# DESIGN FOR OLDER ADULTS – FUNCTIONAL LIMITATIONS AND HUMAN FACTORS ENGINEERING

by

MEGUMI SATO HICE

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Abstract

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Megumi Sato Hice, PhD

The University of Texas at Arlington, 2021

Supervising Professor: Sheik N. Imrhan

Background: Throughout the aging process, people experience changes in functional ability and such changes can happen in physical and mental functions. As a result, older adults develop limitations in their capabilities to perform daily activities. Although many studies have done to identify functional limitations for elderly, many older adults still face negative consequences in daily living conditions due to their functional declines. One of the possible causes may be a lack of feedback or participations of elderly users in the design process. Other reason could be a lack of consideration to identify the needs for a specific task associated with daily activities.

Methods: This research aimed to determine the associations between specific tasks and functional declines utilizing the perspective of the elderly via an opinion survey and a focus group study. Seven daily activities (bathing or showering, dressing, preparing meals, housekeeping, medication adherence, using a computer, and using a cellphone) were identified, and opinion survey was designed to ask specific tasks of each activity based on the functional categories for human factors.

Findings: The results identified specific tasks that are associated with difficulty in performing daily activities. Environmental conditions to improve design to ease the difficulty of performing tasks by older adults were proposed, including bathroom space,

kitchen layout, furniture, and consumer products. This study shows that, despite the accumulated knowledge and efforts to improve the living environment over the decades, these problems are still prevalent. Two important aspects of this study are new: 1) it elucidates difficulties people face in their actual living environment from their own point of view, and 2) it shows specific relationships between activities or tasks perceived as difficult, by the elderly, and their physical and mental capabilities. While most of the older adults seem to be satisfied with their environment a small, but significant, percentage find the environment still too challenging.

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# Chapter 1

## Introduction

Everyday activities require interactions between individuals and their environments (Czaja, 1997). When a demand to use the environment and the person's capacity to handle the demand are not compatible, the interaction becomes complex. A poorly designed environment results in excessive demands from the person to be able to handle the environment; likewise, if one's capacity to manage the environment is limited, the environment cannot be handled properly (Verbrugge & Jette, 1993) and results in poorly performed tasks, health problems, and safety issues.

Throughout the aging process, people experience changes in their physical and mental functions (Fisk, Rogers, Charness, Czaja, & Sharit, 2009; Faragem, Miller, Ajayi, & Hutchins, 2012). As a result, older adults develop limitations in their capabilities to perform activities of daily living (ADLs) such as walking, bathing, or dressing, and instrumental activities of daily living (IADLs) such as shopping, housekeeping, or driving (Chung et al., 2017; Ishizaki, Kai, Kobayashi, Matsuyama, & Imanaka, 2004; Chung, Ozkaynak, & Demiris, 2017). Some studies consider ADLs and/or IADLs key performance indicators for evaluating how well or poorly elderly people are able to perform their everyday activities, despite their declined functionality (Rogers, Mayer, Walker & Fisk, 1998; Stuck, Walthert, Nikolaus, Bula, Hohmann & Beck, 1999; Vorst, Zijlstra, Witte, Duppen, Stuck, Kempen & Schols, 2016). Human factors engineering fits well to promote active engagement, as its basic principle is to fulfil the needs of people by designing the environment to meet their capabilities. This is especially appropriate and important for the elderly whose functional capabilities may change significantly after about 65 years of age.

According to the American Community Survey published by the U.S. Census Bureau, approximately 24 percent of adults between the age of 65 and 74 have some form of disability (U.S. Census Bureau, 2018); by age 75, almost half of them experience physical, mental or emotional problems. The same report indicates that many adults 65 or older have serious difficulty with walking or climbing (21.3%), difficulty with IADLs (13.8%), hearing impairment (13.7%), cognitive disability (8.3%), difficulty with ADLs (7.5%), and visional impairment (6%).

Since the 1970's many studies have been conducted to identify the functional limitations experienced by a substantial number of elderly people, and the Katz Index of ADL (1970) and Lawton IADL scale (1969) have been widely utilized to measure their ability to perform ADL or IADL. The implications of the results have contributed research for assistive technologies (Mitzner, Boron, Fausset, Adams, Charness, Czaja, Dijkstra, Fisk, & Rogers, & Sharit, 2010; O'brien, Rogers & Fisk, 2012; McMurray, Strudwick, Forchuk, Morse, Lachance, Baskaran, Allison & Booth, 2017) and smart homes (Linskell & Hill, 2010; Hossain, 2014; Paiva, Ferrer & Villarouco, 2015; Ni, Hernando & Cruz, 2015). Despite the large number of studies conducted to support the aging population, many older adults still face negative consequences in daily living conditions due to their functional declines. Data from the American Housing Survey (AHS) indicates that nearly 94% of homes in the U.S. have some kind of aging-related accessible feature, yet, almost 30% of adults (age 65 or older) still experience difficulty using them (U.S. Census Bureau, 2020). By age 85, 48.5% are experiencing difficulty.

Chan, Campo, Esteve, & Foumiols (2009) and Mitzner et al. (2010) stated that implementation of assistive technology or smart homes too often fail to assess the users' needs. Similarly, universal design, the purpose of which is to design the environment to conform to the users' abilities, has not been widely adopted due to a lack of feedback

from those who need them such as the users with disabilities, or elderly, in the design process (Sanford, Story, & Ringholz. 1998; Beecher & Paquet, 2005). Imrhan (1994) pointed out that society has not adequately considered performance changes that occur throughout the aging process as a design element. Therefore, many older adults are still forced to adapt to their living environment rather than having the environment modified to suit their capabilities. This phenomenon is succinctly expressed by Myerson's (2017) statement that "many older people are disabled by the design of the environment around them."

Why is "lack of usability" still an issue in designing for older adults? One reason may be that individual differences in functional deterioration make it difficult to generalize a design for elders (Rogers, 1997; Kroemer, 2006). Another may be that older people often compensate for their declined skills by relying on others (Howell, 1997; Rogers et al., 1998). Many studies have promoted health monitoring systems that satisfy the needs of care givers and healthcare providers (Dutta, Holliday & Femie, 2008; Jimison & Pavel, 2008; Hayes, Pavel & Kaye, 2008) but may not be aligned with the needs for elderly people. Monitoring technologies for elders with dementia is an example of this (Kinney & Kart, 2006; Lin, Chiu, Hsiao, Lee & Tsai, 2006, Rowe, Campbell & Lane, 2008; Kearns & Moore, 2008; Adlam & Orpwood, 2008). Other approaches focus on remedies for specific functional limitations (e.g., mobility and balance) without identifying the needs for a specific task associated with daily activities (e.g., adjusting the temperature of water for showering and managing a stove control for cooking). The researches for disability are especially important for ensuring safe environment for elders such as fall preventions (Cheng, Tan, Ning, Gao, Wu, Schwebel, Chu, Yin & Hu, 2018) but their primary focus may be risk mitigations. Various low-tech devices are already on the market to

accommodate task needs, but many of them need to be researched more thoroughly by academics or companies (Yu & Hang, 2010; Kohlbacher & Hang, 2010).

The present study aims to identify specific tasks that elderly people who are affected by functional declines perform daily, and determine the association between the tasks and specific physical, sensory, or cognitive functions. The identification was done from the perspective of the elderly who perform these tasks via an opinion survey. The study also aims to offer suggestions for the designs for the environment that could improve the living conditions of the elderly without increasing their task demands. The study applied quantitative (questionnaire) and qualitative (focus group) research methods and propose human factors interventions.

### 1.1 Novelty of Research

The following are the unique aspects of this research:

- While various aspects of difficulties with ADLs/IADLs and declines in physical and mental functions have been researched, few studies have explored the relationships between specific ADL/IADL tasks and corresponding physical and mental functions in the elderly (e.g., climbing stairs versus mobility in the legs) in terms of human factors design.
- By using a questionnaire to find out the aforementioned relationships involving the elderly, this study gathered information through their perceptions of task difficulties, based on their experience.

### 1.2 Contribution to Knowledge

By analyzing the compatibility between the perceived functional capacities of older adults and task demands, this study may bring new direction and/or more practical implications to the design of living environments to ease the functional challenges that older people experience in daily life. This should lead to less dependence on physical

aids and more independence in their daily lives. This research may also contribute to innovative universal designs for living environments, as older adults are a part of the population of universal design. The human factors engineering approach to elderly living is to encourage independence rather than dependence on human care givers or a proliferation of assistive devices.

## 1.3 Objectives of the Study

The objectives of this study are:

- To identify the specific tasks inherent in daily activities that are difficult to perform, and the functional capacities required to perform these activities.
- To identify the mechanisms that older adults apply to overcome their functional limitations.
- To identify the physical features of the living environment that cause or are associated with mismatches between task demands and the functional capacities of the elderly. The functional capacities include anthropometric, posture and balance, whole body strength, segmental (mainly arm) strength, physiological endurance, mobility, holding slippery things, psychomotor skills, cognitive, vision, and hearing.
- To identify possible changes in the design of the environment that have the potential to alleviate or minimize difficulties with performing daily tasks.
- To identify areas where assistive technology could be designed or improved when direct design of the environment is neither practicable nor possible.

To pursue these objectives, this study utilized a mixed method – quantitative and qualitative research. Quantitative research was conducted via a questionnaire, and qualitative research was conducted via a focus group, in a sequential-explanatory design approach. Chapter 3 discusses the details of the methodologies for this study.

## 1.4 Research Questions and Hypotheses

Based on the above objectives, this study attempted to answer the following questions based on the data obtained from the responses to the questionnaire:

- Can the perceived difficulty with physical, cognitive and mental tasks be identified from a questionnaire on the living experience of the elderly?
- Is there a direct relationship between the difficulty in performing tasks inherent in daily activities and the related functional capacities?
- Can the information from human factors mismatches lead to redesigns that mitigate some of the difficulties faced by older adults?

This research tried to validate the above questions by conducting a focus group study.

## 1.5 Limitations

This study considers older adults to be individuals that are 65 years or older. Required participants for this study had to live in the United States, be able to perform most of the basic activities of daily living (ADLs) and instrumental activities of daily living (IADLs), and perceive themselves to be capable of answering the questionnaire. This study did not evaluate the status of the participants' health with operational or psychological instruments.

# Chapter 2

# Literature Review

## 2.1 Problems Associated with the Physical Decline

The human body progressively loses physical capabilities throughout the aging process, although the timing and level of the changes vary widely among individuals (Vercruyssen, 1997; Rogers et al., 1998; Kroemer, 2006; Fisk et al., 2009). Evidence of this has been verified by many cross-sectional and longitudinal studies (Frontera, Hughes, Lutz, & Evans, 1991; Lindle, Metter, Lynch, Fleg, Fozard, Tobin, Roy, & Hurley, 1997; Hedel & Dietz, 2004; Niksirat, Silpasuwanchai, Wang, Fan, & Ren, 2016). Age-related physiological changes occur in body dimensions, muscle strength, joint and bone configurations, and metabolism (Boss, & Seegmiller, 1981; Kroemer, 1997; Kumar, 2014). Studies indicate that a decline in muscle mass impacts overall strength and physical performance (Larsson, Grimby, & Karlsson, 1979; Metter, Conwit, Tobin, & Fozard, 1997; Goodpaster, Park, Harris, Kritchevski, Nevitt, Schwartz, Simonsick, Tylavsky Visser, & Newman, 2006) while physiological changes interfere with gross motor skills (Lockhart, Smith, & Woldstad, 2005) such as coordination; balance; and movement of the arms, knees, back, and other large parts of the body that enable walking, bending, climbing steps, moving heavy objects, etc.

