to solutions to tasks that they were no longer able to perform (as long as they desired to restart the activity). This facilitator theme was the most easily identifiable theme as these activities were not being met by their present resources (AT, family, hired assistance). Participants were quicker to accept the idea of ST assisting them with these tasks. For example participant-3 who no longer could carry items due to his poor coordination and decreased range of motion in his left hand desired ST to assist with carrying items for him. This point is illustrated by the following quotes,

> That [robotic carrying aid] would be good too, you see I can't really carry anything, this arm really can't hold crap….Even though I try to carry things with it but I just drop it. It would be very nice, it would take a load off or her. Like I said she washes all the clothes and dries all the clothes. (Transcribed Interview, page 23, participant 3).

> Yeah—that'd [climbing stair aid] be kind of nice, if it—if it—if it really helped and I—it didn't, you know, my back didn't kill me when I used it—that would be nice to be able to walk —no—I'd like that. (Transcribed Interview, page 72, participant 7).

This facilitator theme centering on the issue of assisting with an activity that is unable to be performed is central to the participant ST need decision process. If elder consumers perceive that ST devices can assist with activities that they are physically unable to perform then the ST device may be desired.

Replace existing technology to perform activity more safely (physical or cognitive)

The fifth primary facilitator theme that emerged from the analysis of the data centered on the issue of replacing existing technology in order to perform an activity more safely. Forty-five percent of participants expressed a desire for ST to assist in providing assistance (i.e., physical, cognitive) with activities that they felt needed to be performed more safely. Participants frequently cited a desire for ST to assist with physical activities such as carrying items or turning on/off bedroom lights, and with cognitive activities such as appliance monitoring.

A few participants who had difficulty with two-handed tasks frequently expressed a need for ST to assist with carrying activities. For example, participant-1 cited that he felt as though he was 'walking on the edge of disaster' because he would either have to ambulate without his cane or utilize his affected extremity to carry an item while walking. Either method was not ideal as it took him considerable attempts to transfer from a seated position to a standing position and once ambulating his balance and coordination were both poor. This point is illustrated by the following quotes,

Physical assistance:

> Well I tell you something that would be useful, would be a big carrier, a wired controlled carrier, for instance a dolly in which I can put things on it and then control it with a like a remote-controlled car and having carry things back to my bedroom. A radio controlled cart….Yeah it would definitely be a very practical utilitarian device; you can carry your laundry basket on it or trash basket or whatever. You know when I'm walking I'm trying to carry something I have my cane in the left hand and have to carry something in my right hand, so I'm usually walking on the edge of disaster. (Transcribed Interview, page 24, participant 1).

> Yeah—I would—I would probably go for that [voice control lighting], particularly at night would be convenient, you know, if I'm sitting out here reading, and turn this light off, then—I don't want to walk to the bedroom in the dark, so I either have to have a flashlight or have a light already on in there—and, uh, so—that would—that would be a convenient thing to have, uh—you know, we—we function very well this way—uh—my husband doesn't—uh—lights don't annoy him, and a flashing light will immediately awaken me, so we've—we've learned to (laughs)—how to adjust for this, so if I'm in bed, he will use a little flashlight so he doesn't turn on the light and awaken me, and that kind of thing—so,

> if we—if there were some other kinds of ways to uh cope with lighting, that would uh be a useful thing--(Transcribed Interview, page 42, participant 8).

Cognitive assistance:

A few participants who had difficulty remembering to turn off their stovetop expressed a need for ST to assist in notifying them or automatically shutting off the stovetop appliance. For example participant-8 who had a gas stovetop in her previous home expressed that it was difficult to notice if she (or her husband) left the electric stove top on. This point is illustrated by participant-8's quote below,

> Uh huh—I would like that [stovetop monitoring]….Yeah—somebody—you know, somebody's been having something on low heat, and you'll walk away—uh—my spouse has that problem more than I do (laughs), but—uh—we've—we've each done it sometimes—and there—there again, it's—it's principally 'cause we were always used to gas [burners], and then, you know, you—it's off—you know it's off or on (laughs)—and--and with this little [electric] grill, you—you don't necessarily—uh—that also could be better controlled by uh—a smarter stove (laughs)— (Transcribed Interview, page 47, participant 8).

This facilitator theme centering on the issue of replacing existing technology in order to perform an activity more safely is central to the participant ST need decision process. If the elder consumer perceives the ST as assisting with activities that are being performed unsafely then the ST device may be desired.

Add a safety net (physical/psychosocial)

The sixth primary facilitator theme that emerged from the analysis of the data centered on the issue of providing a safety net. Eighteen percent of participants expressed a desire for ST to assist in monitoring for falls. This facilitator was not frequently cited by participants as the majority of participants lived with someone (i.e., spouse, adult-child) and they felt that the live-in person acted as their safety net. However a few participants expressed a desire for ST to assist with monitoring them for falls. For example Participant-1 felt ST would be ideal for monitoring him for falls while his adult-son was gone weeks at a time. Also participant-6 lived alone and

cited a need for a fall monitoring system due to her fear of falling while in her apartment. This point is illustrated by the following quotes,

> Yeah it would be useful especially when my son is on the road, and he gets concerned when I try to do things too fast he is concerned about me falling. I have fallen a few times, but it has been a quite a while since I've fallen. (Transcribed Interview, page 28, participant 1).

> Participant-6: I have felt that way up 'til now, yes. But, lately I've been wondering if I shouldn't—as long as I have a little bit more money than I did have in the past, that maybe I should get that---
> Interviewer: Pendant---the emergency response system?
> Participant-6: Yes. So, out of all of these, nothing's really necessary, whereas the only one that's necessary is the fall [monitoring system]--
> Participant-6: Yeah--
> Interviewer: and, at this present time, it may be necessary--?
> Participant-6: Right. (Transcribed Interview, page 65, participant 6).

This facilitator theme centering on the issue of providing a safety net is central to the participant ST need decision process. If the elder consumer perceives the ST device as effectively providing a safety net (i.e., monitoring for falls) then the ST device may be desired.

Enhance ability to monitor health (cognitive)

The seventh primary facilitator theme that emerged from the analysis of the data centered on the issue of enhancing cognitive ability to monitor health status. Seventy-three percent of participants expressed a desire for ST to assist them with monitoring their health condition. Participants frequently cited a desire to more objectively measure their health status. For example participant-1 felt that his subjective impressions may be inaccurate and he may not become aware that his abilities were declining. Also participant-2 expressed a strong desire for an objective system that would remind him when he needed to get a checkup. This point is illustrated by the following quotes,

> Well, tremors if I, if I starting to get the shakes every once in a while, I would go see the doctor, I have a problem, but I never had before, if I get out of bed, and I get up really fast, there are times that I get a little dizzy, so I called the provider, and I said this happens to me, and she said believe it or not it happens to me too, and I am only a third as old as you

> are, that's perfectly normal, I said well okay, then I won't concern myself with it, but, that's the important thing, you got to find, there should be a checklist, that you, you, like you get a driver's manual, when you buy a new car you open the glove compartment there is always a driver's manual and it. And they say this is the thing you look for, the tire pressure, you know, there should be a manual, and I think that would be more helpful than anything. (Transcribed Interview, page 45, participant 2).

> For me, oh boy. I suppose, yes, because sometimes our subjective perceptions aren't as objective assessment of what we think we are doing, yeah yeah yeah I agree, this [prediction technologies] could be enlightening because sometimes what we think we are doing is not really what we are doing….I suppose that would be useful, if I started to get lazy, and then I would see the graph and say oh my goodness…. I'm just saying it would seem to be more beneficial, because I think that activity could change without being aware of it. You could start getting lazier and lazier, and think that things are just fine. (Transcribed Interview, page 32, participant 1).

Summary

The results suggest that the general perception of the sample was that the majority of their ADL and IADL needs were being met. Participants perceived very little unmet ADL and IADL needs. In addition the results suggest that the general perception of the sample was that ST was perceived as not needed in order to maintain their independence. Participants frequently perceived ST as a novelty or a convenience device but not needed for their independence.

The results suggest that when ST was perceived as needed, robotic assistance technologies may easily match many of the ADL and IADL unmet needs cited by study participants. Robotic assistance technology (i.e., dressing aid, carrying aid, food prep aid) was found to be the most frequently desired ST component area. In addition the results also suggest that prediction technologies may be perceived by study participants as adding something to their abilities. Specifically prediction technology may be perceived as going beyond compensation for a loss in activity performance. Prediction technologies may have been perceived by participants as providing an additional ability (beyond compensation) to monitor their health.

The results also suggest that there are multiple key barriers and facilitators involved when elders with MIs make decisions in choosing which ST is needed or not needed. A predominant

barrier to ST need that was identified in the findings was that study participants were found to be satisfied with their current activity performance. Study participants were content with performing their activities in their own adapted styles. The results suggest that if the study participant was satisfied with their activity performance status, then ST will not be needed to only replace their existing activity performance method that they feel is being performed sufficiently.

Another predominant barrier to ST need that was identified in the findings was that study participants had concerns that utilizing ST would create more stress and problems. For example participants expressed that they may become more anxious, and potentially would assume the 'worst-case scenario' when given so much information regarding their health. The results suggest that if the study participant perceives that the utilization of ST would cause more stress and problems then any perceived value gained from utilizing the ST device would be negated. Therefore ST will not be desired.

A predominant facilitator to ST need decision process that was identified in the findings was that study participants desired to decrease imposition on family and friends. Participants frequently cited that at times family members would be burdened by having to stop doing what they were doing in order to assist the participant with a task. Participants desired to lessen the burden of their live-in family members. The results suggest that if the study participant perceives the ST device as potentially relieving a family member's burden then ST device may be desired.

Another predominant facilitator to ST need decision process that was identified was that study participants desired ST to replace existing technology in order to perform their activities more safely. For example participants reported a need for ST to assist in carrying items, turning on/off lights, and monitoring appliances. The results suggest that if the study participant

perceives the ST as assisting with activities that are being performed unsafely then the ST device may be desired.

Finally the resulting preliminary decision tree model suggests that the elder smart technology need decision process is complex. The model illustrates that there are numerous decision criteria surrounding the elder ST need decision process. The results suggest a decision process that is not linear, but more of a multidirectional process.

Table 4-1. Demographic, health, and activity status information

	N=11 Frequency (%)		N=11 Frequency (%)
Age	Mean = 75.8 (SD= 6.2)	Overall Health Condition Described as	
65-69	3 (27%)	Excellent	
70-74	2 (18%)	Good	7 (63%)
75-79	3 (27%)	Fair	3 (27%)
80-84	2 (18%)	Poor	1 (9%)
85+	1 (9%)	No. of Chronic Conditions	
Sex		0-1	1 (9%)
Male	4 (36%)	2-3	2 (18%)
Female	7 (63%)	4-6	7 (63%)
Race		7+	1 (9%)
Caucasian	11 (100%)	No. of ADL Difficulties	
Education		1-2	2 (18%)
High School	2 (18%)	3-4	6 (55%)
College No Degree	6 (55%)	5-7	3 (27%)
College Degree	3 (27%)	No. of IADL Difficulties	
Living Arrangements		1-2	3 (27%)
Live Alone	4 (36%)	3-4	4 (36%)
Live with Spouse	5 (45%)	5-8	4 (36%)
Live with Adult-Child	2 (18%)	No. of Falls-last 12 months	
Annual Income		none	3 (27%)
Less than $15,000	2 (18%)	1-3	6 (55%)
$15,000-$29,999	3 (27%)	4-6	1 (9%)
$30,000-$49,999	4 (36%)	7-9	1 (9%)
$50,000 or more	2 (18%)	Typical Walking Distance	
No. Assistive Devices Utilized		>100 yards (>300 ft)	6 (55%)
1-5	2 (18%)	House & Yard Only	3 (27%)
6-10	6 (55%)	Household Only	1 (9%)
11-15	2 (18%)	Transfers Only	1 (9%)
16+	1 (9%)		

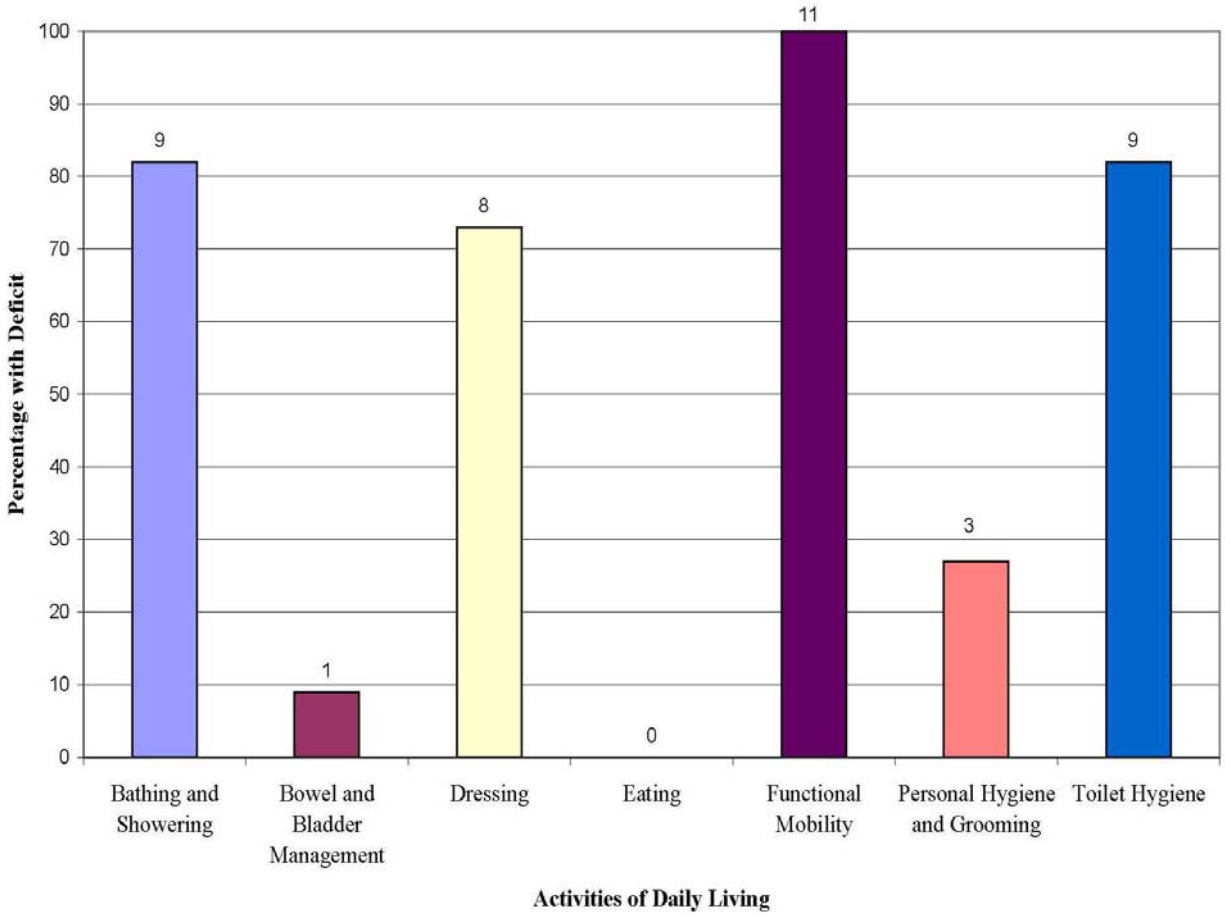

Figure 4-1. Participants with deficits in activities of daily living.