Significant associations in the mobility of older adults have been found between their lower extremity strength and power (Suzuki, Bean, & Fielding, 2001; Bean, Leveille, Kiely, Bandinelli, Guralnik, & Ferrucci, 2003; Tiedemann, Sherrington, & Lord, 2005; Marsh, Miller, Saikin, Rejeski, Hu, Lauretani, Bandinelli, Guralnik, & Ferrucci, 2006; Puthoff & Nielsen, 2007), and leg strength is also considered a predictor of gait speed (Bassey, Fiatarone, O'Neil, Kelly, Evans, & Lipsitz, 1992; Buchner, Larson, Wagner, Koepsell, & Lateur, 1996; Fragala, Alley, Shardell, Marris, McLean, Kiel, Cawthon, Dam,

Ferrucci, Guralnik, Kritchevsky, Vassileva, Gudnason, Eiriksdottir, Koster, Newman, Siggeirsdottir, Satterfield, Studenski, & Kenny, 2016). A cross-sectional study of the gross motor skills of different age groups conducted by Niksirat, Silpasuwanchai, Wang, Fan, and Ren (2016) found that older people, in both arm and leg movements, showed a lack of accuracy and speed and also required more time for recovery. They also identified that older adults face balance issues after moving their legs sideways. Multiple studies also indicated that cognitive functions influence gait speed (Frederiksen, Hjelmborg, Mortensen, McGue, Vaupel, & Christensen, 2006; Holtzer, Verghese, Xue, & Lipton, 2006; Watson, Rosano, Boudreau, Simonsick, Ferrucci, Sutton-Tyrrell, Hardy, Atkinson, Yaffe, Satterfield, Harris, & Newman, 2010). Studies by Spedden, Malling, Andersen, & Jensen (2017) and by Taniguchi, Watanabe, Osuka, Kitamura, Seino, Kim, Kawai, Sakurai, Inagaki, Awata, & Shinkai (2019) also showed a significant association between motor skills and cognitive performance.

Stair negotiation, climbing up and down stairs, is one of the most challenging physical activities among older adults (Startzell, Owens, Mulfinger, & Cavanagh, 2000; Kim, 2009; Jacobs, 2016). According to a report by the Centers for Disease Control and Prevention (2020), 46.8 percent of older adults (age 65 and older) in the United States who have difficulty in stair negotiation reported fall-related injuries, whereas only 6.4 percent of those who have no difficulty with stair negotiation reported such injuries. Kim (2009) mentioned that climbing stairs is a particularly difficult activity for elders with impaired motor functions and lower extremities. Verghese, Wang, Xue, & Holtzer (2008) found a positive correlation between difficulty with climbing up stairs and poor balance, reduced grip strength, and neurological gait abnormalities. Other studies found that many older adults found that going down stairs was more difficult than going up (Startzell et al., 2000; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003). The same studies also described

that age-related impairments in various areas such as vision, sensory functions, and motor control, as well as physiological and biomechanical variables, influence individuals' perceptions of their difficulty with stair negotiation (Startzell et al., 2000; Verhaeghen et al., 2003).

Grip strength is important for many critical activities of daily living, and it too declines with age; however, research findings do not agree about the role that gender plays in the rate of decline. Some studies reported that older men showed a more rapid decline than older women (Proctor, Fauth, Hoffman, Hofer, McClearn, Berg, & Johansson, 2006; Oksuzyan, Maier, McGue, Vaupel, & Christensen, 2010) while others found that longitudinal changes in grip strength were greater in older women than in older men (Rantanen et al., 1997; Rantanen, & Heikkinen, 1998). Studies have shown a clear difference in the decline of males and females between the ages of 50 and 85 years (Mathiowetz, Kashman, Volland, Weber, Dowe, & Rogers, 1985; Kallman, Low, & Molzahn, 1990; Frederiksen et al., 2006; Andersen, Petersen, Frederiksen, Mackenbach, 2009; Cooper, Hardy, Sayer, Ben-Shlomo, Birnie, Cooper, Craig, Deary, Demakakos, Gallacher, McNeill, Martin, Starr, Steptoe, & Kuh, 2011); however, the gender difference tends to diminish with increasing age, especially after age 60 (Metter et al., 1997; Frederksen et al., 2006; Cooper et al., 2011; Nahhas, Choh, Lee, Chumlea, Duren, Siervogel, Sherwood, Towne, & Czerwinski, 2010). Grip strength and physical activity are strongly associated for elderly women (Rantanen, Era, & Heikkinen, 1997; Nahhas et al., 2010) and men 60 years of age and older (Cooper, Lmb, Sharp, Simmons, & Griffin, 2017).

Handgrip strength is also associated with cognitive decline in the elderly population (Christensen, Mackinnon, Korten, Jorm, Henderson, Jacomb, & Rodgers, 1996; Alfaro-Acha, Al Snih, Raji, Kuo, Markides, & Ottenbacher, 2006; Jang & Kim; 2015;

Bohannon, Bear-Lehman, Desrosiers, Massy-Westropp, & Mathiowetz, 2007). A study performed by Giampaoli, Ferrucci, Cecchi, Lo Noce, Poce, Dima, Santaquilani, Vescio, & Menotti (2003) found that grip strength is useful for identifying older adults who are at risk of disability. Jan & Kim (2015) suggested using handgrip strength as a predictor for age-related weakness in overall muscular strength and cognitive abilities. Although some authors espouse that grip strength is a useful indicator for the overall health of elderly people (Sayer & Kirkwood, 2015; Forrest, Williams, Leeds, Robare, & Bechard, 2018; Iconaru, Ciucurel, Georgescu, & Ciucurel, 2018), others warn that the mechanism of how grip strength impacts disabilities is not known (Frederksen et al., 2009; Andersen et al., 2009). Other types of hand strength also decline with age in the elderly population. Mathiowetz et al. (1985) and Imrhan & Loo (1989) found that the finger pinch strength declines significantly with age. This trend was also modeled statistically by Imrhan and Mandahawi (2010). Regardless of the variations in grip strength, it is well known that this decline makes it difficult for senior adults to accomplish tasks that were easy for them when they were younger (squeezing or turning objects such as jar lids, screw drivers, etc.; holding and moving objects such as pots and pans on the stovetop; holding onto rails while climbing stairs, etc.) This difficulty is due to the fact that many tasks in daily living and their physical requirements are designed predominantly for the younger adult population.

A questionnaire-based research conducted by Simard, Chalifoux, Fortin, Archambault, St-Cerny-Gosselin, & Desrosiers (2012) found correlations between females' self-rated difficulty with using their hands to perform tasks such as opening bottles or wringing out towels and measured grip strength; they did not observe such correlation in older males. Koppa, and Congelton (1988) examined handgrip torque in elderly females by having them turn seven different types and shaped of faucet handles,

and they found that the participants could apply the required torque with paddle-type handles, but could not generate sufficient torque to terminate the water flow with other types of handles. Imrhan and Loo (1988) also found a significant decline in the hand-torquing capabilities of elderly people. Tietjen-Smith, Smith, Martin, Henry, Weeks, & Bryant (2006) found no association between grip strength and functional capabilities of ADLs (feeding, grooming, bathing, and controlling of bowels and bladder) older females although they suggested that grip strength was correlated with overall strength.

## 2.2 Remedies for Physical Problems

Various assistive technologies and devices are available to support elderly people's activity of daily living (ADL), with those that support mobility being the most commonly used (LaPlante, Hendershot, & Moss, 1992). Examples of assistive devices are can-openers that are especially designed for those with limited grip strength, electrically powered wheelchairs, stair lifts, and grab/hand rails. Assistive technologies are tools that improve an individual's ability to perform specific tasks, enhance their safety, and increase their functional capabilities (Laurin & Pleasant, 2008). Some scholars, however, express concerns that they are often underused or used erroneously (George, Binns, Clayden, & Mulley, 1988; Hirsch, Forlizzi, Hyder, Goetz, Kurtz, & Stroback, 2000), due to a mismatch between the design and the context of use (Hirsch et al., 2000). Therefore, it is crucial, early in the design process, to consider human-centered design and involvement of end-users (Sanford et al., 1998; Beecher & Paquet, 2005). Gitlin (1995) espoused that one of the reasons that assistive devices are sometimes abandoned is that they are a poor fit between the person and the environment. This result aligns with Lawton's environmental gerontology theory (Lawton, 1985) and the need for a human factors engineering approach to designing the environment to fit the user (the elderly). Many scholars support Lawton's environmental

theory and the need for a physical environment design for the elderly (Golant, 2003; Kendig, 2003; Scheidt & Windley, 2014). Examples are bathrooms that incorporate wheelchair access to toilets, kitchens that accommodate changes in food preparation and food preference, accessibility to the bathroom from the bedroom (Koncelik, 2008), and other environmental designs such as wider hallways, ramps, and improved entry points (Fisk et al., 2009). Designs for elders must consider the dynamic human factors of aging that encompass physiological, psychophysical, psychological, and sociological changes (Czaja, 1997; Koncelik, 2008; Fisk et al., 2009; Lin, Zhao, & Zeng, 2013).

Studies have shown that older adults prefer to use handrails to negotiate stairs (Reid, Novak, Brower, & Costigan, 2011). Haptic cues such as a light-touch contact device also contribute to postural stability (Krishnamoorthy, Slijper, & Latash, 2002; Dickstein, & Laufer, 2004; Baccini, Rinaldi, Federighi, Vannucchi, Paci, & Masotti, 2007) and their effect may be stronger in older adults (Baccini et al., 2007). Scovil, Corbeil, Lee, McKay, Peters, & Maki (2008) conducted an experiment with a handrail cueing system that was designed to prevent falls among the elderly. They used a combination of visual and auditory indications that were triggered when a sensor detected someone approaching the stairs. Their results suggested that older adults tend to use the handrail more often when cueing system is activated. This may improve the accuracy and speed of elderly people's grasping reactions and be a potential aid to help them achieve better balance for stair negotiation (Scovil et al., 2008). They also expressed concerns that the cueing could have adverse effects by distracting the elderly and making them more vulnerable to falling. Cheng, Bateni, and Maki (2008) modified the design of walkers by removing the restrictions of lateral stepping movements. The results showed a significant decrease in the number of foot/device collisions while maintaining other positive features

(e.g., lateral step distance) of the original walker. Nevertheless, they did not find strong evidence that the new design improved postural stability.