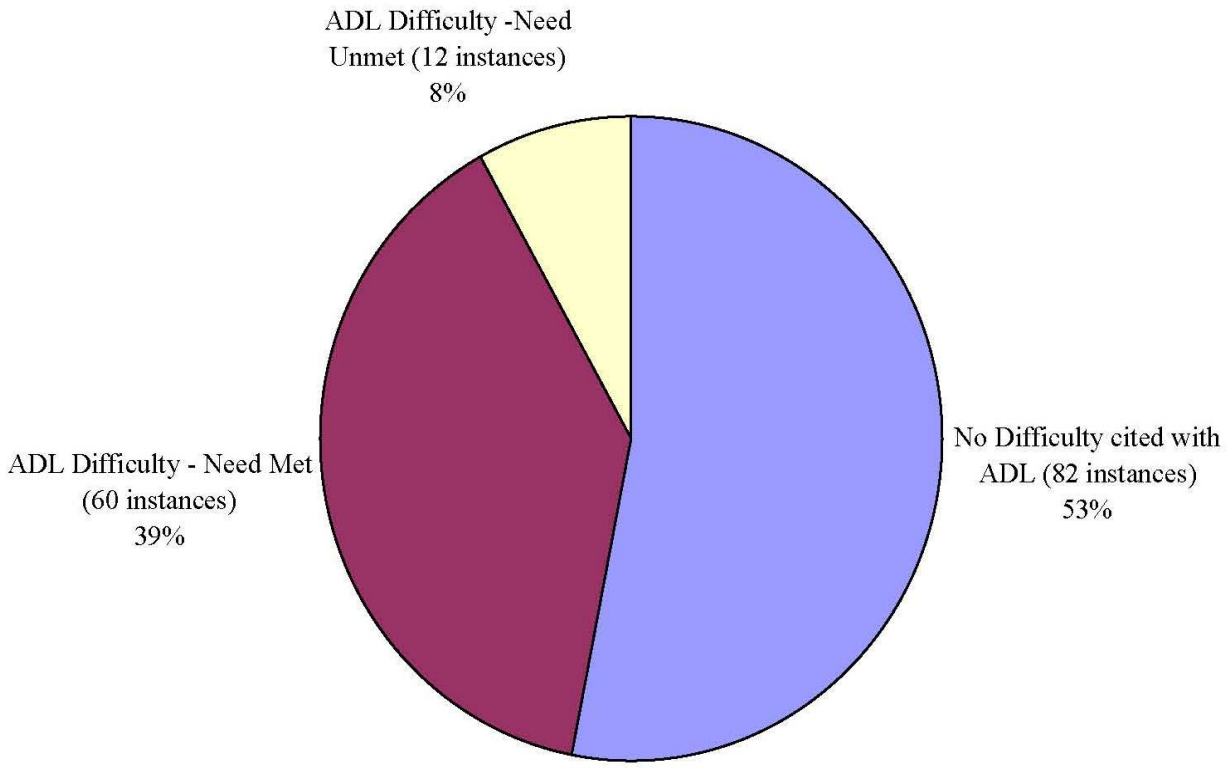

Figure 4-2. Report of ADL tasks with/without difficulty and whether need was met/unmet for the sample. A total of 154 instances ADL tasks were assessed (that is 14 ADL tasks x 11 participants = 154 instances).

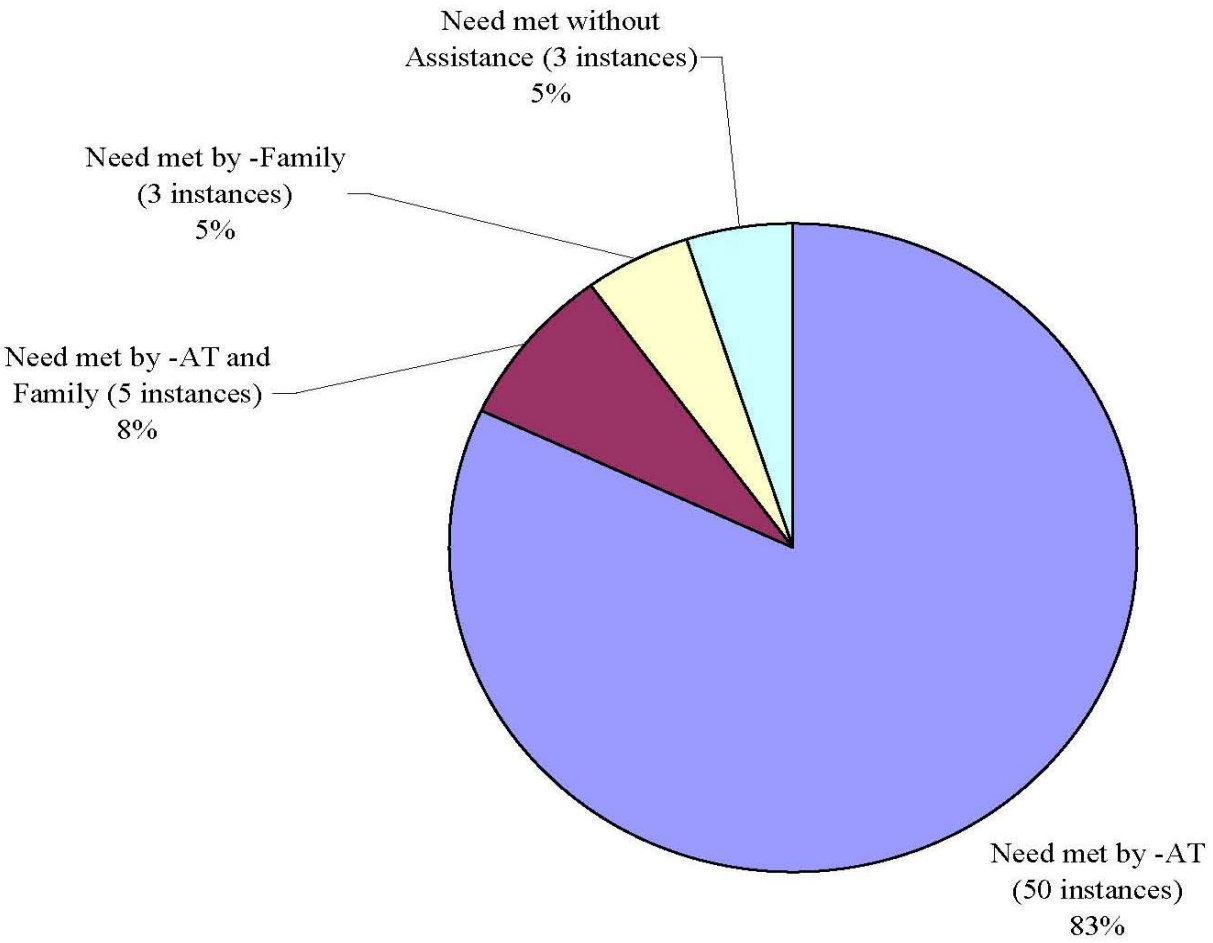

Figure 4-3. Report of how ADL-difficulty needs are being met. This is out of a total of 60 instances were ADL tasks were reported as difficult whilst needs were met for the sample.

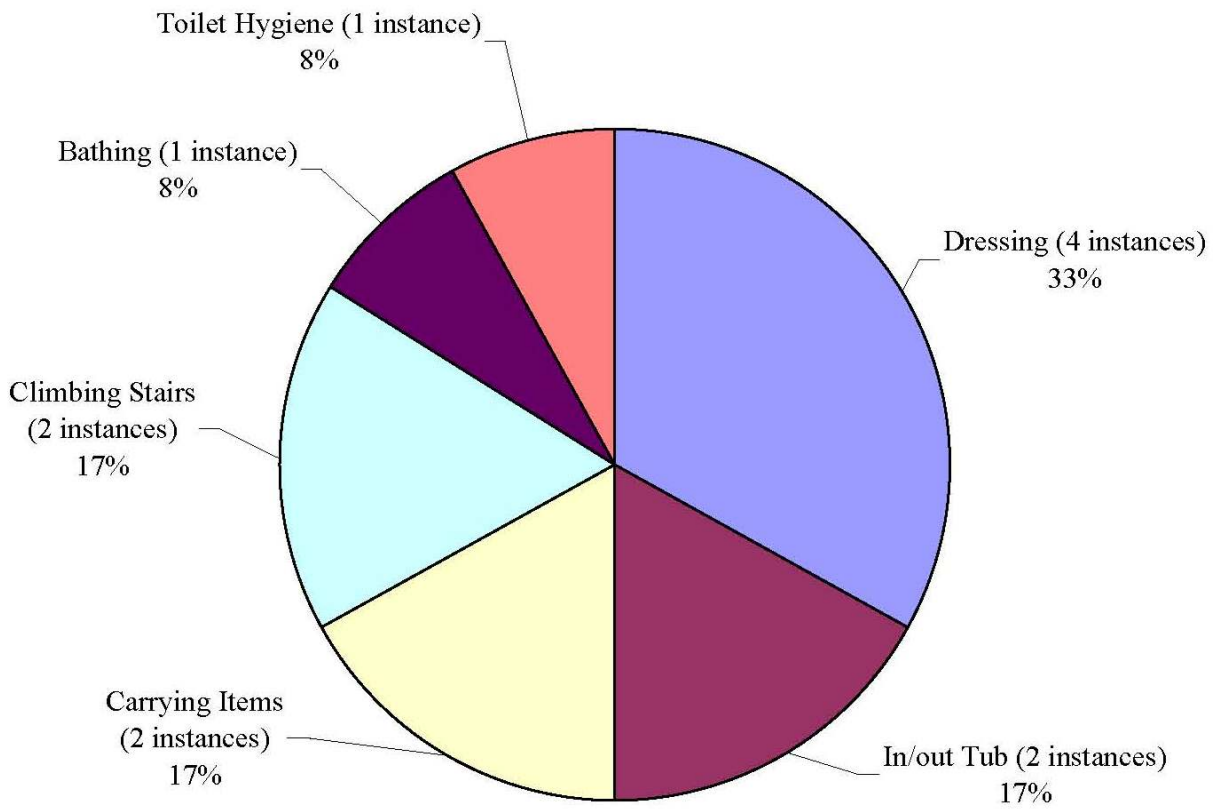

Figure 4-4. Report of unmet ADL-difficulty needs. This is out of a total of 12 instances were ADL tasks were reported as difficult whilst needs were unmet for the sample.

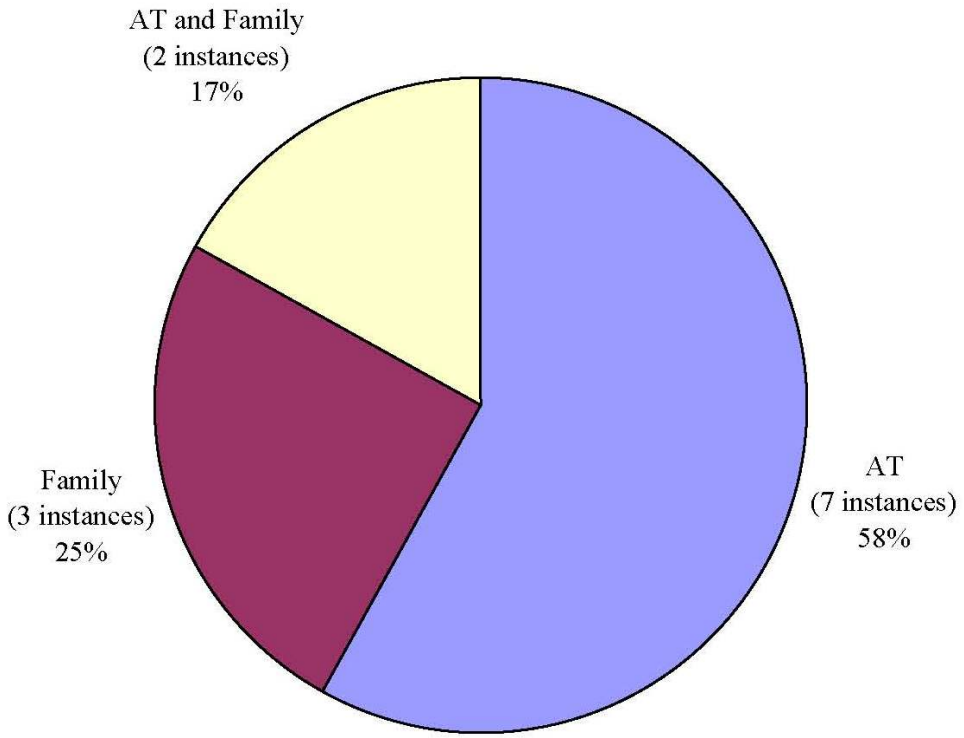

Figure 4-5. Perceived unmet ADL assistance areas that participants cited could be replaced or improved to resolve unmet need. This is out of a total of 12 instances were ADL tasks were reported as difficult whilst needs were unmet for the sample.

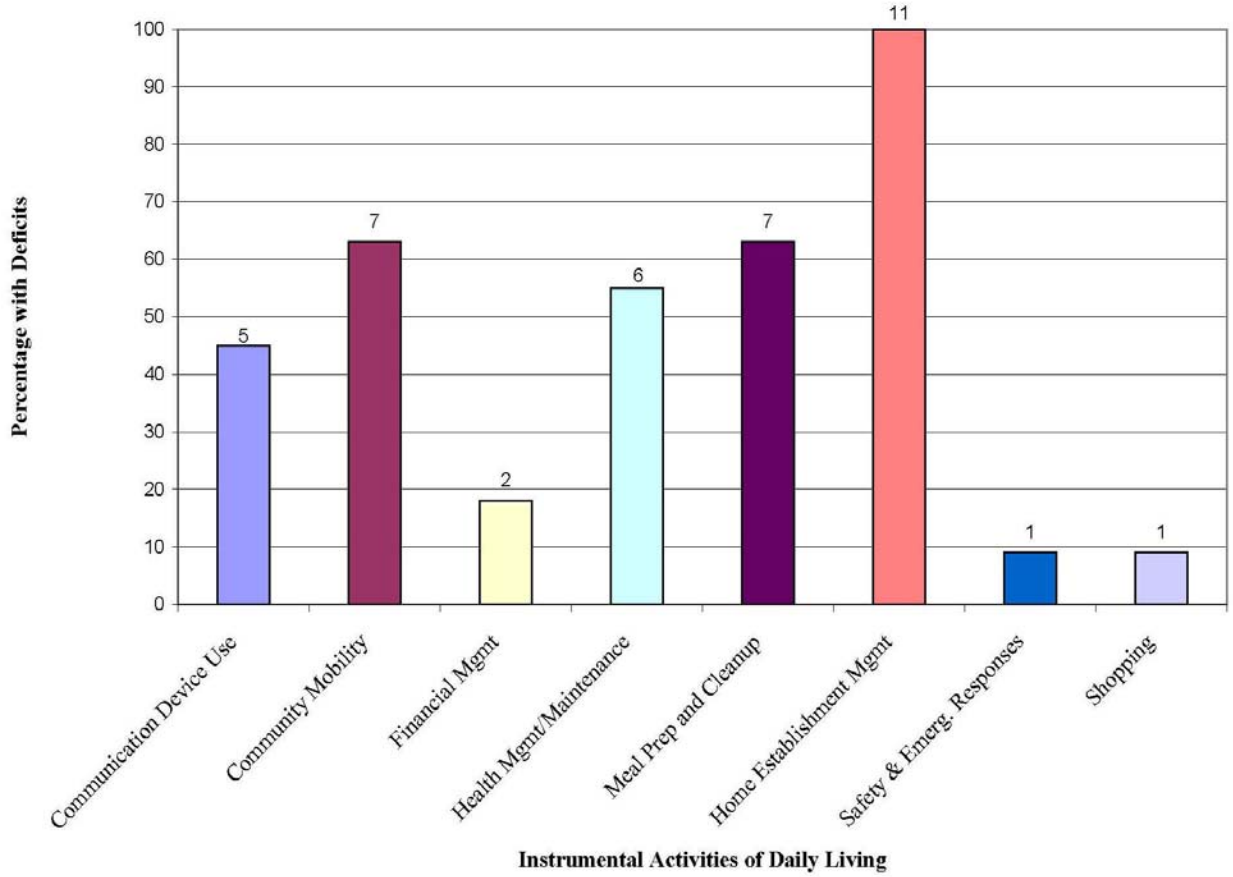

Figure 4-6. Participants with deficits in instrumental activities of daily living.

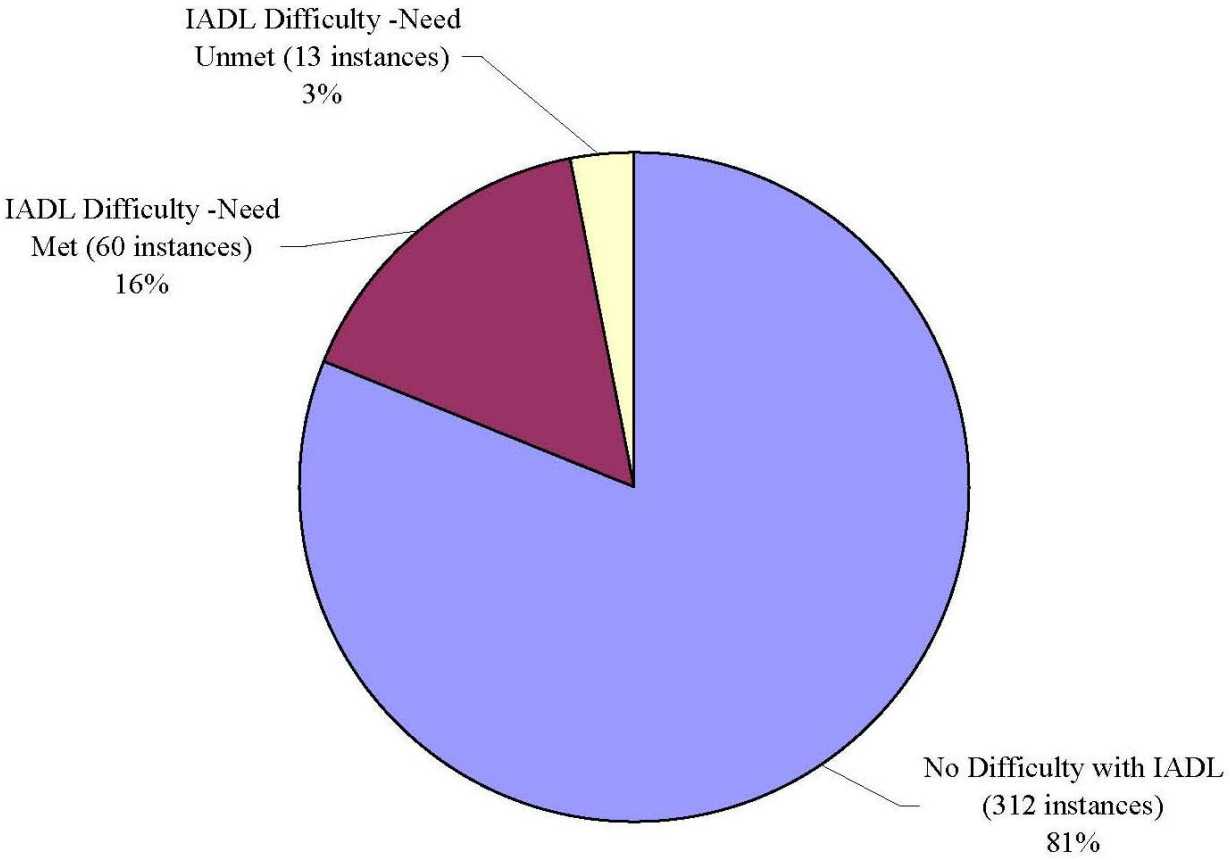

Figure 4-7. Report of IADL tasks with/without difficulty and whether need is met/unmet for the sample. A total of 385 instances IADL tasks were assessed (that is 35 IADL tasks x 11 participants = 385 instances).

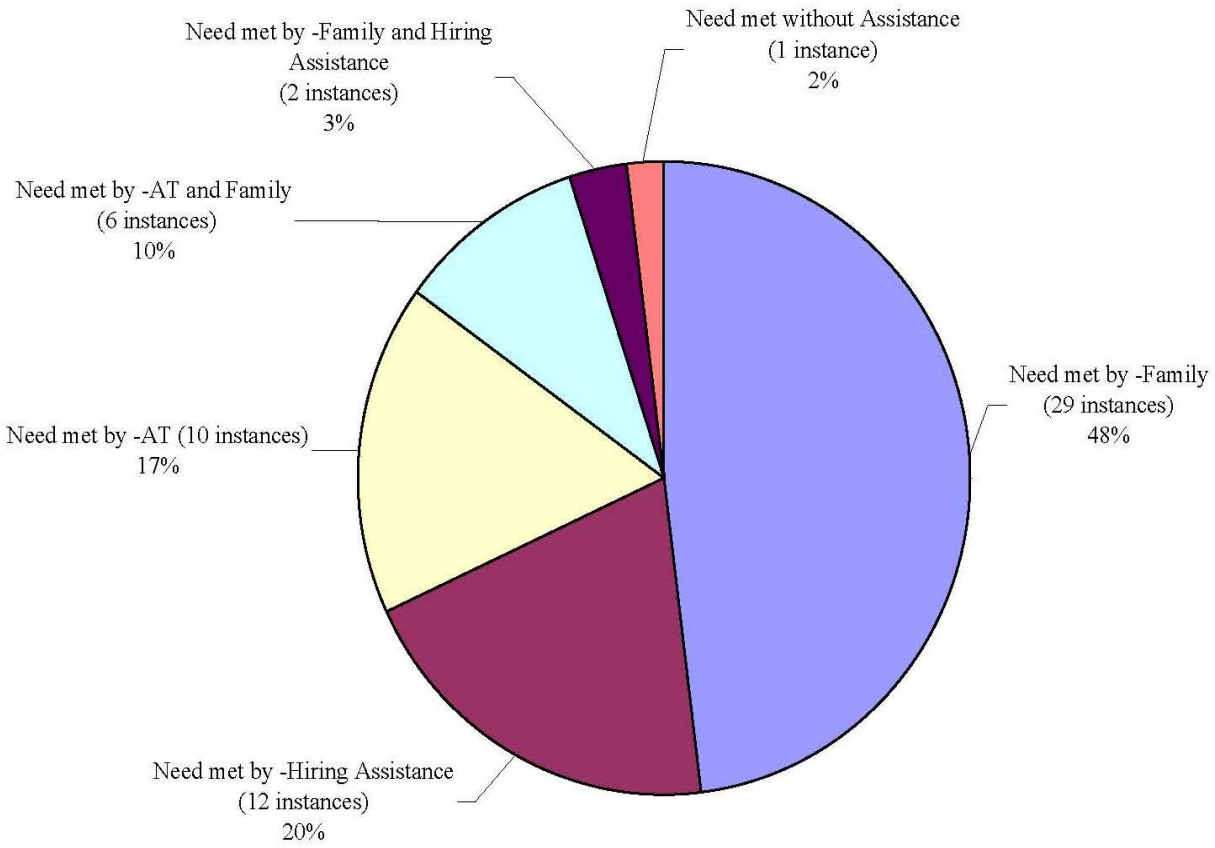

Figure 4-8. Report of how IADL-difficulty needs are being met. This is out of a total of 60 instances were IADL tasks were reported as difficult whilst needs were met for the sample.

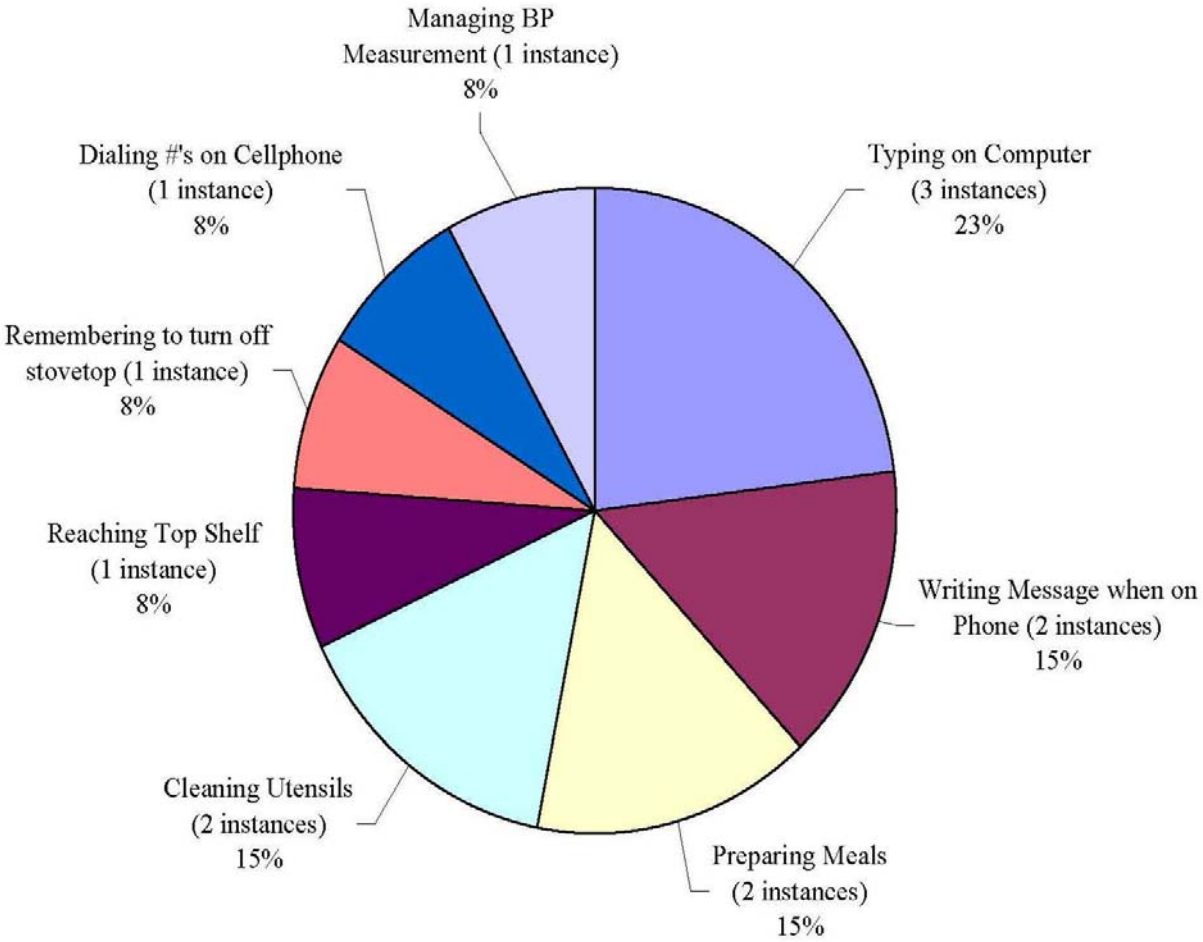

Figure 4-9. Report of unmet IADL-difficulty needs. This is out of a total of 13 instances were IADL tasks were reported as difficult whilst needs were unmet for the sample.

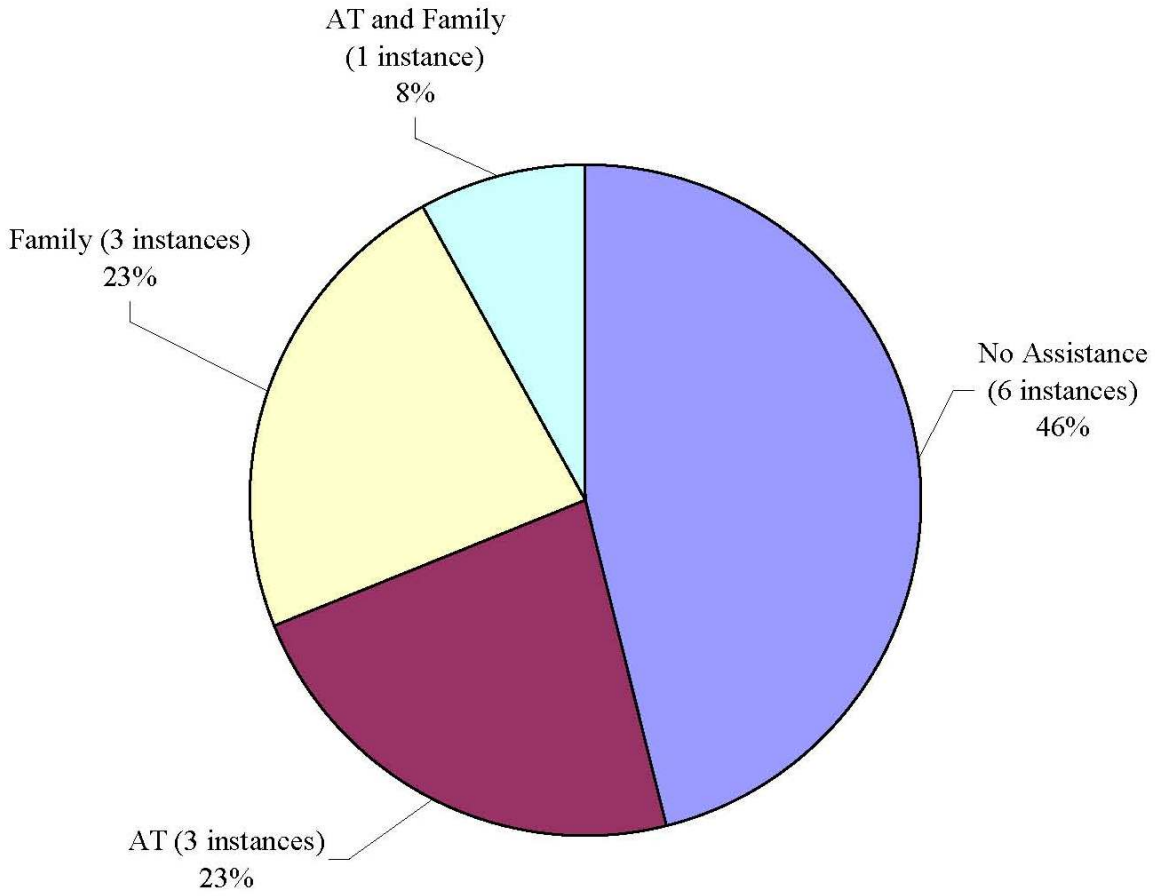

Figure 4-10. Perceived unmet IADL assistance areas that participants cited could be replaced or improved to resolve unmet need. This is out of a total of 13 instances were IADL tasks were reported as difficult whilst needs were unmet for the sample.