Bathroom aids such as non-slip bath mats and bathroom rails are among the assistive devices commonly used by older adults living in senior communities (George et al., 1988; Edwards & Jones, 1998; Sonn & Grimby, 1994). Some studies have shown; however, many elderly participants still manage bathing without the aids although they acknowledged the need of them (George et al., 1988; Sveistrup, Lockett, Edwards, & Aminzadeh, 2006). A common reason for older adults not using bath grab bars is that they feel awkward and unsafe while doing so (Aminzadeh, Edwards, Lockett, & Nair, 2000; Sveistrup et al., 2006), instead, they use the rim of the bathtub, shower curtain rods, etc. (Aminzadeh et al., 2000; Sveistrup et al., 2006). Some experimental studies identified that vertically mounted grab bars in the bathroom improve postural stability and are useful for both entering and exiting the tub (Sveistrup et al., 2006; Guitard, Sveistrup, Edwards, & Lockett, 2011; King, & Novak, 2017). Sveistrup et al., (2006) and King & Novak (2017) suggested the additional use of a non-slip device, such as a bath mat, to ensure greater safety for older adults.

Passive monitoring technologies such as motion and pressure sensors are also available. These devices are typically used in residential facilities called Smart Homes (Demiris et al., 2004; Courtney, 2008; Ni, Hernando, & Cruz, 2015) to keep the residents safe and to monitor their activities so that family caregivers can be told when unusual events occur (Demiris, Rantz, Aud, Marek, Tyrer, Skubic, & Hussam, 2004; Daniel, Cason, & Ferrell, 2009). For instance, if the motion sensors in a living room do not detect any activity for a period of time, it might be a sign that the senior resident fell in the bathroom. Although this type of technology does not directly assist the physical needs of older people, it helps caregivers quickly take appropriate actions when accidents occur

(Daniel et al., 2009). Snoek, Hoey, and Mihailidis (2008) developed a computer system that monitor and analyze the motions of persons on a staircase. Although more research is required for actual use, this technology might be useful for detecting unsafe behavior that could be a sign of physical or cognitive changes. The areas of this application could be in a home environment or hospitals where elders need help getting out of bed.

### 2.3 Problems Associated with the Cognitive Decline

Cognitive deterioration is one of the critical impairments that leads an elevated risk of decreased quality of life and independence (Buscemi, Steglitz, & Spring, 2012; Harada, Love, & Triebel, 2013; Blazer, Yaffe, & Liverman, 2015). According to the Older Americans 2016: Key Indicators of Well-Being, published by the Federal Interagency Forum on Ageing-Related Statistics, in 2011, approximately 10 percent of older adults (65 or over) not living in nursing homes had dementia, and the number increases with age. The same report mentioned that 41 percent to 68 percent of nursing home residents demonstrate moderate or severe cognitive impairment.

It is commonly known that memory becomes worse as people get older (Howard & Howard, 1997; Fisk et al., 2009; Harada et al., 2013) but age-related declines in memory are not uniform in size (Lusting & Lin, 2006; Fjell & Walhovd, 2010). Older adults show signs of decline in three different aspects of memory: working memory (or short-term memory), prospective memory (remembering to do something in the future), and procedural memory (knowing how to do something) (Fisk et al., 2009). Howard & Howard (1997), Lusting & Lin (2006) , and Fisk et al. (2009) also mentioned that age-related deficits in semantic memory (abstract representation of the meaning of a stimulus) are rare.

Salthouse (1994) examined the age differences in working memory through an experiment of computation span (the number of digits a person can remember without

error while performing a simple calculation). The result showed that people in their 70's, on an average, could remember one or two digits while young adults in their 20's were able to recall three to five digits. He attributed this largely to age-related processing speed. McBride, Rogers, and Fisk (2011) performed a series of experiments to understand the role of workloads in human-automation interactions among two age groups (young vs. older). The participants interacted with a computer warehouse management system where they were required to perform tasks of receiving and dispatching packages in a virtual environment. Performance was measured by the number and accuracy of the processed tasks while the workload was scaled to low, medium, or large, depending on the number of packages assigned. The results showed that in the perfect automation environment, where computer provided feedback to assist the participants in processing the assigned workload, the performance of the older people with high workloads was worse than that of those with low workloads. However, when the older adults performed the same tasks under the imperfect automation environment, as when words were mispronounced or not clearly annunciated, the workload, rather than automation errors, influenced the performance. The older adults complied with and relied on automation more intensively than the younger adults, implying that older adults are less sensitive to automation errors.

As their ability to process information declines, people also suffer from attention issues (Cerella, Rybash, Hoyer, & Commons, 1993; Salthouse, 1993; Fisk et al., 2009). Three general types of attention are selective attention (searching for things), focusing attention (focusing on one location and excluding others), and dividing attention (multi-tasking) (Fisk et al., 2009). Older adults perform less well than younger adults when any kind of attention is required (Commodari, & Guarnera, 2008; Fisk et al., 2009).

Rogers and Fisk (1991) conducted an experiment to observe the difference in Stroop effect on young and older adults. They discovered that older adults are unable to ignore distractions, while, with practice, younger adults are able to learn to shut them out. They also found, by proposing real-world examples such as placing stop signs next to yield signs or placing a green-colored sign next to a stop sign, that older adults have difficulties in modifying or inhibiting previously learned automatic processes. Commodari and Guarnera (2008) performed tests that consisted of seven tasks to compare the focusing abilities of two age groups. The tasks consisted of a simple reaction time; speed; accuracy of the reaction time; auditory and visual tasks; digit spans; divided attention; resistance to distraction; and attention shifting. The older participants were less able to resist distractions, inhibit irrelevant stimuli, and shift their attention from one thing to another, and it took them longer to process complex tasks.

Some tasks that involve cognitive functions are simple activities such as dressing and eating, other are more complicated tasks such as understanding a medical label and driving. Older adults generally have trouble comprehending and remembering medical information since it requires multiple cognitive steps (Insel, Morrow, Brewer, & Figueredo, 2006; Bosworth & Ayotte, 2009). Neupert, Allaire, Davis, and Patterson (2011) found that older people are likely to remember their medication routine when they are less busy; therefore, workload affects their cognitive performance. Driving is another task that requires multiple intensive cognitive processes. According to Fisk (2017), most older drivers are reluctant to give up driving, which results in an increase in the number of automobile accidents that they are responsible for. Miller, Taylor, and Insel (2016) argued that cognitive functions such as working memory, attention, and processing speed were strongly are associated with an unsafe driving performance and increased crash risk.

## 2.4 Remedies for Cognitive Problems

As described in earlier sections, their impaired working memory and attention deficit limit the performance of older adults. Therefore, it is important that all technology that is designed to assists them considers these limitations and minimizes demands on their working memory and attention capability. This is also true for providing instruction and training programs that are targeted for elders (Lusting & Lin, 2006; Kramer, & Madden, 2008; Fisk et al., 2009), as controlling cognitive load is an important element of imparting instructional methods to them (Fisk et al., 2009). Park and Gutchess (2000) suggested that automated processes for complex cognitive tasks might help elders maintain their cognitive ability. For instance, an automatic pill dispenser could prevent elders from double-dosing a medication. Similarly, automated driving devices, such as a Global Positioning System (GPS), could assist elderly drivers in getting their destinations safely. In both instances, performing accurately may be more critical than performing quickly (Charness, 2008). Redesigning the tools and environment, as well as training senior users to adopt new technologies, are both important and inevitable (Charness, 2008).

Another method that has been proposed to aid cognitive functioning is clinical *dohsa-hou,* a Japanese body-oriented psychotherapy that Adachi (2015) studied to determine whether it could improve cognitive functions among elderly people. According to the Japanese Society of Certified Clinical Psychologists (JSCCP) (2018), clinical *dohsa-hou* is a psycho rehabilitation training designed to improve psychological problems through a holistic process of motor actions. Adachi (2015) examined two groups of healthy elderly subjects: one group performed *dohsa-hou* and the other group did not. Their cognitive abilities were assessed by the Stroop test, in which the participants were asked to read randomly arranged words that were written in a color different from their

meaning. The results implied that the cognitive ability to process a task improved in the older adults performing *dohsa-hou*, as did their postural balance, and their anxiety was reduced.

Although its intended purpose is not to improve cognition functions directly, a home equipped with a passive monitoring system of motion and pressure sensors could help detect unusual events experienced by a cognitively impaired elder. For instance, Rowe, Campbell, and Lane (2008) examined a home monitoring system that was designed to improve night-home safety of persons with dementia. The system consisted of various sensors to detect motion, door opening, and bed occupancy. When a sensor detected a signal, it transmitted it to the control panel, and an alarm was then activated to gain a caregiver's attention. Twelve-month clinical study encompassed 26 experimental homes and 27 control homes, and caregivers from the experimental group reported high satisfaction with the system. The study further identified five control subjects that experienced an incident resulted in an injury or an unattended exit that would have been prevented if the system had been implemented.

### 2.5 Problems Associated with the Sensory Characteristics

As people age, their sensorimotor skills decline or become more erratic (Fisk et al., 2009; Poletti, Sleimen-Malkoun, Temprado, & Lemaire, 2015). Some older adults impaired in this area cannot control their body position or movements unconsciously (Fisk et al., 2009). Studies associated with arm movements indicate that older adults spend more time decelerating arm movements than accelerating them (Haaland, Hamngton, & Grice, 1993; Darling, Cooke, & Brown, 1989; Stelmach, Goggin, & Amrhein, 1988). Seidler and Stelmach (1995) espoused that a possible cause of this result is declined sensory and motor process skills associated with aging because the deceleration phase is considered under closed-loop control, which utilizes error detection and corrective

information from motor and sensory systems while the acceleration phase is under open-loop control that does not require such information. An experiment by Haaland et al. (1993) further discovered that removing visual feedback during arm movement increases deceleration time substantially for elderly people. Another experiment by Hedel and Dietz (2004) discovered that older people cannot perform locomotor tasks as accurately as younger people and that they depend more on visual control when performing a precise task, which may be due to a decreased function of proprioceptive feedback mechanisms. Some studies show relationships between increased postural sway and a decline in sensorimotor skills such as vision (Ring, Nayak, & Isaacs, 1989; Duncan, Wilson, MacLennan, & Lewis, 1992), sense of vibration (Lord, McLean, & Stathers, 1992), and proprioception (Duncan et al., 1992; Fife & Baloh, 1993).

Fisk et al. (2009) stated that age is the single best predictor of visual decline or blindness. As eyes age, their lenses become yellow, thick, and stiff due to the loss of water to lubricate them (Kline & Scialfa, 1997). As a result, the range to which the lens can adjust focus decreases (Kline & Scialfa, 1997), and it becomes difficult to clearly see objects that are close (Kroemer, 2017). The resting diameter of the pupil also declines with age, making older adults more vulnerable under low illumination conditions (Kline & Scialfa, 1997). They also become more sensitive to light change and it takes them longer time to adapt to darkness (Sturr, Zhang, Taub, Hannon & Jackowski, 1997; Jackson & Owsley, 2000; Kroemer, 2017), and to recover from glare (Kline & Scialfa, 1997). Kline and Scialfa (1997) mention that contrast sensitivity, especially intermediate and higher spatial frequencies, declines with age, and Fisk et al. (2009) reported that the older adults' ability to judge depth and motion also weakens with age.