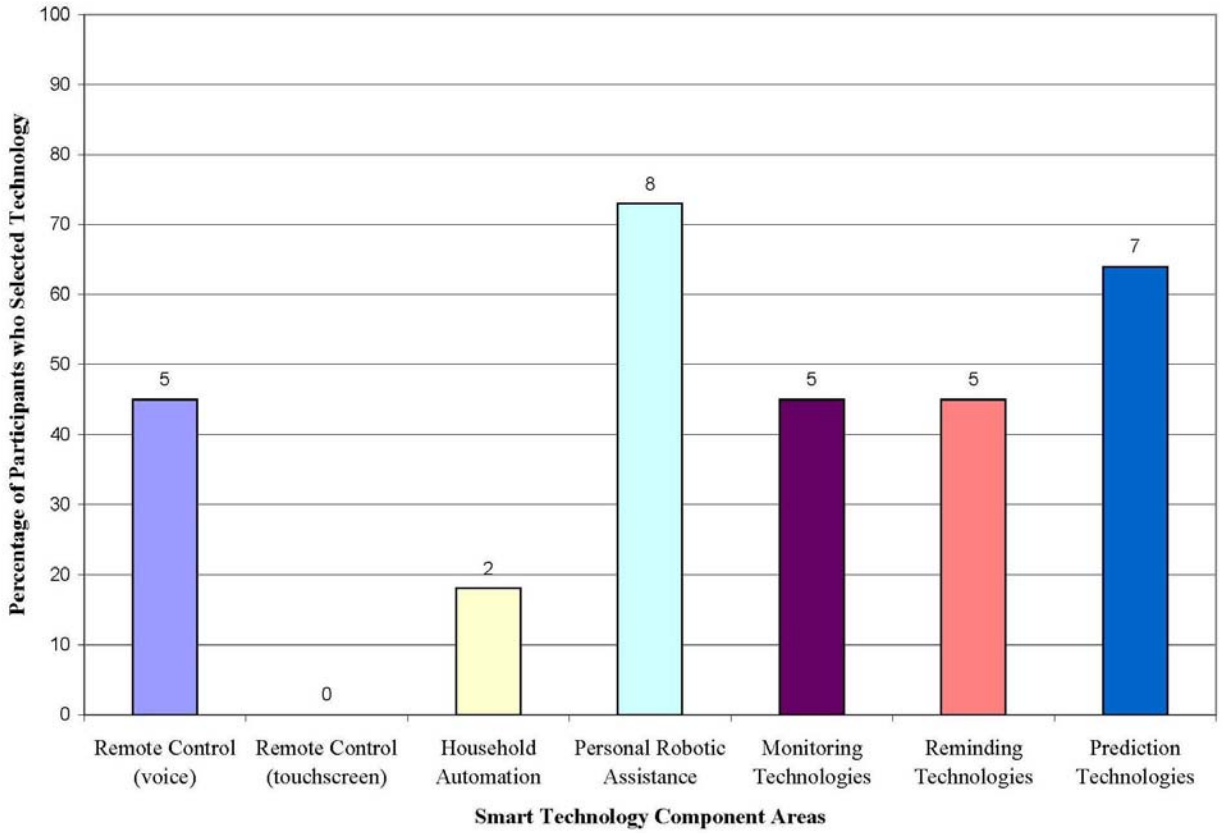

Figure 4-11. Percentage of sample that cited a major smart technology component area need.

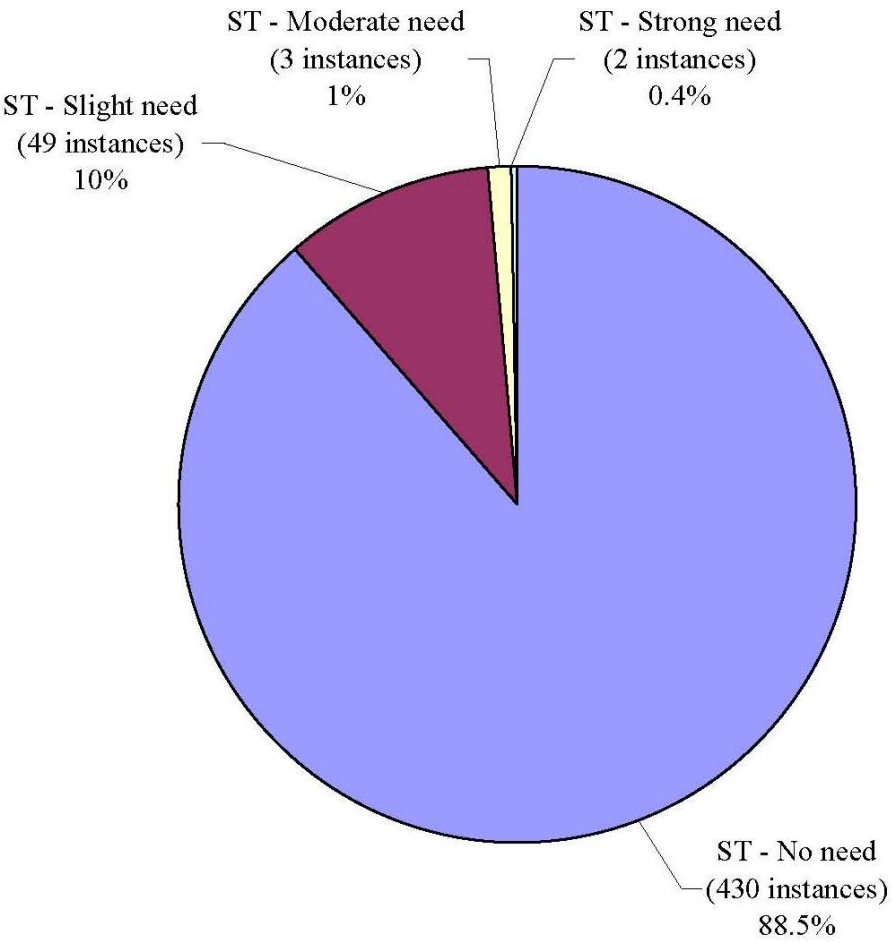

Figure 4-12. Percentage of need cited by sample regarding smart technology applications. A total of 484 instances of smart technology devices were assessed (that is 44 ST devices x 11 participants = 484 instances).

Table 4-2. Itemization of smart technology cited as needed by participants

Smart Technology Assessed	Selected		Selected
Remote Control-Voice (10)		Personal Robotic Assistance (7)	
Voice- Thermostat	0	Walking Aid	2
Voice- TV set	0	Bathing Aid	2
Voice- Security System	0	Transfer Aid	2
Voice- Blinds	0	Dressing Aid	7
Voice- Washer + Dryer	0	Carrying Aid	3
Voice- Microwave Oven	0	*Food Prep Aid	3
Voice- Lights	2	*Utensil Cleaning Aid	1
*Voice- Message Aid	2	Monitoring Technologies(9)	
*Voice- Typing Aid	3	Monitor- Medication Management	0
*Voice- Dialing #'s on Cellphone	2	Monitor- Blood Pressure	0
Remote Control-Touch (6)		Monitor- Weight	1
Touch- Thermostat	0	Monitor- Visits to the Bathroom	0
Touch- TV set	0	Monitor- Fall Detection	2
Touch- Security System	0	Monitor- Cooking Patterns	0
Touch- Washer and Dryer	0	Monitor- Walking Patterns	0
Touch- Microwave Oven	0	Monitor- Sleep Patterns	0
Touch- Lights	0	*Monitor- Appliances left on	2
Household Automation (8)		Reminding Technologies (6)	1
Auto- Thermostat	0	Health condition management	0
Auto- TV set	0	Mental Exercise	0
Auto- Security System	0	Important event reminder	0
Auto- Blinds	0	Medication Reminding	3
Auto- Washer + Dryer	0	Food Recommendation	0
Auto- Microwave Oven	0	Physical exercise	1
Auto- Lights	0	*Auto- checklist remind when appropriate time for routine checkups	1
Auto- Front Door	2		
Prediction Technologies (4)			
Early detection changes in activity level	7		
Early detection of memory loss	4		
Early detection changes in walking patterns	4		
Early detection of changes in eating/ drinking patterns	4		

Note: *Smart technology suggestions made by participants that were not included in initial form.

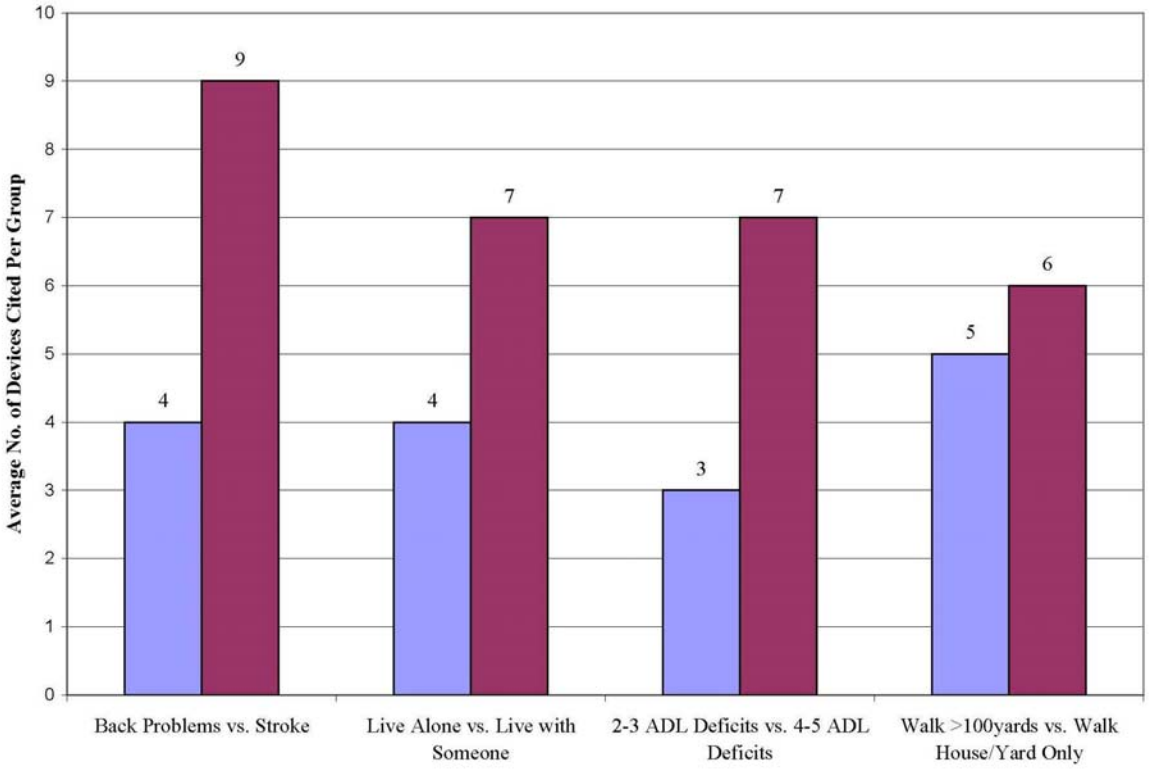

Figure 4-13. Comparison of average smart technology device need cited per group.

Table 4-3. Key need barrier themes

Theme (potential barrier)	Number of participants who cited theme (%)
Do I desire to start performing all or part of the activity again?	11 (100%)
Satisfied with current activity performance?	11 (100%)
Is ST a practical solution?	11 (100%)
Any gain to having ST device	5 (45%)
Cost Prohibitive	10 (91%)
Excessive technology	7 (64%)
Can I physically use the ST device?	3 (27%)
Is the ST easy to learn and use?	7 (64%)
Will using the ST create more stress/problems?	6 (55%)
Misinterpretation of info	2 (18%)
Information overload	3 (27%)
Fear of dependency	3 (27%)
Potential stigma	1 (9%)
Privacy concerns	2 (18%)
Loss of human contact	3 (27%)
Is the ST reliable?	8 (73%)

Table 4-4. Key facilitator themes

Theme (potential facilitators)	Number of participants who cited theme (%)
Decrease imposition on family/friends	6 (55%)
Increase sense of autonomy	2 (18%)
Assist with a *difficult* activity	9 (82%)
Assist with an activity currently *unable* to perform	6 (55%)
Replace existing technology to perform activity more safely	5 (45%)
Add a safety net	2 (18%)
Enhance ability to monitor health	8 (73%)

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

Introduction

Comparatively little research has been conducted regarding the smart technology needs of the elder population despite the proliferation of smart technology prototypes (Baillie, 2003; Mihailidis, Cockburn, & Longley, 2005). A majority of studies involve evaluating smart technology already in the prototype stages. There were few qualitative studies that specifically addressed this gap in the literature on elder ST needs analysis, which would help in determining what prototypes to create and test (Baillie, 2003; Mihailidis et al., 2005). Qualitative studies are needed to provide insights to assist developers in the design of products (Mariampolski, 2006). The purpose of this study was to explore the perceived ST needs of elders with mobility impairments while constructing a preliminary decision tree model of how these decisions are made. The resultant decision tree model was developed from data collected from in-depth interviews and participant observations (Figure 3-15). This model conceptually outlines the criteria surrounding how elders with mobility impairments make decisions in choosing which ST device are needed. This decision model adds to the elder ST needs literature and potentially will help future designers create appropriately matched technological devices that will assist in the care of aging baby boomers with mobility impairments.

Major Findings

The results of this study expanded and clarified many of the previous ST themes reported in the literature (Figure 2-2). Previous ST themes (i.e., fear of dependency, privacy concerns) are illustrated in the decision tree model along with newly identified barriers and facilitators in the ST need decision process. Only one ST theme (perceived abilities) reported in the literature is not illustrated in the decision tree model. Although interviews with participants lasted from 2.5-4

hours, the design of the study (which assessed 44 ST devices) did not allow for complete exploration of each ST concept that emerged. For example a few participants would express that they did not need a fall monitoring system or a personal emergency response system (PERS) and that they knew how to properly fall or that if they fell they felt that they would not be knocked unconscious. This researcher did not further explore this perceived ability. Future researchers could further explore the issues surrounding this barrier theme, which may have many subcomponents tied into it (i.e., pride, denial, calculated risk, independence).