Mitzner and Rogers (2006) conducted a study to assess the effects of contrast on seniors' reading speed and comprehension, and their experiments found that, under

low contrast conditions, older people require 40 percent more time to read the same material than younger adults, although older adults maintain their comprehension regardless of the contrast level. Furthermore, the older adults can read faster under the high and medium contrast conditions when high word predictability is present; however, word predictability does not influence their reading time at the low contrast level. Charness and Dijkstra (1999) evaluated the legibility performance of older adults in three different environments with varying luminance levels. They concluded that inadequate lighting negatively influence the seniors' performance in legibility tasks, and their performance declined with lower luminance levels.

A longitudinal study conducted by Swenor, Simonsick, Ferrucci, Newman, Rubin, & Wilson (2015) revealed that older adults with impairments in contrast sensitivity and stereoacuity (or depth perception) had greater risk of developing mobility limitations. Another study discovered that older adults with visual impairments that affect their near sight have an increased risk of experiencing limitations in using stairs or walking (Pérès, Matharan, Daien, Nael, Edjolo, Bourdel-Marchasson, Ritchie, Tzourio, Delcourt, & Carriere, 2007), although it did not indicate significant association with transferring to the toilet (Swanson & McGwin, 2004; Peres et al., 2007). Slower visual processing speed in older adults affects everyday task such as searching for an item on a shelf or reading a medicine bottle label (Owsley, McGwin, Sloane, Stalvey, & Wells, 2001; Ball, Berch, Helmers, Jobe, Leveck, Marsiske, Morris, Rebok, Smith, Tennstedt, Unverzagt, & Willis, 2002; Edwards, Wadley, Myers, Roenker, Cissell, Ball, 2002). Other studies found that older adults with visual impairments have difficulty in performing IADLs more than ADLs (Berger & Porell, 2008; Hochberg, Maul, Chan, Van Landingham, Ferrucci, Friedman, & Ramulu, 2012; Lam, Christ, Zheng, West, Munoz, Swenor, & Lee, 2013). Good, Alpass,

and LaGrow (2008) discovered that visually impaired older adults engage less frequently in social activities, enjoy less independence, and less satisfied with their lives.

Hearing impairment is common among older adults (Czaja, 1990; Ciorba, Bianchini, Pelucchi, & Pastore, 2012; Meister, Rahlmann, Walger, Margolf-Hackl, & Kiebling, 2015; Taljaard, Olaithe, Brennan-Jones, Eikelboom, & Bucks, 2016). According to the Profile of Older Americans 2018, published by the Administration for Community Living, 14 percent of Americans 65 years or older report difficulty in hearing. Although young people can hear pure tones up to 15,000 vibrations per second, older adults may not be able to hear sounds above 4,000 vibrations per second (Fisk et al., 2009). In the normal aging process, humans lose hair cells in the inner ear, especially outer layer cells that are responsible for coding high frequencies (Kline & Scialfa, 1997; Schmiedt, 2010), which may be a cause for impaired hearing of high-frequencies among elderly people. In addition, excess wax in the auditory canal affects pure tone sensitivity (Kline & Scialfa, 1997). Moreover, Slawinski, Hartel, and Kline (1993) report seven types of auditory problems associated with aging: temporal resolution, hearing with background noise, understanding distorted speech, perception of normal speech, detection of high-pitched sounds, telephone communication, and detection of environmental sounds (Slawinski et al., 1993).

Even common speech in everyday life may be difficult for many older adults to understand when there is background noise (Duquesnoy, 1983; Cordon-Salant, 1987; Tun & Wingfield, 1997; Edwards, 2007). Edwards (2007) further indicated that the combination of hearing impairment and background noise may cause greater impairment to the cognitive system. A literature review by Glyde, Hickeson, Cameron, & Dillon (2011) introduced many other studies that confirmed the effect of background noise on hearing among older adults. Jayakody, Friedland, Eikelboom, Martins and Sohrabi (2018)

discovered strong correlations between age-related hearing impairment and cognition as well as other psychological issues such as depression, anxiety, and stress. Similarly, other studies reported a relationship between cognitive decline and age-related hearing loss (Peters, Potter, & Scholer, 1988; Lin, Yaffe, Xia, Xue, Harris, Purchase-Helzner, Satterfield, Ayonayon, Ferrucci, & Simonsick, 2013; Taljaard, Olaithe, Brennan-Jones, Eikelboom, & Bucks, 2016).

Two studies indicated an association between hearing impairment and an increased risk for falls, potentially because decreased hearing could limit spatial orientation that would normally avert environmental hazards that might lead to a fall (Viljanen, Kaprio, Pyykko, Sorri, Pajala, Kauppinen, Koskenvuo, & Rantanen, 2009; Lin, & Ferrucci, 2012). Other longitudinal analyses suggested that the level of hearing loss among elderly people is associated with limitations in ADLs, IADLs (Strawbridge, Wallhagen, Shema, & Kaplan, 2000), and physical performance (Strawbridge et al., 2000; Chen, Betz, Yaffe, Ayonayon, Kritchevsky, Martin, Harris, Purchase-Helzner, Satterfield, Xue, Pratt, Simonsick, & Lin, 2015). Thorslund, Ahlstrom, Eriksson, Lidestam, Lyxell, & Peters (2014) found that elderly drivers with severe hearing loss showed significantly worse driving performance than those with normal hearing or mild hearing loss.

## 2.6 Remedies for Sensory Problems

Hearing aids and glasses are the most common devices that accommodate poor sensory systems. Unfortunately, commercially available hearing aids have much room for improvement for remediation of different kinds of hearing issues (Czaja, 1990). Another assistive technology for sensory systems is a modified telephone that displays the captions of a conversation in large text on a display. This device is helpful for elders who have developed hearing loss. Another example is a cell phone with voice activation

technologies (Daniel et al., 2009) that visually support impaired elders and enable them to make phone calls without touching the numeric buttons.

Fisk et al. (2009) insist that visual interfaces for older adults should consider improving the signal strength of messages and reducing the sources of noise in the system. Examples of signal strength that are sufficient for elders are increased text font size, brightness, and contrast (Fisk et al., 2009). Minimizing noise could be done by isolating messages from other message channels (Fisk et al., 2009). Visual products for older people should also consider utilizing alternative sensory systems, such as a visual warning sign with sound and vibration (Fisk et al., 2009). Lertwiriyaprapa and Fakkheow (2015) introduced an audio prescription labeling (APL) device equipped with a radio-frequency identification (RFID) reader. This device reads the prescription information from medicine bottles with an RFID label and audibly transmits the information to the visually impaired person. The results demonstrated that 96 percent of the subjects were satisfied with the usability of the device.

Ahlmark and Hyyppa (2015) evaluated the existing commercial and non-commercial navigation aids for visually impaired people. They addressed the fundamental limitations of auditory feedback (speech), which requires much mental effort although it is the most widely used method for transmitting complex information non-visually. Their evaluation of haptic feedback, such as vibrations, was that could be a viable solution for warning those with visual and auditory limitations about obstacles; however, further development is needed before it can be implemented. Similarly, a path-following experiment using GPS with on/off course confirmation via vibrotactile and auditory stimuli suggested that these simple binary cues are sufficient to provide guidance system for visually impaired people (Marston, Loomis, Klatzky, & Golledge, 2007).

Fisk et al. (2009) made several considerations of how to improve hearing impaired elders' perception of information. First, auditory products (e.g., phones) for hearing impaired adults should have adjustable sound volumes, mechanisms to provide redundant information (e.g., sound and vibration or light), and a display with textual or graphical information. These features would help users compensate for their loss of hearing, as cues are present. Second, the products should not utilize high frequency sounds. For instance, a telephone answering machine could use male voices instead of female voices, with slower rather than fast speech. Lastly, minimizing background noise helps elders with auditory impairments hear and understand speech. Examples are providing headphone sets, not using background music, and using sound-absorbing materials on walls. Additionally, a training program may be utilized to introduce lip reading. Sharit, Czaja, Nair, and Lee (2003) conducted experiments among different age groups, using a telephone voice menu system. The results demonstrated that the rate of speech does not affect any the age groups while the additional graphical navigation benefit the older participants the most. They also concluded that sufficient training is necessary for older adults to be able to use a complex voice menu system. Bakke (2008) introduced alerting and warning systems such as flashing lights to indicate a phone call or a doorbell ring, bed vibrators, and/or flashing lamps as an alternative to alarm clocks.

### 2.7 Problems Associated with the Psychosocial Interactions

Psychosocial disorders among elderly people may be caused by physical or mental health issues. Kourkouta, Iliadis, and Monios (2015) espoused that dementia and depression are two of the leading problems that limit elders' psychosocial interactions. Kourkouta et al. (2015) identified two sectors of the elderly population who suffer from depression: those who live in an environment that induces pressure and stress and those who experience biological changes in their bodies. Living in an environment in which they

cannot properly perform everyday activities can negatively impact older adults' psychosocial interactions, and physical injuries can cause them to be isolated because of lack of mobility. Both conditions may lead to depression and further limit potential psychosocial interactions. Heine and Browning (2004) conducted a pilot study of elderly people who had both visual and hearing loss, and discovered that sensory loss has implications for both communication and psychosocial behavior. The study showed that the elders with sensory loss are sensitive to their disability, experience communication and psychosocial difficulties, and experience fatigue, embarrassment, and social restriction because of related communication breakdowns.

Pohl , Cochrane, Schepp, and Woods (2017) examined the correlation of social isolation, depression, and well-being among older adults through data retrieved from National Health and Aging Trends Study (NHATS). The study indicated positive correlations between social isolation and the depression risk score, and negative correlations between social isolation and well-being. They also reported that older adults who reported being in excellent health are five times more likely socially connected than isolated. Hand, Retrum, Ware, Iwasaki, Moaalii, and Main (2017) found through their research that a lack of information about a range of topics can contribute to social isolation, and they reported that isolated elders listen to the radio and read newspapers less often than non-isolated elders.

### 2.8 Solutions to Remedy Psychosocial Problems

Cattan, White, Bond, and Learmouth (2005) reviewed the experimental studies of health interventions and assessed their impact on preventing social isolation. The results of their review showed that interventions made by an educational or social groups were effective at easing social isolation and loneliness among elders while one-on-one interventions such as home visits and telephone contact were not effective. The group

interventions, however, may be limited to those who are relatively healthy. Raymond, Grenier, and Hanley (2014) conducted a case study to observe how elders with disabilities experience social participation. All the participants in their study said that they wanted to be involved in social activities but criticized the lack of symbolic and physical access to a participative environment that accommodated their needs. Raymond et al. (2014) expressed that environmental obstacles could be more critical than a disability in limiting impaired elders' participation in social activities.

Artificial intelligence (AI) is considered to have great potential for assisting elders with day-to-day activities, but little research has been done in this area. Some companies have begun developing robots to mitigate psychosocial issues of elders (Sharkey & Sharkey, 2010), and Sharkey and Sharkey (2010) identified three areas in which robots could be utilized to care for elderly people: 1) assisting with daily activities, 2) monitoring health or behavior, and 3) providing companionship. Although the utilization of robots has potential benefits for easing elders' lives, it may raise ethical concerns that need to be addressed (Sharkey & Sharkey, 2010). Baisch et al. (2017) conducted an experiment to evaluate whether social robots could improve the psychosocial functions of elderly people, and their findings indicated that the acceptance of the robots by elderly people varied, based on the fit of the user and technology.