The results of the study suggest that elder participants continually assess the cost-benefit ratio prior to determining if a ST device is needed or not needed. Elder participants would weigh the cost aspect against the benefit aspect to determine if the ST device was desired. Barrier themes (i.e., reliability, loss of human contact) that were cited by the participant were the *cost* aspect and the facilitator themes (i.e., increase sense of autonomy, enhance ability to monitor health) were the *benefit* aspect. For example participants would assess the cost-benefit ratio of whether the need to decrease the imposition of a family member (benefit) was greater than the potential of becoming dependent on the ST device (cost). Future researchers could further explore the threshold needed in order for each ST device to be perceived as needed.

Barrier Themes

Do I desire to start performing all or part of the activity again?

This study has several important findings that have implications for designers needing to create appropriately matched elder friendly technological devices. Elder participants were content with stopping all or part of an activity. Therefore to create more appropriately matched technological devices designers should conduct studies to confirm all or part of the specific activity being addressed is in fact perceived as being missed. Elder consumers may be content

with limiting or no longer performing certain tasks, therefore products that address these activity limitations may not be readily adopted.

Satisfied with current activity performance?

Elder participants were primarily satisfied with their current activity performance. Elder participants were content with limiting and/or taking longer to complete activities. To create more appropriately matched technological devices designers should be wary of developing ST devices based solely on whether the device can do a task faster, more efficiently, and/or for a longer duration. Elder participants were found to be content with performing activities in their own adapted style. As identified in the model if a participant is satisfied with his/her current activity performance level then he/she may decide that ST is not needed.

Is ST a practical solution?

A distinct feature of the study was to assess all 44 ST devices regardless of impairment level. Participants were asked about each of the ST devices, specifically if the device could assist in their daily activities. For example even if participants did not have difficulty operating their TV remote control, they were still asked if a voice recognition remote control would be desired, and similarly if a medication reminding system would be desired without having any difficulty managing medications. This would explain some types of barrier themes that were revealed in the findings, such as perception of 'no gain' from the ST device. For instance, if a participant did not have an impairment that the specific ST device addressed then they may not easily see any gain to adopting the ST device.

To create more appropriately matched technological devices designers should be wary of developing ST devices that may be perceived by elder consumers as too costly for their needs. Elder participants were often concerned with the costs associated with utilizing ST. Elder participants cited being content with making minor adaptations in their behavior rather than

desiring ST to assist with a difficult task. Elder participants expressed that they only spent money on necessities; therefore if a participant viewed a device as only slightly needed and the cost was perceived as high, then he/she may decide that the ST device is too costly for his/her needs.

Can I physically use the ST device? Is the ST easy to learn and use?

To create more appropriately matched technological devices designers should be wary of developing ST devices that utilize a touchscreen as the primary interface. When given the option elder participants preferred voice recognition technology over touchscreen technology. Touchscreen interfaces were perceived as cumbersome to learn and use. To create more appropriately matched technological devices designers should be aware of how far removed from existing technology a ST device may be perceived by the elder consumer. Elder participants expressed concerns of having to learn a completely new system. Possibly incorporating ST components into an existing technology design may be more readily adopted.

Will using the smart technology device create more stress/problems?

Elder participants had concerns of problems and stresses associated with utilizing ST. To create more appropriately matched technological devices designers should be aware of the level of information generated by the device. Elder participants perceived technology as potentially overwhelming them with constant reminders or personal health information. To create more appropriately matched technological devices designers should be cognizant of the amount of human contact being replaced by the ST. The need for ST was often trumped by the desire of the elder participants to have human interaction.

Is the ST reliable?

Elder participants were found to be concerned with the reliability of the technology. ST was often perceived as not being advanced enough to be reliable. To create more appropriately matched technological devices designers should be alert to the fact that elder consumers often

compare ST reliability with the reliability performance of humans. As identified in the model if a participant is concerned about the reliability of the device then they may decide that ST is not needed.

Facilitator Themes

The model identifies numerous facilitator criteria (i.e., decrease imposition, increase autonomy) surrounding the elder ST need decision process (Figure 3-15). These facilitator criteria are important additions to the elder ST needs literature as they outline potential motivators to adopting ST assistance. Previous literature simply utilized terminology such as 'favorable', 'open to the idea', 'convenient', 'willingness to accept or have in home' when describing elder ST decision criteria (Demiris et al., 2004; Johnson, Davenport, & Mann, 2007; Mihailidis et al., 2005). This decision criteria knowledge will help designers create appropriately matched technological devices that potentially decreases imposition on family/friends, increases sense of autonomy, assists with difficult activities, assists with unsafe activities, and enhances the monitoring of health.

Decrease imposition on family/friends

To create more appropriately matched technological devices designers could incorporate features in the ST device that focus on decreasing the level of assistance participants receive from family. Specifically elder participants frequently expressed a desire for ST to assist in decreasing imposition on family caring for them. Incorporating ST features that are able to decrease imposition on family members may increase the desirability of the ST device.

Increase sense of autonomy

Elder participants desired ST that assisted with increasing their sense of autonomy. Elder participants felt more in control of a robot than with a hired caregiver, therefore ST devices that replaced certain caregiver tasks may increase the participants' sense of autonomy. To create

more appropriately matched technological devices designers could focus on ST devices (such as a robotic dressing aid, transfer aid, or bathing aid) that would decrease the participants' reliance on others, thus increasing their sense of autonomy. As identified in the model if a participant perceives the ST device as potentially increasing his/her sense of autonomy then ST device may be desired.

Assist with a *difficult* activity/Assist with an activity currently unable to perform

Generally the findings indicate that ST is perceived as a poor substitute for elder participants' own skills, especially when they are satisfied with their current activity performance status. However when elder participants cited an unmet need (i.e., unsatisfied with activity performance) then ST was increasingly seen more as a potential solution. To create more appropriately matched technological devices designers could focus on ST devices that would address any frequently cited unmet activity need (i.e., dressing tasks, carrying items, or preparing meals).

Replace existing technology to perform activity more safely

To create more appropriately matched technological devices designers could focus on ST devices that would allow activities to be performed more safely. It was found that elder participants desired ST to replace existing technology (i.e., ambulatory device, stove safety device) in order to perform activities more safely. Developers could focus on designing ST devices (i.e., robotic carrying aid, smart stove) that would help meet these unmet activity needs.

Add a safety net

To create more appropriately matched technological devices designers could focus on ST devices that provide elder participants with safety nets. Specifically elder participants felt a need for a fall monitoring system to act as a backup incase they were to fall and be unable to call for assistance. Incorporating a safety net feature may increase the desirability of the ST device.

Enhance ability to monitor health

It was found that elder participants frequently desired ST to assist with their ability to monitor their health. This frequently expressed need may have been due to fact that this category of ST device goes beyond compensation of a task. As elder participants were generally found satisfied with their current activity performance level, they did not express a need for assistance with tasks that they were already comfortable with. This specific prediction technology went beyond compensation and may have been perceived as adding something to the participant's abilities, specifically providing an additional ability to monitor their health. Therefore to create more appropriately matched technological devices designers may focus on ST devices that would be perceived as enhancing their abilities. Future researchers could further explore the issues surrounding this facilitator theme, which may have many subcomponents tied into it (i.e., satisfaction level with their healthcare management, number of chronic conditions).

Limitations

Several limitations exist in this study. The first limitation in this study is generalizability of the findings. The findings can not be generalized to the elder mobility impaired population due to the purposive sampling method, small sample size, and lack of ethnic diversity (all Caucasian participants) in this study. The findings can not be generalized to the population due to the fact that all participants had 12 months to adapt to their impairment (all were at least 1 year status post onset of decline). A cohort of elders with a more recent decline in mobility impairment may provide a more unique reception to ST providing assistance.

Generalizability of findings to all ST devices may be limited due to the fact that the majority of ST devices (i.e., remote control voice/touchscreen, household automation, personal robotic assistance) assessed in this study provided compensatory interventions. Participants were satisfied with their current activity performance level, therefore evaluating primarily ST that only

provided compensation assistance for tasks that they were already comfortable with may have been incomplete.

An additional limitation may involve researcher bias. Having a background in occupational therapy where the objective is to return clients to full functional status may have influenced the progression of questions during the interviews. For example many of the questions centered on exploring how to enable the participants to achieve full functioning. This may have limited the number of questions that explored how participants were satisfied with limiting their activity performance level.

Another limitation of the study is its conceptual nature. At times participants would express a desire to physically see or utilize the ST device in order to be able to make a more informed decision regarding whether they would use the device. Without being able to fully test the ST devices, participants may have been able to only provide perfunctory answers. If the participants were confronted with the actual ST device their perceptions may vary from those reported during their interviews.

An additional limitation of this study is the study design. Although interviews lasted from 2.5-4 hours, the large quantity of activities (49) and ST (44) assessed, limited the researchers ability to completely explore each concept that emerged. Future researchers could further explore the issues surrounding each barrier/facilitator theme that was revealed by this study.

Implications

As advances are made with underlying ST we can expect commercial smart home ventures to significantly move into the mainstream population. As a rule commercial products are not created solely for the benefit of their users, they are created by companies whose target is to make money (Kuniavsky, 2003). Therefore designers may design smart technology that benefits primarily the technology-enthusiast or younger cohorts, as has been shown in the past with

communication and business technologies (Eriksson & Timpka, 2002). Therefore an important role of university-based research is to ensure that ST also be developed with the elder consumer in mind and provide the most support for older people with disabilities. The results of this study have added to the literature that describes the elder consumer needs regarding ST. This knowledge will help designers create appropriately matched technological devices that will assist in the care of aging baby boomers with mobility impairments.

Future Research

The qualitative nature of this study served to create an initial overall conceptual ethnographic decision tree model. This composite elder ST decision tree model illustrates the decision criteria involved in determining elder ST need. This study carried out the initial stages of the first of two phases in ethnographic decision tree modeling, resulting in a preliminary ethnographic decision model of the elder ST decision process. Utilizing the composite decision tree model created from this study, future studies can further explore each of the individual 44 ST devices that were assessed. Decision trees can be built for each of the 44 ST devices. During phase two of the ethnographic decision tree modeling process these individual decision trees can be formally tested for their predictive accuracy on a separate group of elder consumers from the same population. Knowing the elder consumers' ST decision making process could provide future direction for developers and policymakers.

The overall conceptual ethnographic decision tree model can also provide a basis for future qualitative studies to further explore the issues surrounding each barrier/facilitator theme that was revealed. These end-user concepts and decision criteria identified could also provide the needed conceptual framework for future quantitative studies. Understanding concepts and categories utilized by the end-user can improve upon the validity of future quantitative studies (i.e., survey design) where the terms and categories have to be known in advance (Blomberg,

Burrell, & Guest, 2003). Therefore a quantitative survey design study could be fruitful and would assist with generalizing the findings.

Specifically, a study focusing on a younger cohort (<50 years of age) would be beneficial in establishing if a younger population would be eager to regain as much function and efficiency as possible. Possibly this younger cohort would exhibit a stronger ST need, as they would be willing to accept any ST in order to accomplish more throughout the day.

Finally a study focusing specifically on elders who have recently been admitted to an assisted living facility or nursing home (or their caregivers) could be beneficial. These cohorts may be able to provide further insights into what ST would be needed to slow decline and delay the onset of transitioning to an ALF or nursing home.

Conclusions

The construction of a preliminary decision tree model adds to the literature on elder ST needs analysis. The awareness of multiple barriers and facilitators to the ST need decision process potentially will help future designers create appropriately matched technological devices. As illustrated in the findings of this study the elder ST need decision process is complex and multifaceted. Unmet activity needs are potentially effective ST gateways as these needs are not being met. Satisfaction with current activity performance level is potentially a major barrier for ST to be adopted. The findings of this research suggest that compensatory ST interventions may not be readily accepted by elders with MIs. Potentially ST devices that could be presented as preventing further decline, retraining physical abilities, or restoring cognitive functioning, may be found to be more readily accepted.

APPENDIX A
INITIAL INTERVIEW GUIDE

Confidential Study Participant Number: _____

Interview Date: _____ Start Time _____ Completion Time: _____

DEMOGRAPHIC INFORMATION:

1. **Age:** _____ *[≥ 90yo - will be utilized in future to de-identify data]*

2. **Gender:**
   1. Male 2. Female

3. **Race:**
   1. Black
   2. White
   3. Hispanic
   4. Asian
   5. Native American
   6. Other_____

4. **Level of Completed Education:**
   1. Less than 12th Grade
   2. High School Graduate
   3. Some college, no degree
   4. Vocational, tech, or business school degree
   5. Bachelor's degree
   6. Master's degree
   7. Doctorate/Medical degree

5. **Marital Status:**
   1. Married
   2. Widowed
   3. Divorced
   4. Single
   5. Other _____

6. **Living Arrangement:**
   1. Live alone
   2. Live with someone (Please Circle)
      - -Spouse
      - -Adult Child
      - -Parent
      - -Other Family Member
      - -Friend
      - -Roommate
   3. Occasionally have family/friend stay overnight in home to help with care
   4. Other _____

7. **Description of Home:**
   1. A single-family detached home
   2. A multi-unit building (apartment, either low-rise or high-rise)
   3. A mobile home
   4. A semi-detached home (townhouse or duplex)
   5. Other _____

8. **How much income do you (and your husband/wife) have a year?**

Yearly

A 0-$10,000
B $10,000- $20,000
C $20,000- $30,000
D $30,000- $40,000
E $40,000- $50,000
F $50,000- $60,000
G $60,000- $70,000
H $70,000- $80,000
I $80,000- $90,000
J $90,000- $100,000
K >$100,000

9. **How many people altogether live on this income** (that is, it provides at least half of their income)? _____

HEALTH AND ACTIVITY INFORMATION:

1. **What best describes your overall health condition?**
   1. Excellent
   2. Good
   3. Fair
   4. Poor
   5. Other_____

2. **Description of Health Condition:**

Type of Condition	**Has Condition** **(Description)**
Speech or Communication Difficulties	
Poor Hearing	
Memory Difficulties	
Low Vision **RIGHT EYE**	
Low Vision **LEFT EYE**	
Function of **RIGHT** Hand	Full/Partial Paralysis Not Fully Open/Close Pain Arthritis
Function of **RIGHT** Upper Arm	Full/Partial Paralysis Not Raise over Shoulder Pain Arthritis
Function of **LEFT** Hand	Full/Partial Paralysis Not Fully Open/Close Pain Arthritis
Function of **LEFT** Upper Arm	Full/Partial Paralysis Not Raise over Shoulder Pain Arthritis
Function of **RIGHT** Leg	Full/Partial Paralysis Pain Arthritis
Function of **LEFT** Leg	Full/Partial Paralysis Pain Arthritis

Type of Condition	Has Condition (Description)
***Other (Heart dz, diabetes, COPD, HTN, dizziness, etc.):	
Other:	

3. **Description of Fine Motor Assistive Device Used:**
   1. None
   2. Built up Handle on Utensils
   3. Universal Cuff Utensils
   4. Other_____
   5. Button Hook
   6. Plate Food Guard
   7. Writing Aid

4. **Description of Mobility Assistive Device Used:**
   (Please indicate primary mobility AD utilized indoor/outdoor)
   1. None
   2. Cane_____
   3. Walker_____
   4. Other_____
   5. Wheelchair_____
   6. Scooter_____
   7. Powered Wheelchair_____