## 2.9 Summary of Literature Review Findings

Many studies have been conducted to identify physical and functional limitations that older adults experience in everyday life, and technologies have been introduced to assist these conditions. With increasing age, physical daily activities such as walking, bending, climbing steps, lifting objects, gripping and squeezing objects, and exerting muscular forces for other purposes become difficult. Loss of kinesthetic senses, declined muscle strength, and lack of haptic control are examples of age-related conditions that

cause these problems. Sensory organs such as eyes and ears also deteriorate with age, and result in older adults experiencing impaired vision and hearing loss. Psychosocial interactions are vital for maintaining physical and mental health, and elders who cannot function well in everyday life tend to fall into social isolation or loneliness. A significant number of assistive technologies have been introduced to support the everyday life of elderly people, most of which attempt to utilize cues and redundant information so that elders can maximize their functioning while compensating for their impairments. Many researchers also insist on the importance of providing sufficient training for elders so that they can learn these technologies.

It is imperative that designers and engineers fully understand age-related changes in perception, cognition, and movement control (Fisk et al., 2009) in order to design the most effective products for older people. The ultimate goal of human factors engineering is to develop a human environment system that is error-free, productive, safe, comfortable, and enjoyable (Fisk et al., 2009). However, many consumer products, regardless of the age they are designed for, have usability problems (Fisk & Rogers, 2002). Users typically respond to the problem by assuming that they are incompetent or made a mistake although the truth is often that there is a flaw in the product's design or in the instructions on how to use it (Fisk & Rogers, 2002). Although the ultimate goal of older adults is to maintain their quality of life in a safe environment, everyday products can be a hindrance to improving their lives. There still exist many areas where human factors engineering design can improve the quality of life for elderly populations around the world. Given the steady improvements in medicine and consequent increased life expectancy, these areas are expected to become greater.

# Chapter 3

# Method

## 3.1 Research Design

The purpose of this study is to investigate physical features of the living environment that are caused by or are associated with mismatches between the demands of tasks and the functional capacities of older adults through an opinion survey on the living experience of the elderly. The opinion survey was developed to assess the degree to which older adults feel that their living environment meets their functional needs. The survey encompassed everyday activities that are affected by functional declines, and common tasks that require physical, sensory, or cognitive functions. The survey questions were categorized according to human factors characteristics: body size (anthropometric), posture and balance, physical strength (whole body and segmental), physiological endurance, mobility, tactile tasks (holding slippery objects), psychomotor, cognitive, and sensory (seeing and hearing) functions. The human factors approach to this research focused on how well environments are designed to fit the functional capabilities of the elderly and offered design suggestions for improving their living conditions without increasing task demands.

This study used mixed method: quantitative and qualitative research. Quantitative data was derived from the responses to the questionnaire and then analyzed, while qualitative data was collected and analyzed through a focus group study intended to complement and enhance the understanding of the results of the quantitative analysis. Therefore, this study follows the sequential-explanatory design, which primarily uses the quantitative research whereas the qualitative research serves as a secondary source. A focus group study was chosen because it has proven to be beneficial for collecting evaluation data (Israel & Galindo, 1992), and can be used to follow up research

findings from another method (Morgan, 2011). To the end, the results from both analyses were integrated to answer the research questions. Developing a unique questionnaire was determined as a necessary part of this study since the researcher could not find any previously published questionnaire that addressed design of living environment as an instrument of this area of research. A pilot study was conducted to help finalize the questions in the questionnaire.

Data for the research was gathered in three phases. Phase 1 consisted of the design of the questionnaire, phase 2 focused on the quantitative research that collected and analyzed data from the questionnaire, and phase 3 implemented a focus group study to further interpret the results from the quantitative research. Figure 3-1 displays the schematic view of the research design flow.

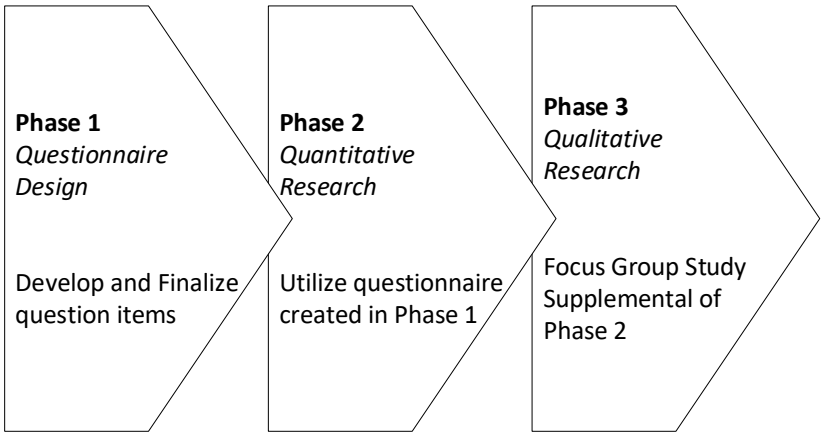


Figure 3-1 Research Design Flow

## 3.2 Participants and Sampling

The participants in this study were adults 65 years or older. The criteria being a participant was that they live in the United States, are capable of performing most of the basic activities of daily living (ADLs) and instrumental activities of daily living (IADLs), and consider themselves capable of responding to a questionnaire. Originally, the researcher

planned to recruit participants from public and private community sites such as retirement homes, nursing homes, and churches; however, the plan had to be changed to a 100% online survey because of COVID-19, and the participants were recruited via QuestionPro, an online panel provider. All the participants were required to provide informed consent, the form for which is included in Appendix A.

## 3.3 Instruments

### *3.3.1 Quantitative Research*

The survey was web-based (QuestionPro) and consisted of questions that ask level of difficulty of specific physical or mental tasks that are necessary for performing an ADL or IADL. Each daily activity included questions that address potential design hinderance such as the size of food jar lids, medicine bottles, and cleaning equipment. Each question is on a 1-5 scale basis. Additionally, the survey included general daily functions, demographic questions, and status of healthy aging.

### *3.3.2 Qualitative Research*

The study utilized a structured focus group to address the reasons why older adults interact with their living environment in a particular way and why certain tasks are difficult for them to perform. An interview guide or protocol was utilized for the qualitative research. Due to coronavirus pandemic, a virtual meeting “Zoom” was used to conduct the focus group study.

## 3.4 Research Procedure

This section describes the research procedure employed for each phase of this research.

### *3.4.1 Phase 1 – Questionnaire Design*

The questionnaire for this study was based on literature reviews of existing questionnaires associated with ADL/IADL and the Home Safety Checklist for Seniors

(Centers for Disease Control and Prevention, 2005). The questions were designed to elicit information on how well older adults function physically and mentally in their living environment. A mismatch between the design of the environment and the functional capacity of a person is likely to result in a task not being accomplished or performed below requirements, and resulting in physical or mental fatigue, or even accidents and injuries. Important tasks of daily living, therefore, were identified, and grouped according to their functional requirements. The questions were designed to help in quantifying the difficulties experienced by the elderly and were based on their self-perception. These questions shown below represent most of the questions in the questionnaire. They are based on various categories of functions or characteristics: body size (anthropometric), posture and balance, physical strength (whole body and segmental), physiological endurance, mobility, tactile tasks (holding slippery objects), psychomotor, cognitive, and sensory (seeing and hearing).

It is theorized that many design features in the living environment, including so called “smart homes,” do not conform to the physical or mental capabilities of their elderly residents, and that their experiences with difficulties caused by the mismatch can provide valuable information that can influence the design or redesign of the living environment and improve the seniors’ living experiences. Some laboratory studies, based on human factors design principles (Imrhan & Loo, 1988; Imrhan, 1989; Imrhan & Loo, 1989; Bordett et al., 1988) have been performed over the decades to address these mismatches, but the older adults’ experiences have not been systematically documented. This study aims to elicit those experiences in an opinion survey. The questionnaire questions that were intended to provide the necessary information are listed in the tables below, according to category of function. The effects of the mismatch of each category

(anthropometric, posture and balance, etc.) are stated, and the tasks or ADLs/IADLs are listed (See Appendix B).

**Anthropometric**

- Effects: not fitting in certain spaces; not reaching things; working at wrong height; objects not fitting in hands; bending too much; cramped for space to move around
- Tasks: holding and using a cell phone; gripping and turning jar lids; working at certain working heights in a kitchen; reaching for things in a kitchen; location of handles in bathroom

Table 3-1 Questionnaire Questions - Anthropometric

| Item Number | Question |
|---|---|
| 8 | How comfortable do you feel moving around in your shower area because of the amount of space available? |
| 15 | How do you consider the space where you dress? |
| 18 | How do you consider the size of the most jar lids for you to grip and turn? |
| 28 | How do you consider the height of kitchen shelves/cabinets that you use most frequently? |
| 31 | In general, how comfortable are the heights of the work surfaces in your kitchen? |
| 32 | How difficult is it for reaching into cupboards and shelves above your head, in your kitchen? |
| 33 | How difficult is it to reach forward or sideways for things that are not directly in front of you; for example, reaching for pots on a stove? |
| 34 | How difficult is it to hold large objects in your home because of their size; for example, pots in the kitchen? |
| 35 | How difficult is it to cope with the heat from hot pots in the kitchen, when moving them? |
| 45 | How difficult is it to move around your furniture due to their weight? |
| 46 | How hard is it on your body due to bending while moving around furniture or other things in your home when cleaning or doing other forms of housekeeping? |

**Posture and balance**

- Effects: slips and falls
- Tasks: bathing and showering; walking on level floors; walking up and down stairs; walking on smooth surfaces; walking on floor where objects are obstacles; uneven floor surfaces and loose rugs or carpets; leaning on furniture while dressing; climbing ladders; standing on ladders and cleaning or clearing shelves; dressing; location of handles in bathroom

Table 3-2 Questionnaire Questions – Posture and Balance

| Item Number | Question |
|---|---|
| 1 | How hard is it for you to bathe or shower? |
| 3 | How slippery is the shower (or bathtub) floor? |
| 4 | Do you think the handles in your bathroom are properly located for you to hold to help maintain your balance? Answer if your shower or bathtub area has grab handles |
| 12 | How hard is it for you to maintain balance while dressing? |
| 14 | How often do you sit or lean on furniture while dressing? |
| 37 | How crowded are various objects, such as books, papers, boxes and shoes, found on your floors that might obstruct walking? |
| 38 | How difficult is it to walk on any of your floors due to uneven or loose rugs or carpet? |
| 40 | How hard is it for you to reach upward to perform housekeeping such as dusting shelves? |
| 42 | How hard is it for you to maintain balance when climbing stepladders or other step-up aids to reach, clean or clear high shelves? |
| 80 | What level of difficulty do you have in walking or maintaining balance? |