5. **Description of Typical Walking Distance (can be with use of cane/walker):**
   1. No difficulty
   2. Slow Gait Only
   3. House and Yard Only
   4. Household Distances Only
   5. Transfers Only

6. **Description of Falling History -Over the Past Year:**
   1. None
   2. One
   3. Two
   4. Three-Five
   5. >Five
   6. Other _____

7. **Do you find yourself limiting your activities because of a fear of falling?**
   1. Yes
   2. No
   3. Other _____

8. **Description of Visual Assistive Device Used:**
   1. **None**
   2. **Glasses** _____
   3. **Magnifier** _____
   _____
   4. **Bioptic Telescope System** (auto near and far focusing) _____

_____

5. **Closed Circuit Television Systems** CCTV (video camera used to capture image of reading material and magnify it on a monitor) _____

_____

6. **Screen Reader Software** (software system that converts text to speech) ___

_____

7. **Blind Cane**_____

_____

9. **Description of Visual Impairment:**
(With Better Eye –can be with Glasses)
1. No Impairment
2. Unable to Read Prescription Bottle Directions
3. Unable to Read Newspaper Text
4. Unable to Drive Due to Loss of Vision
5. Unable to Read Facial Expressions
6. Frequently Bump into Objects in an Unfamiliar Environment

10. **Description of Security around Home:**
1. Gated Community
2. Home Security System
3. Personal Emergency Response System
4. Dog
5. Other _____

11. **Description of Resident Safety Check System:**
1. None
2. Live-in spouse/family/roommate built in multiple daily check system
3. Personal Emergency Response System
4. Daily phone call/visit from family/friend/agency to check in
5. Weekly phone call/visit from family/friend/agency to check in
6. Monthly phone call/visit from family/friend/agency to check in
7. Other _____

12. **Description of Availability Assistance from Outside Home:**
1. None
2. Local family/friends available to assist when needed
3. Out of town family/friends available to assist when needed
4. Assisted Living Facility
5. Continuing Care Retirement Community

13. **How would you define the word 'independence'?**

1. Do everything by self – **without** use of assistive devices (cane, walker, button hook)
2. Do everything by self – **can use** assistive devices (cane, walker, button hook)
3. Do everything by self – **Can use** high-tech assistive devices (automatic front door, floor safety monitoring)
3. Can accept assistance from **spouse or family member**
4. Can accept assistance from **neighbor**
5. Can accept having an **agency personal attendant**
6. Will **accept anything** to remain in home. Comfort level remains steady as long as stay in home.

AGING IN PLACE INFORMATION:

1. **Do you own or rent your place of residence?**
   1. Own
   2. Rent
   3. Other _____

2. **How long have you lived in your current residence?**
   1. Less than 5 years
   2. 6-10 years
   3. 11-20 years
   4. 21-30 years
   5. 31-40 years
   6. Over 41 years

3. **Do you plan to continue to live in your current residence for the next 10 years?**
   1. Yes _____
   2. No _____
      a. Plan to move into smaller home (easier to maintain)
      b. Plan to move in with family/friend
      c. Plan to move into ALF or CCRC
   3. Don't Know _____

4. **What best describes your reaction to the following statement?**
   I'd really like to live in my current residence for as long as possible
   1. Strongly Agree
   2. Somewhat Agree
   3. Somewhat Disagree
   4. Strongly Disagree
   5. Don't Know

5. **You are living alone and you discover you require some assistance to continue living in your home, where would you seek assistance to remain living at home?**
   (Rank)
   _____ Family Assist
   _____ Friends Assist
   _____ Hire Personal Care Assistance
   _____ Purchase Technology to Assist (PERS, robotic vacuum)
   _____ Don't Know

6. **If it was not safe (d/t falling, constantly forgetting medication) to live alone in your home do you think you would continue to choose to live there?**
   1. Yes
   2. No

7. **Name three things that you feel may cause you to have to move out of your home (whether to an ALF, NH, family or friends)?**
   1. Fall
   2. Vision loss
   3. Arthritis
   4. SOB
   5. Other _____

TECHNOLOGY ATTITUDES/EXPERIENCE INFORMATION:

1. **Which statement would you agree with more strongly (e.g., high definition TV, robotic vacuum, automatic front door)?**
   1. I like to try out new technology
   2. I do not like to try new technology

2. **Which statement would you agree with more strongly?**
   1. Technology helps me connect with other people
   2. Technology makes me feel detached from other people
   3. I feel neutral about technology

3. **Do you have a computer at home?**
   1. Yes
   2. No

4. **Do you have a web-camera at home?**
   1. Yes
   2. No

5. **How would you describe your familiarity with computers?**
   1. Very familiar
   2. Somewhat familiar
   3. Somewhat unfamiliar
   4. Not familiar

6. **How would you describe your frequency of computer use?**
   1. Daily
   2. Few times a week
   3. Few times a month
   4. Rarely Use
   5. Never Use

7. **Do you have high-speed internet access?**
   1. Yes
   2. No

8. **How would you describe your familiarity with the internet?**
   1. Very familiar
   2. Somewhat familiar
   3. Somewhat unfamiliar
   4. Not familiar

9. **How would you describe your comfort level with the internet?**
   1. Comfortable
   2. Somewhat Comfortable
   3. Somewhat uncomfortable
   4. Uncomfortable

10. **Do you have a cell phone?**
    1. Yes
    2. No

11. **How would you describe your familiarity with <u>cell phones</u>?**
    1. Very familiar
    2. Somewhat familiar
    3. Somewhat unfamiliar
    4. Not familiar

12. **How would you describe your frequency of <u>cell phone use</u>?**
    1. Daily
    2. Few times a week
    3. Few times a month
    4. For Emergencies Only
    5. Never Use

13. **Do you have a <u>Personal Emergency Response System</u> (PERS) at Home?**
    1. Yes
    2. No

14. **How often do you wear your <u>PERS system</u>?**
    1. All the time
    2. During the daytime
    3. During the nighttime
    4. When feeling sick
    5. Leave PERS (pendant, bracelet) by bed
    6. Never use

15. **What is your experience with smart technology?**
    1. No experience
    2. Have seen it on TV or in Newspaper
    3. Been on a tour of the local smart house in Gainesville
    4. Have participated in Focus Groups on smart house technology in Gainesville

APPENDIX B
CURRENT ACTIVITY PERFORMANCE GUIDE

CURRENT ACTIVITY PERFORMANCE GUIDE:

Confidential Study Participant Number: _____

Interview Date: _____ Start Time _____ Completion Time: _____

Remote Control - **(RC)**, Automation - **(A)** Monitoring - **(M)**, Prompting /Reminding- **(P)**	**Current Activity Performance Evaluation** **Legend:** C=current status P=preferred solution I=informal care (family, spouse) F=formal care (paid caregiver) **Last column will be completed during in-depth interview (phase 2) where thorough exploration of elder's perceptions of ST occurs.*	Does **Not** Do or Have in Home	**No** Difficulties Performing	Takes **Considerable Time** Only **Has Pain** but able to Successfully Perform without AD	Successfully Performs (with AD) **Modified Independence**	Successfully Performs with **Slight (25%)** Caregiver/ Family Assistance	Impossible to Perform without **Moderate (50%)** Assistance	Impossible to Perform without **Total (100%)** Assistance	No Assistance Available **Not a Priority (not needed)**	No Assistance Available **Is a Priority (missed a lot)**	***Open to the Idea** and **Would Use ST** if available
	ADLs *(taking care of one's own body)*										
(A)	***Example: Cooking Popcorn***				*P*		*CI*				*X*
(A)	Physically Bathing/ Showering self										
(A)	Turning on Shower/Sink Faucets										
(A)	Adjusting Water Temperature of Shower/Sink										
(A)	Grooming (brushing teeth, combing hair, etc)										
(A)	Bowel and Bladder Management (intentional control bowel/bladder)										

Remote Control - **(RC)**, Automation - **(A)** Monitoring - **(M)**, Prompting /Reminding- **(P)**	**Current Activity Performance Evaluation** **Legend:** C=current status P=preferred solution I=informal care (family, spouse) F=formal care (paid caregiver) **Last column will be completed during in-depth interview (phase 2) where thorough exploration of elder's perceptions of ST occurs.*	Does **Not** Do or Have in Home	**No** Difficulties Performing	Takes **Considerable Time** Only **Has Pain** but able to Successfully Perform without AD	Successfully Performs (with AD) **Modified Independence**	Successfully Performs with **Slight (25%)** Caregiver/ Family Assistance	Impossible to Perform without **Moderate (50%)** Assistance	Impossible to Perform without **Total (100%)** Assistance	No Assistance Available **Not a Priority (not needed)**	No Assistance Available **Is a Priority (missed a lot)**	***Open to the Idea** and **Would Use ST** if available
(A)	**Functional Mobility:**										
(A)	Getting in/out of Bed										
(A)	Getting in/out of Shower										
(A)	Getting in/out of Tub										
(A)	Transferring on/off Toilet										
(A)	Carrying Items around the House										
(A)	LB -Dressing (including shoes)										
(A)	UB -Dressing										
(A)	Eating										
	IADLs ***(oriented toward interacting with the environment)***										
(RC)	Turning on/off Lights in Home										
(RC)	Opening/closing Blinds in Home										
(RC)	Unlocking/Locking Front Door										
(RC)	Opening/closing Front Door										
(RC)	Answering the Doorbell in Time										

Remote Control - **(RC)**, Automation - **(A)** Monitoring - **(M)**, Prompting /Reminding- **(P)**	**Current Activity Performance Evaluation** **Legend:** C=current status P=preferred solution I=informal care (family, spouse) F=formal care (paid caregiver) **Last column will be completed during in-depth interview (phase 2) where thorough exploration of elder's perceptions of ST occurs.*	Does **Not** Do or Have in Home	**No** Difficulties Performing	Takes **Considerable Time** Only **Has Pain** but able to Successfully Perform without AD	Successfully Performs (with AD) **Modified Independence**	Successfully Performs with **Slight (25%)** Caregiver/ Family Assistance	Impossible to Perform without **Moderate (50%)** Assistance	Impossible to Perform without **Total (100%)** Assistance	No Assistance Available **Not a Priority (not needed)**	No Assistance Available **Is a Priority (missed a lot)**	***Open to the Idea** and **Would Use ST** if available
(A)	**Meal Preparation and Cleanup:**										
(P)	Planning/Preparing Meals										
(A)	Using a Microwave to Reheat Items										
(A)	Using a Microwave to Cook a Prepackaged Frozen Meal										
(A)	Cleaning up Food and Utensils										
(M)	Remembering to Turn Off Stove Top/Oven										
	Communication Device Use:										
	Cell phone										
	Telephone										
	Computer										
	Shopping:										
(M)	Preparing Grocery Shopping List										
	Purchasing Items at a Store										
	Community mobility:										

Remote Control - **(RC)**, Automation - **(A)** Monitoring - **(M)**, Prompting /Reminding- **(P)**	**Current Activity Performance Evaluation** **Legend:** C=current status P=preferred solution I=informal care (family, spouse) F=formal care (paid caregiver) **Last column will be completed during in-depth interview (phase 2) where thorough exploration of elder's perceptions of ST occurs.*	Does **Not** Do or Have in Home	**No** Difficulties Performing	Takes **Considerable Time** Only **Has Pain** but able to Successfully Perform without AD	Successfully Performs (with AD) **Modified Independence**	Successfully Performs with **Slight (25%)** Caregiver/ Family Assistance	Impossible to Perform without **Moderate (50%)** Assistance	Impossible to Perform without **Total (100%)** Assistance	No Assistance Available **Not a Priority (not needed)**	No Assistance Available **Is a Priority (missed a lot)**	***Open to the Idea** and **Would Use ST** if available
	Driving										
	Using Public Trans. -taxi, bus										
	Financial Management										
	Home establishment management (home, yard, garden, appliances, vehicles):										
(RC)	Adjusting the Thermostat in Home										
(M)	Checking the mail										
(M)	Preventing Food from Expiring Before Use										
(M)	Keeping Track of Food in Kitchen										
(A)	Doing Laundry										
(A)	Vacuuming										
(P)	Remembering Appliance Maintenance										
(A)	Mowing the Yard										

Remote Control - **(RC)**, Automation - **(A)** Monitoring - **(M)**, Prompting /Reminding- **(P)**	**Current Activity Performance Evaluation** **Legend:** C=current status P=preferred solution I=informal care (family, spouse) F=formal care (paid caregiver) **Last column will be completed during in-depth interview (phase 2) where thorough exploration of elder's perceptions of ST occurs.*	Does **Not** Do or Have in Home	**No** Difficulties Performing	Takes **Considerable Time** Only **Has Pain** but able to Successfully Perform without AD	Successfully Performs (with AD) **Modified Independence**	Successfully Performs with **Slight (25%)** Caregiver/ Family Assistance	Impossible to Perform without **Moderate (50%)** Assistance	Impossible to Perform without **Total (100%)** Assistance	No Assistance Available **Not a Priority (not needed)**	No Assistance Available **Is a Priority (missed a lot)**	***Open to the Idea** and **Would Use ST** if available
	Safety Procedures and Emergency Responses (knowing and performing preventive procedures to maintain a safe environment as well as recognizing sudden, unexpected hazardous situations…):										
(RC)	Seeing who is at the front door										
(RC)	Closing all doors/windows in home										
(RC)	Locking all the doors/windows in home										
(RC)	Setting the Home Security Alarm										
(P)	Remembering to check in with designated family/friend (daily/weekly/monthly)										
(M)	Remembering to turn off all appliances										
(M)	Knowing which stove top burner is on/off										
	Health Management/Maintenance (developing, managing, maintaining routines for health and wellness promotion):										

Remote Control - **(RC)**, Automation - **(A)** Monitoring - **(M)**, Prompting /Reminding- **(P)**	**Current Activity Performance Evaluation** **Legend:** C=current status P=preferred solution I=informal care (family, spouse) F=formal care (paid caregiver) **Last column will be completed during in-depth interview (phase 2) where thorough exploration of elder's perceptions of ST occurs.*	Does **Not** Do or Have in Home	**No** Difficulties Performing	Takes **Considerable Time** Only **Has Pain** but able to Successfully Perform without AD	Successfully Performs (with AD) **Modified Independence**	Successfully Performs with **Slight (25%)** Caregiver/ Family Assistance	Impossible to Perform without **Moderate (50%)** Assistance	Impossible to Perform without **Total (100%)** Assistance	No Assistance Available **Not a Priority (not needed)**	No Assistance Available **Is a Priority (missed a lot)**	***Open to the Idea** and **Would Use ST** if available
(M)	Monitoring Vital Signs (Blood Pressure, Temp, Respiration Rate)										
(M)	Monitoring Sleep Patterns										
(M)	Tracking the Frequency of Trips to the Bathroom at Night										
(P)	Physical Fitness Activity/Routines										
(P)	Mental Fitness Activity/Routines										
(P)	Maintaining Well Balanced Nutritional Meal Choices										
(P)	Decreasing Health Risk Behaviors										
(P)	Medication Management/Routines										
(P)	Remembering MD Appointments										
	LEISURE ACTIVITIES:										
	Viewing TV										
(RC)	Changing the Channel										
(RC)	Changing the Volume										
	SOCIAL PARTICIPATION:										

Remote Control - **(RC)**, Automation - **(A)** Monitoring - **(M)**, Prompting /Reminding- **(P)**	**Current Activity Performance Evaluation** **Legend:** C=current status P=preferred solution I=informal care (family, spouse) F=formal care (paid caregiver) **Last column will be completed during in-depth interview (phase 2) where thorough exploration of elder's perceptions of ST occurs.*	Does **Not** Do or Have in Home	**No** Difficulties Performing	Takes **Considerable Time** Only **Has Pain** but able to Successfully Perform without AD	Successfully Performs (with AD) **Modified Independence**	Successfully Performs with **Slight (25%)** Caregiver/ Family Assistance	Impossible to Perform without **Moderate (50%)** Assistance	Impossible to Perform without **Total (100%)** Assistance	No Assistance Available **Not a Priority (not needed)**	No Assistance Available **Is a Priority (missed a lot)**	***Open to the Idea** and **Would Use ST** if available
	Family/Peer/Friend:										
(P)	Remembering Birthdays										
(P)	Remembering Important Community Events										

APPENDIX C
IN-DEPTH INTERVIEW GUIDE

Confidential Study Participant Number: _____

Interview Date: _____ Start Time _____ Completion Time: _____

In-depth Interview Questions:

[Eight visual display boards will be utilized to introduce smart technology and help subjects visualize the differences between automating, monitoring, prompting/reminding, predicting, and remote controlling technologies in smart home design.]