**Whole body strength**

- Effects: failure to accomplish a task; being afflicted with physical injuries or cumulative traumas
- Tasks: lifting/lowering objects; pushing/pulling objects; opening kitchen cabinets; opening refrigerator door; housekeeping; moving around cleaning

equipment; lifting and holding heavy pots; lifting or moving around heavy cleaning equipment

Table 3-3 Questionnaire Questions – Whole Body Strength

| Item Number | Question |
|---|---|
| 25 | In general, how difficult is it to handle the weights of pots when cooking or serving meals? |
| 29 | How hard is it for you to open the kitchen cabinets (because of hand strength)? |
| 30 | How hard is it for you to open the refrigerator door (because of hand strength)? |
| 43 | How heavy is it to lift or move around the cleaning equipment you use in your residence? |
| 44 | How hard is it for you to handle cleaning equipment, in general, due to its weight? |

**Segmental (mainly arm) strength**

- Effects: failure to accomplish a task; being afflicted with physical injuries or cumulative traumas
- Tasks: turning faucets on or off; opening or closing medicine bottle caps; opening food jars, new and used; tightening food jars; handling pots while cooking; using hands and fingers for general tasks

Table 3-4 Questionnaire Questions – Segmental Strength

| Item Number | Question |
|---|---|
| 5 | How painful or uncomfortable is it for you to turn the faucet on and off? |
| 17 | How hard is it for you to open food jars with your hands alone (not with tools or opening aids)? |
| 21 | How often do you find new jar lids (that have never opened before) difficult to open? |
| 22 | How often do you find used jar lids (that have been opened) difficult to open or tighten? |

| Item Number | Question |
|---|---|
| 48 | How hard is it to grip a medicine bottle and turn its cap for opening? |
| 49 | How hard is it to grip a medicine bottle and turn its cap for closing? |
| 82 | What level of difficulty do you have in using fingers or hands? |

**Physiological endurance**

- Effects: fatigue in the back, neck, shoulder, arm, or leg
- Tasks: sitting and using a computer for long periods of time; bending neck or raising arms and shoulders when using a computer; bending wrists when using a computer; sitting on an adjustable chair

Table 3-5 Questionnaire Questions – Physiological Endurance

| Item Number | Question |
|---|---|
| 56 | What level of pain do you experience in your neck, shoulders, or arms when/after using a computer? |
| 57 | How sharply do you bend your neck or raise shoulders/arms when using a computer? |
| 58 | How often do you experience pain in your back or legs when/after using a computer? |
| 59 | How often do you sit on an adjustable chair when using a computer? |
| 60 | How often do you experience pain in your fingers when/after using a computer? |
| 71 | How often do you bend your wrists sharply when using a cellphone? |

**Mobility**

- Effects: difficulty in reaching for things; difficulty in moving around from place to place, or from one position to the other
- Tasks: bending to reach bathroom faucet; bending to vacuuming or mopping floor; bending while dressing; reaching high shelves; reaching far into

shelves; reaching sideways or forward for housekeeping; getting in/out of bath tub; moving arms while dressing; using crutches and other mobility aids

Table 3-6 Questionnaire Questions - Mobility

| Item Number | Question |
|---|---|
| 2 | How often do you bend your neck, knees, or back because the bathroom faucet is too low? |
| 7 | How hard is it for you to get in or out of the tub or shower? |
| 10 | How hard is it for you to bend your neck, knees, or back (upper body) while dressing? |
| 11 | How hard is it for you to move your arms while dressing? |
| 39 | How hard is it for you to bend your body downward to perform housekeeping such as vacuuming and mopping floors? |
| 41 | How hard is it for you to reach forward or sideways to perform housekeeping such as picking up or moving things? |
| 81 | How often do you use wheelchairs, walker, cane or crutches to support your mobility? |

**Holding slippery things**

- Tasks: holding a cell phone and preventing it from slipping; difficulty in opening or closing smooth jar lids

Table 3-7 Questionnaire Questions – Holding Slippery Things

| Item Number | Question |
|---|---|
| 19 | How slippery do you find jar lids when trying to open or close them? |
| 72 | How slippery is your cellphone when you hold it? |
| 86 | How slippery do you find things, in general, when holding them? |

**Psychomotor skills**

- Effects: not completing a task with the hand because of difficulties in bending, gripping, or turning with the fingers

- Tasks: buttoning clothes or tying shoe laces; gripping food jars; picking up medicine pills with the fingers; opening food packages or boxes; gripping and tearing wrappers; picking up pills with fingers; using a keyboard or a mouse for computer; using a keypad on a cellphone

Table 3-8 Questionnaire Questions – Psychomotor Skills

| Item Number | Question |
|---|---|
| 13 | How hard is it for you to button a shirt or tie shoelaces? |
| 21 | How often do you find new jar lids (that have never opened before) difficult to open? |
| 22 | How often do you find used jar lids (that have been opened) difficult to open or tighten? |
| 23 | How difficult is it for you to open food packages or boxes (e.g., meat, cookies)? |
| 50 | How hard is it to grip a pill wrapper and tear it with your fingers? |
| 51 | How hard is it to pick up pills with your fingers? |
| 61 | How hard is it for you to use a keyboard or a mouse? |
| 76 | How hard is it to use a keypad on your cellphone because of difficulty in bending or moving your fingers? |

**Cognitive**

- Effects: not performing a task correctly
- Tasks: mixing hot and cold water; turning off stove; understanding medication instructions on a medicine bottle; taking medication in correct dosage/time; understanding information on a computer screen; troubleshooting computer problems; troubleshooting cellphone problems; remembering things

Table 3-9 Questionnaire Questions - Cognitive

| Item Number | Question |
|---|---|
| 6 | How hard is it for you to adjust hot and cold water to get a comfortable temperature? |
| 26 | How often do you turn on or off the wrong stove control for a particular heating surface? |
| 27 | How often do you forget to turn off the stove? |
| 52 | How often do you forget to take medication in the correct dosage or at the correct time? |
| 54 | How hard is it for you to understand a medicine label because instructions are too complicated? |
| 62 | How hard is it for you to understand a user manual or instructions on a computer screen? |
| 65 | How difficult is it for you to solve or diagnose a computer problem when printing a document, emailing, or installing software? |
| 77 | How difficult is it for you to solve or diagnose a cellphone problem such as calling, emailing, or installing applications? |
| 85 | What level of difficulty do you have in remembering things? |

**Seeing**

- Effects: spending more time to accomplish tasks; failure to accomplish tasks
- Tasks: reading a medicine label; reading the contents on PC screen; amount of lighting to work with a computer; reading, in general

Table 3-10 Questionnaire Questions - Seeing

| Item Number | Question |
|---|---|
| 53 | How hard is it for you to read a medicine label because lettering is too small? |
| 63 | How hard is it for you to read the contents on a computer screen? |
| 64 | Do you think the lighting in the room is bright enough for you to work with your computer? |
| 79 | How hard is it to read the contents on a cellphone? |
| 83 | What level of difficulty do you have in seeing things around you or reading without glasses? |
| 87 | How hard is it for you to walk or climbing stairs because of difficulty recognizing obstacles? |

**Hearing**

- Effects: inability to understand conversations, instructions from doctors, or fire alarm (safety sign); inability to hear sounds, in general; decreasing communication
- Tasks: listening and talking over the cellphone with background noise; listening and talking to people nearby

Table 3-11 Questionnaire Questions - Hearing

| Item Number | Question |
|---|---|
| 78 | How difficult is it for you to talk over the cellphone with background noise? |
| 84 | What level of difficulty do you have in hearing? |

Before the final questionnaire, shown in Appendix B, was compiled, a trial questionnaire was administered to a small sample of elderly subjects in an effort to assess the survey's face validity and reliability, and to conduct preliminary tests on certain hypotheses. A validity test is a quality test that is administered to ensure that a questionnaire measures the concept intended to be measured (Siedlecki, Butler, & Burchill, 2015). Face validity involves a selected group of people who participate in a pilot study to review survey questions and provide their opinions (Siedlecki et al., 2015). Face validity enabled the researcher to modify the formatting, wording, and font size of the questionnaire, and formulate the questions so that they are not ambiguous. The results from the validity test are shown in the Section 3.7.3 Quality Testing – Validity Analysis. The participants of the pilot study were recruited via a convenience sampling from the public and private community. Hill (1998) suggested that there should be 10 to 30 participants in a pilot study. Twenty-three older adults were recruited for this one. Data

obtained from the pilot study was used to finalize the questions in the questionnaire for the next phase.

*3.4.2 Phase 2 – Quantitative Research*

According to Profile of Older Americans 2018, published by Administration for Community Living, there were 50.9 million adults age 65 and older in 2017. Due to this large population, the Cochran's formula (Barlett, Kotrilik, & Higgins, 2001) was used to calculate the required sample sizes, with 10 percent of margin of error and 90 percent of confidence level.

The Cochran formula is:

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where:

- *e* is the margin of error
- *p* is the estimated proportion of the population that has the attribute in question (use 50% if any specific number is not given)
- *q* is 1 - *p*
- *Z* is the corresponding z-value for 90% confidence level

$$n_0 = \frac{Z^2 pq}{e^2} = \frac{(1.645)^2\,(0.5)\,(1-0.5)}{(0.10/2)^2} = 271$$

p = 0.5 provides the worst-case assessment with maximum variability and thus is used to represent the largest sample size such as the elderly population in the U.S. (over 50+ million) for this study. It resulted at least two hundred and seventy-one (271) participants were needed to fill in the questionnaire for this study. The researcher recruited three hundred and fifty (350) older adults and three hundred and seventeen (317) individuals successfully completed the web-based (online) questionnaire. Prior to starting the questionnaire, the participants were asked to read a consent and

acknowledge their willingness to participate as well as an opportunity to withdraw from the study at any time. The survey questions were not visible until the participant indicated their consent. Appendix A shows a consent form although it should be noted that the consent form for the online survey was slightly different. Upon completion of the data collection from the survey, appropriate descriptive and inferential statistical tools were used to test the hypotheses and research questions.

### *3.4.3 Phase 3 – Qualitative Research*

This phase involved five older adults who were recruited by the researcher. All participants signed the informed consent form shown in Appendix A. The researcher served as the moderator and developed an interview script prior to conducting the focus group interview. Her qualifications for serving as the moderator include having taken a qualitative research class, as well as having participated in a focus group project. The discussion topics included the questions that are listed in Section 1.4 Research Questions and Hypotheses. All sessions were recorded for data transcription and analysis. Due to the coronavirus pandemic, a virtual meeting on “Zoom” was utilized to avoid face-to-face contact.

## 3.5 Plan for Data Analysis

This section describes the data analysis for each phase of the research.

### *3.5.1 Phase 1 – Questionnaire Design*

The results from the pilot study were used to assess the internal consistency of the questionnaire. Any items that did not elicit sufficient information were modified to exclude ambiguity or were removed from the questionnaire. The formatting and the font size of the questionnaire were modified to improve clarity. The results from the pilot study were also used to measure the internal reliability of the questionnaire. One of the most common methods of demonstrating reliability is the Cronbach’s α statistic (Rattray &

Jones, 2005). Cronbach's α is the coefficient of reliability. It ranges from 0 to 1 (Siedlecki, Butler, & Burchill, 2015). If the items show good internal consistency, it should exceed 0.7 (Rattray & Jones, 2005). Other studies use Cronbach's α of 0.7 or greater to show acceptable internal consistency (Kalfoss, Low, & Mozahn, 2010; Siedlecki, Butler, & Burchill, 2015). If the Cronbach's α is lower than 0.7, it suggests that some items may not belong in the scale (Siedlecki, Butler, & Burchill, 2015) and may be removed before the Cronbach's α is recalculated.

Table 3-12~~Table 3-12~~~~Table 3-12~~ shows the categories and corresponding number of questions. A reliability analysis was performed using the Statistical Package for the Social Sciences (SPSS), and the results are shown in Section 3.7.2 Quality Testing – Reliability Analysis.

Table 3-12 Questionnaire Scale and Category – Draft Version for Reliability Analysis

| Scale | Item Category | Item (QTY) |
|---|---|---|
| 1 | Gross Mobility | 12 |
| 2 | Fine Mobility | 20 |
| 3 | Balance | 7 |
| 4 | Cognition | 9 |
| 5 | Sensory | 7 |
| n/a | General Activity | 7 |
| n/a | Specific Environment/Product | 12 |
| n/a | Demographic | 7 |

*3.5.2 Phase 2 – Quantitative Research*

Statistical analysis, using SPSS, was performed and a descriptive analysis was conducted to measure the basic features of the data, such as variability and pattern, and provide insight into the difficulties faced by the elderly as they perform tasks. The Chi-

square test of independence was performed to determine whether certain activities of daily living are associated with specific tasks. For example, “Is difficulty in bathing or showering associated with slipperiness of the bathroom floor?” Specific hypotheses were defined for each functional category and were tested accordingly.

The formula for Chi-square test of independence is:

$$\chi^2 = \sum \frac{(o - e)^2}{e}$$

Where:

- $o$ is observed (actual) value/frequency
- $e$ is expected value/frequency

The following table is an example of the contingency table with two rows and three columns, which is referred to as a 2 x 3 table.

Table 3-13: Example of Contingency Table

| | | | Q3 - 3. How slippery is the shower (or bathtub) floor? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q1 - 1. How hard is it for you to bathe or shower? | Not at all | Count | 150 | 56 | 31 | 237 |
| | | Expected Count | 133.1 | 65.8 | 38.1 | 237.0 |
| | | % within Q1 | 63.3% | 23.6% | 13.1% | 100.0% |
| | | % within Q3 | 84.3% | 63.6% | 60.8% | 74.8% |
| | | % of Total | 47.3% | 17.7% | 9.8% | 74.8% |
| | Slightly or more | Count | 28 | 32 | 20 | 80 |
| | | Expected Count | 44.9 | 22.2 | 12.9 | 80.0 |
| | | % within Q1 | 35.0% | 40.0% | 25.0% | 100.0% |
| | | % within Q3 | 15.7% | 36.4% | 39.2% | 25.2% |
| | | % of Total | 8.8% | 10.1% | 6.3% | 25.2% |
| Total | | Count | 178 | 88 | 51 | 317 |
| | | Expected Count | 178.0 | 88.0 | 51.0 | 317.0 |
| | | % within Q1 | 56.2% | 27.8% | 16.1% | 100.0% |
| | | % within Q3 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 56.2% | 27.8% | 16.1% | 100.0% |

Expected value/frequency is calculated by:

$$Expected\ value = \frac{(Column\ Total) \times (Row\ Total)}{Grand\ Total}$$

Using the data in Table 3-13 as an example, expected value of the first cell is:

$$Expected\ value = \frac{(178) \times (237)}{317} = 133.1$$

The null hypothesis, $H_0$, of independence between difficulty in bathing or showering and slipperiness of the bathroom floor is based on how good a fit it has between the observed frequencies in each of the 6 cells of Table 3-13 and frequencies that would be expected for each cell under the assumption that $H_0$ is true.

$$\chi^2 = \frac{(150 - 133.1)^2}{133.1} + \frac{(56 - 65.8)^2}{65.8} + \frac{(31 - 38.1)^2}{38.1} + \frac{(28 - 44.9)^2}{44.9} + \frac{(32 - 22.2)^2}{22.2} + \frac{(20 - 12.9)^2}{12.9} = 19.52$$

Degree of freedom $v$ = (2-1)(3-1) = 2, and $\chi^2_{0.05}$ for 2 degree of freedom is 5.991. Since $\chi^2 = 19.52 > 5.991$, the null hypothesis is rejected and conclude that difficulty in bathing or showring and the slipperiness of the bathroom floor is not independent.

The Mann-Whitney U test (an alternative to the parametric T-test) was used to analyze gender-related differences (an independent variable) in the level of difficulty encountered in performing tasks. The Mann-Whitney U test is a nonparametric test that is used to compare two groups when the data distribution of the dependent variable is not normal (Qu, Zhao, and Rahardja, 2008). This is applicable as the dependent variable in this study: the level of difficulty to perform tasks, is ordinal. The Kruskal-Wallis test was performed to compare multiple independent variables to one dependent variable, assuming that the dependent variable was not normally distributed (Guo, Zhong, & Zhong, 2013). All statistical tests were performed at the five percent level of significance.

*3.5.3 Phase 3 – Qualitative Research*

The audio recording from the Zoom meeting was transcribed, and the researcher manually corrected errors and missing information by listening to the recording. After the transcription was completed, the data was coded and categorized with common themes.

Content analysis was performed, which systematically examines words and images captured from media materials, and identifies their relevance to the research topics, themes, concepts, and ideas (Saldana & Omasta, 2017). Vaismoradi, Turunen and Bondas (2013) espoused that content analysis is an appropriate method for studies that do not require a high level of interpretive complexity.

## 3.6 Ethical Considerations

The participants were required to agree to and sign an informed consent. The consent pertaining to their right to privacy as well as their right to withdraw from the study at any time. The consent form, shown in Appendix A, was developed from a template that was provided by the Institutional Review Board (IRB) at the University of Texas at Arlington (UTA), which also reviewed and approved all of the materials related to the research. All the participants remained anonymous.

## 3.7 Pilot Study Results

The pilot study conducted in June 2020 for this research served two purposes. The primary purpose was to evaluate the quality of the questionnaire and ensure the reliability and validity of the questions. The secondary purpose was to perform a data analysis of a small sample of participants to assess the results of the preliminary research questions. The pilot study was conducted after receiving the first IRB approval. The pilot study consisted of two parts. The survey was administrated in the first part, and a discussion group of the participants was formed in the second part. The results from the survey were used for the reliability analysis while the verbal feedback from the discussion group was used to assess the face validity. A total of twenty-four (24) older adults were recruited from Dallas Fort Worth area in Texas. Due to the coronavirus pandemic, an online survey and a virtual meeting were utilized to avoid face-to-face contact.

*3.7.1 Participants*

Of the 24 recruited participants, twenty-three (23) attempted to answer the online survey. Two failed to complete it, one did not sign the consent form, and two others did not respond to the questions that asked their age. Consequently, eighteen (18) participants (13 males and 5 females) answered all the questions and completed the survey. All the participants were Caucasian, and their mean age was 76 years. A more detailed description of the participants is shown in Table 3-14.

Table 3-14 Pilot Study Participant Characteristics (n=18)

| Variable | Categories | N | % |
|---|---|---|---|
| Age | 65-69 | 1 | 5.5 |
| | 70-79 | 14 | 77.8 |
| | 80-89 | 3 | 16.7 |
| Sex | Female | 13 | 72.2 |
| | Male | 5 | 27.8 |
| Race | Caucasian | 18 | 100 |
| Marital Status | Single | 1 | 5.5 |
| | Married | 7 | 38.9 |
| | Widowed | 5 | 27.8 |
| | Divorced | 5 | 27.8 |
| Employment Status | Retired | 15 | 83.3 |
| | Full-time | 2 | 11.1 |
| | Out of work | 1 | 5.6 |
| Housing | House | 12 | 66.7 |
| | Apartment or Condominium | 2 | 11.1 |
| | Senior Living Community | 4 | 22.2 |
| Self-health rating | Poor | 0 | 0 |
| | Fair | 2 | 11.1 |
| | Good | 7 | 38.9 |
| | Very good | 9 | 50 |
| | Excellent | 0 | 0 |
| Self-perceived successful aging | Not at all | 0 | 0 |

| Variable | Categories | N | % |
|---|---|---|---|
| | Slightly | 1 | 5.6 |
| | Moderately | 6 | 33.3 |
| | Very | 10 | 55.5 |
| | Extremely | 1 | 5.6 |

Additionally, eighteen (18) older adults from those who attempted or completed the online survey participated in a virtual meeting scheduled on June 18th, 2020, approximately ten days after all the participants accessed the online survey. The researcher utilized "Zoom" and organized the virtual meeting as a facilitator.

*3.7.2 Quality Testing – Reliability Analysis*

Internal consistency was measured by Cronbach's α for each category defined in Table 3-12~~Table 3-12~~Table 3-12 to determine how closely related the test questions were within each category. Each category included a set of questions that could present a consistent measure of concept. Five categories were developed to measure functional difficulty in gross motor skills, fine motor skills, balancing, cognition, and sensory capacities such as vision and hearing. Questions that did not represent functional difficulties were further categorized in demographic information, daily activities, and environment/product condition.

Table 3-15 shows the questions belonging to each category and the results of the reliability test from the pilot study. Cronbach's α for gross motor was 0.842 (>0.7) which is considered sufficient to demonstrate reliability. Likewise, the scores of 0.89 for fine motor, 0.815 for balancing, 0.803 for cognition were acceptable for showing internal consistency. Cronbach's α for the sensory skills resulted in a score of 0.674 (< 0.7), which is not ideal for showing reliability (Siedlecki, Butler, & Burchill, 2015). However, Taber (2016) espoused that a range of 0.67 to 0.87 is reasonably reliable. The item-total statistics shown in Table 3-16~~Table 3-16~~Table 3-16 were used to determine whether the

reliability could be improved by removing items. The item-total statistics present the value of Cronbach's α if that particular item was deleted from the category. Since no significant improvement was observed, no sensory skills questions were removed; however, a new question was included to assess hearing level, as the preliminary survey does not have a question to address hearing through daily functions.

Table 3-15 Pilot Study Reliability Test Results

| Scale/Category | Question Item | Cronbach's alpha | Reliability* |
|---|---|---|---|
| Gross Motor | 2,9,10,23,26,27,28,32,36,47,48,49 | 0.842 | Reliable |
| Fine Motor | 5,16,17,18,19,20,21,22,39,40,41,42,51,62 ,63,64,65,66,71 | 0.890 | Reliable |
| Balance | 7,11,13,33,34,35,69 | 0.815 | Fairly high |
| Cognition | 12,24,25,43,45,52,56,68,74 | 0.803 | Fairly high |
| Sensory | 6,44,53,54,67,72,73 | 0.674 | Reasonable |
| Daily Activity | 1,8,14,29,38,46,57 | n/a | n/a |
| Environment/Product | 3,4,30,31,37,50,55,58,59,60,61,70 | n/a | n/a |

* Reference for reliability indicator: Taber, K. (2016).