What are your initial thoughts about smart home technology? Prompt Questions: How do you feel about smart home technology? Do you feel it will help save you time, allow you to conserve energy, you connect with people, or make you feel detached, frustrate you, be too expensive)? What role do you see technology having in your future?

What are your thoughts on having a house that can be operated by a remote (voice or touch screen) control? Prompt Questions:

- Would having remote control abilities in your home enhance your daily activities?
- Is there a task that you are no longer able to perform in your home that a voice control device would be able to assist? (blinds, lights, thermostat, security)
- Do you currently have difficulty getting around your home to (answer the door, phone, turn on/off lights etc.)?
- Do you feel unsafe or rushed when getting around in your home?
- Would you prefer voice interface or touch screen interface?

What are your thoughts on having a house that is more automated (smartwave, TV/Stereo, vacuum)? Prompt Questions:

- Do you currently have any tasks in your home automated (lights, sprinkler system, security system, water heater, and thermostat)?
- What if your front door could be automated?
- Microwave that was automated?
- Robot that would help you dress?
- Robot that would help you bathe?
- Robot that would help you get in and out of the bath tub?
- How about windows and doors that were automated?
- Automated lawn mower?
- Personal robot that would help bring things to you or open things?

What are your thoughts on having a house <u>that is able to monitor you</u>? Prompt Questions:

- Do you currently have any monitoring devices in your home (security system, PERS, BP machine, blood glucose machine)?
- What are your thoughts on having a house that could monitor for falls?
- What about a house that could monitor your sleep patterns?
- Or check to see how many times you have been getting up to use the bathroom?
- Medication use?
- Monitor your blood sugar (via commode)?
- Monitor what you were eating?
- Monitor the items in the refrigerator and let you know if something was about to expire?
- Monitor if you left your stove or oven on?
- Monitor for water leaks?
- Monitor if someone is at the door?
- Monitored how much you were exercising?
- Monitor all your doors and windows?
- Monitor if your mail has arrived?

What are your thoughts on having a house <u>that is able to prompt you</u>? Prompt Questions:

- Do you currently have any problems remembering to do things while at home?
- What methods do you currently employ (post-it notes, spouse/family do the reminding, have a check system)?
- Do you have problems remembering you put something in the microwave, oven, on stove top, in W/D?
- Do you frequently have to throw out expired food items?
- Do you feel you are able to do all the things that you want to do in a day?
- Is their anything that you wish you had more time to do?
- How do you feel you are managing your health?
- What type of role would you say you play in maintaining your health (passive, active, don't know)?
- Do you feel having a house that would remind you when to take medications could benefit?
- What about diet choices?
- What if a house were to schedule exercise appointments with you each day?
- Or if it were to remind you of someone's birthday or automatically let you know it has been a month since you talked to a particular friend?

What are your thoughts on having a house <u>that is able to make predictions and suggestions</u>? Prompt Questions:

- Do you feel that you would not want to have to interact with your house, would rather have your house make suggestions for you? (let you know when a favorite TV program is about to start, let you know of storm that is approaching).

- What about a house that learns what bath water temp. you like and sets it for you?
- Or learns when you use hot water during the week and turns on/off your water heater automatically.
- What if you did not have to manual turn on/off your lights the house knows when you are in the room and what lighting you need?
- What do you think about a house that could monitor your walking pattern and if it changes in negative way make predictions?
- Or a house that can monitor if your hands shaking is changing (when you use your mouse, remote control) and lets you know?

Do you <u>foresee yourself having smart technology installed</u> in your home in the future? Prompt Questions:

- If so, what would it be for (physically helping, reminding you, monitoring your health)?
- If not, what are the barriers (no need, too expensive, too hard to learn)?

APPENDIX D
SMART TECHNOLOGY DEVELOPMENT FRAMEWORK

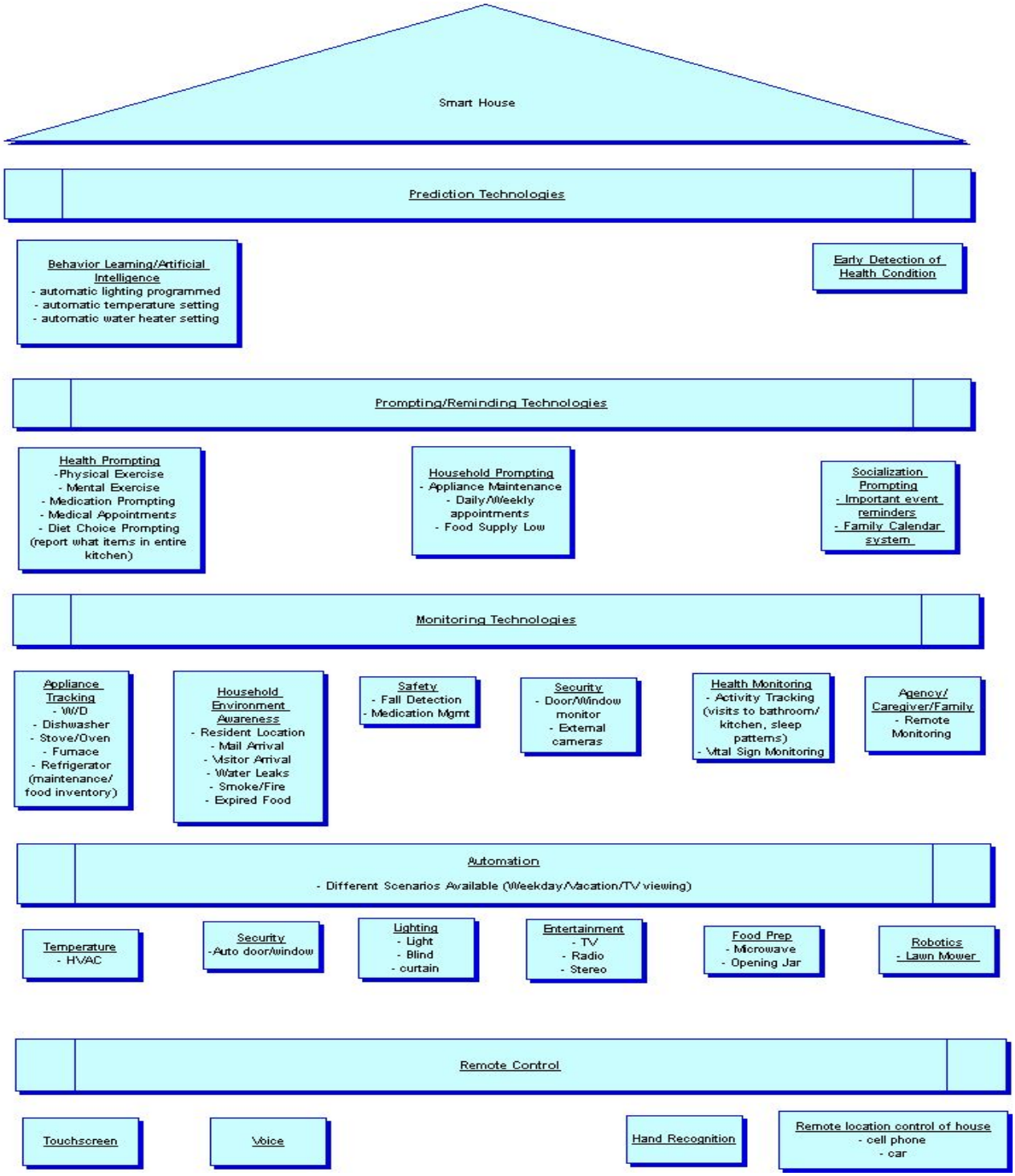

Figure D-1. Smart technology development framework.

APPENDIX E
SMART HOME TECHNOLOGY VISUAL INFORMATION BOARDS

Smart Home

- Home capable of intelligently supporting residents in their daily activities.
  - Such as:
    - Voice activated lights and blinds
    - Automated front door
    - Monitoring support (fall detection, sleep patterns)
    - Reminders to take medications
    - Early detection of health conditions

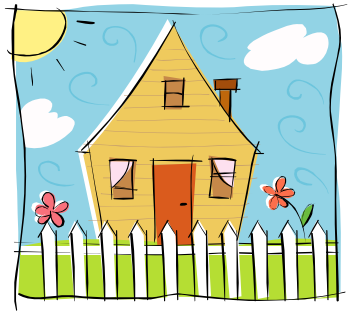

Figure E-1. Smart home description display board.

Remote Control – (voice recognition)

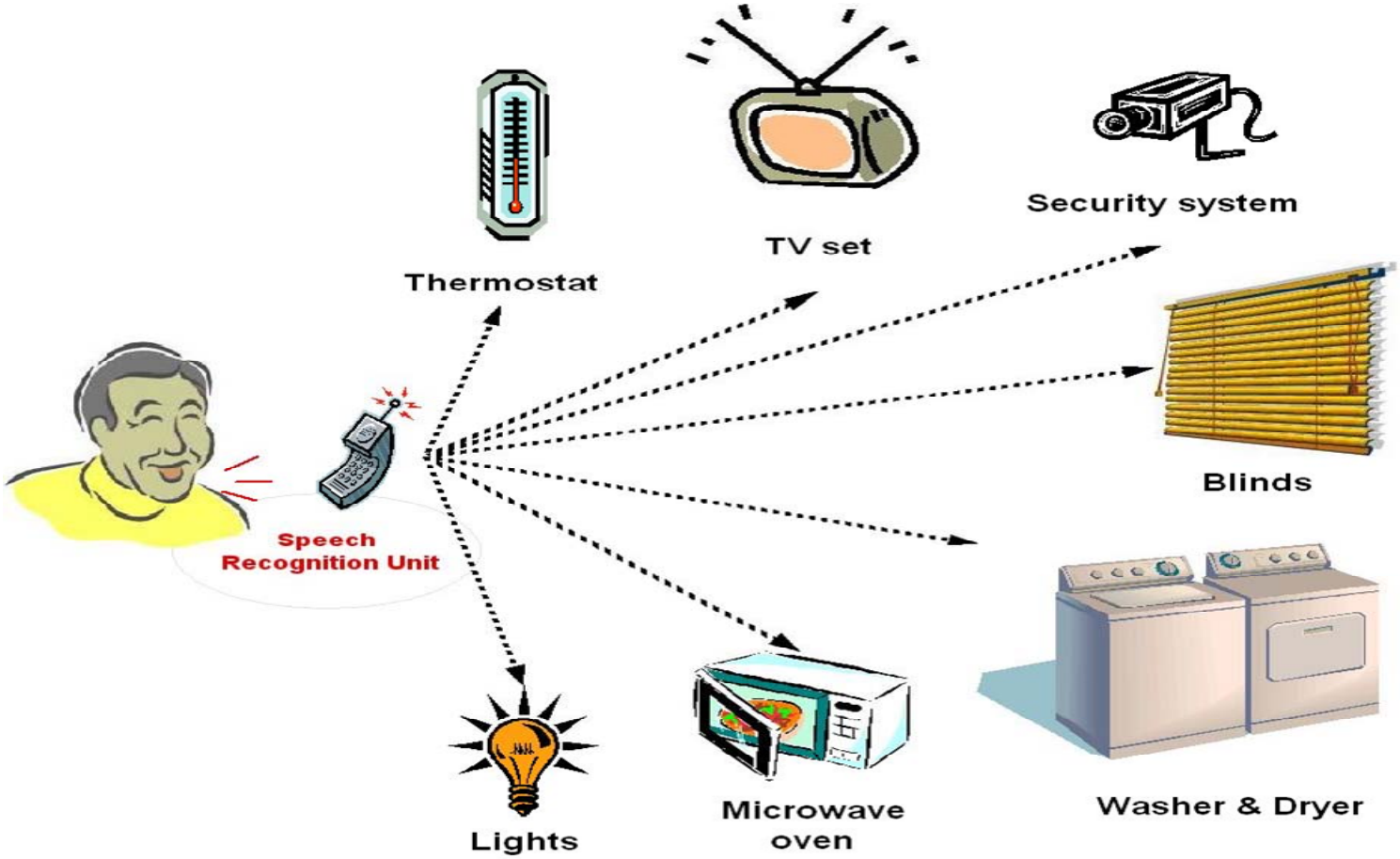

Figure E-2. Remote control voice recognition display board.

Remote Control – (touchscreen)

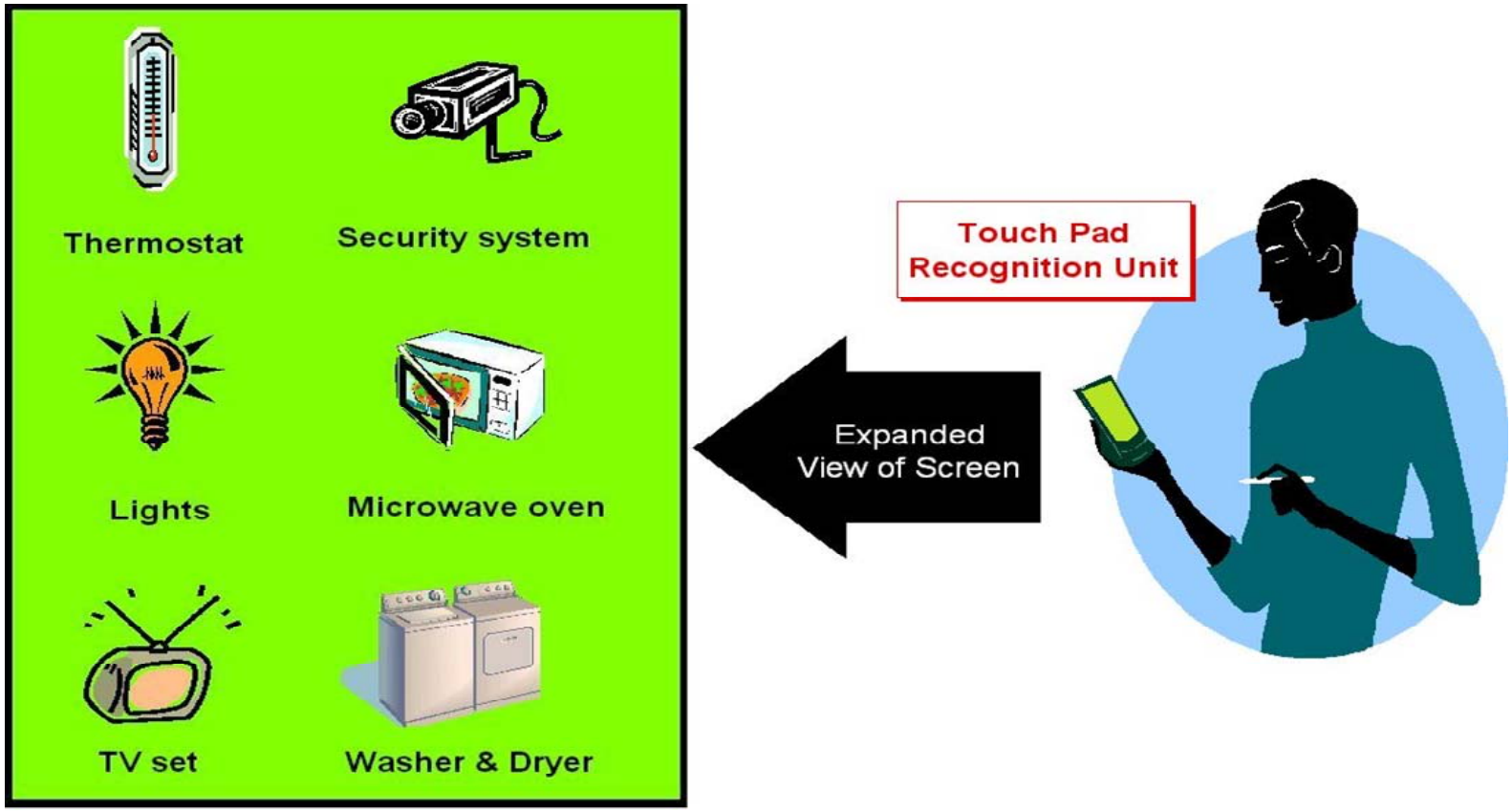

Figure E-3. Remote control touchscreen display board.

Household Automation/Monitoring

Figure E-4. Household automation/monitoring display board.

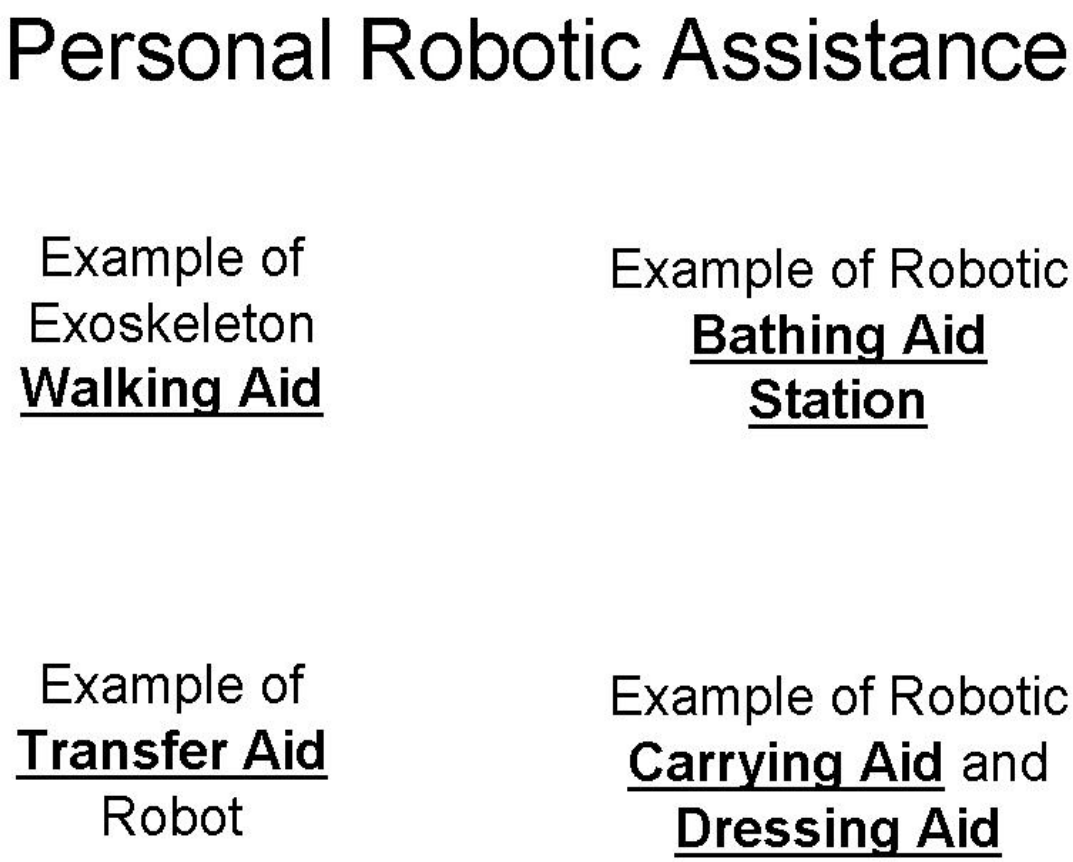

Figure E-5. Personal robotic assistance display board.

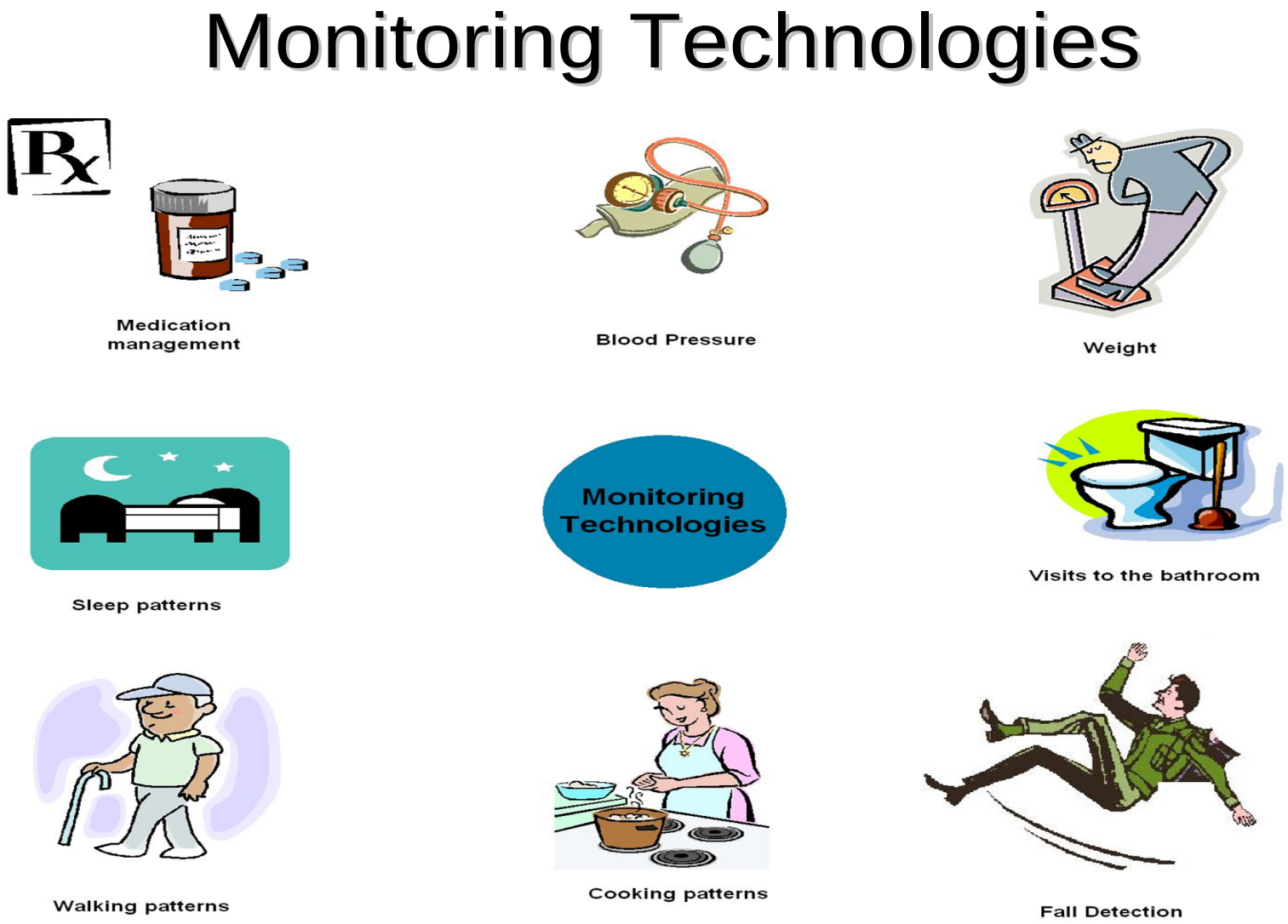

Figure E-6. Monitoring technologies display board.

Prompting/Reminding Technologies

Health condition management
(high blood pressure, diabetes,
heart condition, arthritis)

Mental exercise

Important event reminder
(birthdays, medical appointments,
and social events)

Prompting/
Reminding
Technologies

Physical exercise

Food Recommendations

Medication reminding

Figure E-7. Prompting/reminding technologies display board.

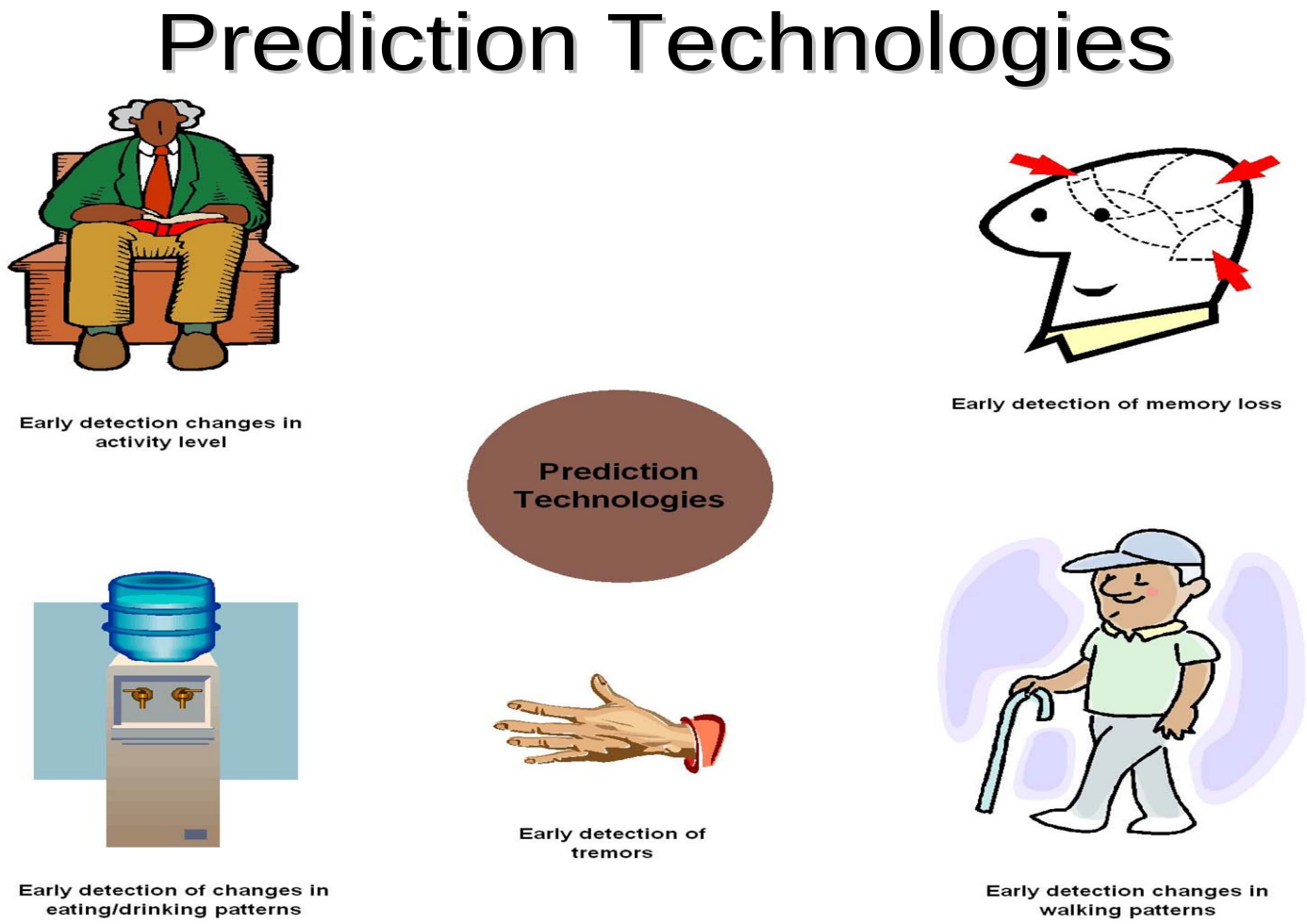

Figure E-8. Prediction technologies display board.

APPENDIX F
PARTICIPANT OBSERVATION GRID GUIDE

PARTICIPANT OBSERVATION GRID GUIDE

Confidential Study Participant Number: _____

Interview Date: _____ Start Time _____ Completion Time: _____

Observation	Description
1. Who is present in the house? a) Friends/family/pets 2. What are their roles? a) Participant caring for others? 3. How do the people behave toward one another? a) Who makes the decisions for whom? b) What nonverbal communication do they use? 4. How does participant move in home? a) Furniture walking, alternating between cane and walker, frequently bumps into furniture. 5. How has the space in the home been allocated? a) Clear pathways vs. aesthetics b) Majority of time spent in which room c) Are commonly used items centered around a favorite chair? d) Safety concerns overridden for aesthetics (smoke alarms, fire extinguisher)	

Observation	Description
6. How has the AT been integrated? a) Walker, scooter, cane, grab bars, in prominent locations (safety is priority?) b) A lot of environmental modifications? c) Any homegrown modifications? 7. How has the technology been integrated? a) Multiple or separate computer room(s)? b) Highly used Tivo, PDA, cell phone	

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BIOGRAPHICAL SKETCH

Rick D. Davenport entered the University of Florida's Rehabilitation Science Doctoral Program in August of 2002. The past 5 years of work as a research assistant in the Rehabilitation Engineering Research Center on Technology for Successful Aging has set the foundation for Rick's dissertation area in smart home technology. Having shared authorship on four peer-reviewed articles, authored a book chapter, and led a conference workshop, Rick's interests lie primarily in designing elder friendly technology.