Table 3-16 Item Total Statistics for Sensory Category

| Item | Cronbach's Alpha if Item Deleted |
|---|---|
| 6 | 0.649 |
| 44 | 0.597 |
| 53 | 0.620 |
| 54 | 0.681 |
| 67 | 0.587 |
| 72 | 0.664 |
| 73 | 0.658 |

*3.7.3 Quality Testing – Validity Analysis*

Polit and Beck (2006) states that expert validation is an important step in the development of a new questionnaire and improves the overall quality of the scale items. Therefore, a human factors engineering expert was consulted on the validity of the contents of the questionnaire prior to submitting it to the IRB for approval. Each question of the questionnaire was carefully reviewed and adjusted to enhance its contents. The research further developed another important step, face validity, to verify the context of the questionnaire, and to understand how the targeted population conceptualizes the questionnaire and is sometimes critical to the success of the project (Artino, Rochelle, Dezee, & Gehlback, 2014). The face validity of this research was achieved via a virtual discussion among the survey participants, during which they discussed areas of improvement such as the duration of the online survey (e.g., too long or too short), clarity of the questions, wording and context of the questions, font size, and appropriateness of the answer choices. The meeting lasted for approximately 30 minutes. A total of 18 participants shared their experience with the online survey, with most reporting that it took them less than 20 minutes to complete it. This is consistent with survey data that shows a mean duration of the surveys to be 18.6 minutes. The participants did not have issues with the font size of the questionnaire, but there were issues with the meaning of certain questions. These were later reworded, and the revised questionnaire was re-submitted to IRB and approved in March, 2021.

*3.7.4 Trial Data Analysis*

All the analyses were performed using SPSS (Statistical Package for the Social Sciences), and the statistical significance level was set at five percent. Descriptive statistics were applied to observe the general characteristics of the data and to evaluate the daily activities that the participants reported challenging. Some of the questionnaire

questions were used to create testable hypotheses, and were analyzed to get a preliminary view of the association between variables. For example, is “difficulty in raising the arms” associated with “difficulty in dressing?” Spearman’s correlation was chosen to determine the correlation between variables, since the data in this study is ordinal. Fisher’s exact test was then performed to further determine, in more detail, whether the relationship (or association) between variables was statistically significant. Fisher’s exact test was chosen as an alternative to the Chi-square test, which is not adequate when more than 20% of the cells have expected frequencies below 5 (Kim, 2017). In the trial data, there were the cells with frequencies below 5, and some were even with zero frequency. Additionally, the Mann Whitney U test, an alternative to the parametric T-test, was utilized to compare gender-related differences; for example, “Is there a difference in the level of difficulty that males and females experience in using a computer?”

Hypotheses to be tested in this study concerned the association between an activity and the tasks required to complete the activity, as described in Section 1.4 Research Questions and Hypotheses. Seven groups of hypotheses and associated variables were identified for daily activities (Table 3-17). For instance, the hypothesis in Group 1 in this table is for testing whether there is an association between difficulty in bathing or showering and difficulty in performing individual tasks required for this activity, such as 1) turning the faucet off and on, 2) mixing hot and cold water to get the comfortable temperature, and 3) getting in or out of the bathtub or shower.

Table 3-17: Hypotheses and Variables – Daily Activity

| Hypothesis | Daily Activity (Dependent Variable) | Selected Tasks for the Activity (Predictors) |
|---|---|---|
| 1 | Q1: Bathing/Showering | Q5: Open/close faucet without pain<br>Q6: Mixing hot/cold water<br>Q7: Getting in/out of the tub |
| 2 | Q8: Dressing | Q9: Bend upper body |

| Hypothesis | Daily Activity (Dependent Variable) | Selected Tasks for the Activity (Predictors) |
|---|---|---|
| | | Q10: Move arms around |
| | | Q11: Maintain balance |
| | | Q12: Button a shirt or tie shoelaces |
| 3 | Q14: Preparing meals | Q15: Open food jars |
| | | Q21: Open food packages |
| | | Q24: Stove control - mixing up controls |
| | | Q25: Stove control - forget to turn off |
| | | Q27: Open kitchen cabinet |
| 4 | Q29: Housekeeping | Q32: Bend body downward (e.g., vacuuming) |
| | | Q33: Reach upward (e.g., dusting shelves) |
| | | Q34: Reach forward (e.g., picking up things) |
| | | Q35: Maintain balance on ladders |
| 5 | Q38: Taking medication | Q39: Grip a medicine bottle for opening |
| | | Q40: Grip a medicine bottle for closing |
| | | Q41: Tear a pill wrapper with fingers |
| | | Q42: Pick up pills with fingers |
| | | Q43: Medication adherence (proper dosage & time) |
| 6 | Q46: Using computer | Q52: Type keyboards or use a mouse |
| | | Q53: Understand user manual |
| | | Q54: Read contents on screen |
| | | Q56: Troubleshoot a computer problem |
| 7 | Q57: Using cellphone | Q66: Carry around |
| | | Q67: Type keypads on cellphone |
| | | Q68: Troubleshoot a cellphone problem |

* All questions in this table are obtained from the trial questionnaire

Hypotheses relating to tasks that may be associated with environment/product design are shown in Table 3-18.

Table 3-18: Hypotheses and Variables – Environment/Product Design

| Hypothesis | Task (Dependent Variable) | Environment/Product Design (Predictors) |
|---|---|---|
| 1 | Q7: Getting in/out of the tub | Q3: Slipperiness of the bathroom floor |
| | | Q4: Location of grab handle in the bathroom |
| 2 | Q14: Cooking or preparing meals | Q23: Weight of cooking pots |
| | | Q26: Height of kitchen cabinets |
| 3 | Q15: Opening food jars | Q16: Size of jar lids being small |
| | | Q17: Size of jar lids being large |

| Hypothesis | Task (Dependent Variable) | Environment/Product Design (Predictors) |
|---|---|---|
| | | Q18: Slipperiness of jar lids |
| 4 | Q32: Bend body downward (e.g., vacuuming) | Q36: Weight of cleaning equipment |
| | | Q37: Size of cleaning equipment |
| 5 | Q43: Medication adherence (proper dosage and time) | Q44: Letter size of the medicine label |
| | | Q45: Instructions of medication adherence |
| 6 | Q46: Using computer | Q47: Pain in neck/shoulder/arms when using computer |
| | | Q49: Pain in back/legs when using computer |
| | | Q50: Usage of adjustable chair |
| | | Q51: Pain in fingers when/after using computer |
| 7 | Q52: Typing keyboards or use a mouse | Q51: Pain in fingers when/after using computer |
| 8 | Q57: Using cellphone | Q62: Position of wrist when taking pictures |
| | | Q63: Slipperiness of cellphone |
| | | Q64: Size of cellphone being small |
| | | Q65: Size of cellphone being large |
| 9 | Q59: Frequency of texting with cellphone | Q63: Slipperiness of cellphone |

* All questions in this table are obtained from the trial questionnaire

### *3.7.5 Trial Data Results and Discussion*

#### 3.7.5.1 Difficulty in Daily Activity

Table 3-19 shows a summary of the descriptive statistics for daily activity tasks. The medians were all either 1 or 2, indicating that the level of difficulty in performing these tasks was slight or not present. The standard deviations for the tasks varied widely, with cellphone use being the most variable and bathing and showering the least variable. However, no strong conclusions can be made from these analyses because of the limited sample size; a preliminary understanding of the variable relationships is sufficient.

Table 3-19: Descriptive Statistics for Difficulty in Daily Activity

| Activity | N | Mean | Median | Mode | SD | Min | Max |
|---|---|---|---|---|---|---|---|
| Bathing or Showering | 18 | 1.17 | 1 | 1 | 0.38 | 1 | 2 |
| Dressing | 18 | 1.33 | 1 | 1 | 0.49 | 1 | 2 |
| Preparing meals | 18 | 1.33 | 1 | 1 | 0.59 | 1 | 3 |
| Housekeeping | 18 | 1.83 | 2 | 1 | 0.79 | 1 | 3 |

| Activity | N | Mean | Median | Mode | SD | Min | Max |
|---|---|---|---|---|---|---|---|
| Taking medication | 18 | 1.28 | 1 | 1 | 0.57 | 1 | 3 |
| Using computer | * 16 | 1.81 | 2 | 1 | 0.83 | 1 | 3 |
| Using cellphone | 18 | 2.00 | 2 | 2 | 1.03 | 1 | 5 |

* Two participants were excluded as they do not use a computer
Difficulty scale: 1 = not at all, 2 = slightly, 3 = moderately, 4 = very, 5 = extremely
SD = standard deviation

#### 3.7.5.2 Bathing or Showering

Spearman's correlations between bathing/showering activities and their associated tasks are shown in Table 3-20. There was a significant correlation ($r = 0.69$; $p = 0.025$) with the task of "mixing hot and cold water" (Q6), but not with the other two tasks. Fisher's exact test also showed only a weak association between bathing or showering activities and the other tasks.

Table 3-20: Correlation Table for Bathing or Showering

| | Q1: Bathing or Showering | Q5: Open/close faucet | Q6: Mixing hot/cold water | Q7: In/out of the tub |
|---|---|---|---|---|
| Q1: Bathing or Showering | 1.00 | -0.16 | 0.69 | 0.44 |
| Q5: Open/close faucet | -0.16 | 1.00 | 0.16 | 0.15 |
| Q6: Mixing hot/cold water | 0.69 | 0.16 | 1.00 | 0.44 |
| Q7: In/out of the tub | 0.44 | 0.15 | 0.44 | 1.00 |

Qx presents question ID in the questionnaire

For the tasks concerning environmental/product design, neither Spearman's correlations nor Fisher's exact test showed any significant association between "getting in/out of tub" and slipperiness of the bathroom floor or the location of the grab handles in the bathroom. However, these results may be due to the small sample size, and no strong conclusions should be made, as further investigation is necessary.

3.7.5.3 Dressing

Correlations between dressing and its associated tasks are shown in Table 3-21. A significant correlation (0.65) was observed between difficulty in dressing (Q8) and difficulty in bending the upper body while dressing (Q9). Fisher's extract test was in agreement (p = 0.013).

Table 3-21: Correlation Table for Dressing

| | Q8: Dressing | Q9: Bend upper body | Q10: Move arms around | Q11: Maintain balance | Q12: Button a shirt |
|---|---|---|---|---|---|
| Q8: Dressing | 1.00 | 0.65 | 0.50 | 0.52 | 0.50 |
| Q9: Bend upper body | 0.65 | 1.00 | 0.65 | 0.54 | 0.65 |
| Q10: Move arms around | 0.50 | 0.65 | 1.00 | 0.52 | 0.50 |
| Q11: Maintain balance | 0.52 | 0.54 | 0.52 | 1.00 | 0.52 |
| Q12: Button a shirt | 0.50 | 0.65 | 0.50 | 0.52 | 1.00 |

Qx presents question ID in the questionnaire

3.7.5.3 Preparing Meals

For preparing meals, only the frequency of "turning on/off the wrong stove control" showed a significant correlation (Spearman's r = 0.63). Fisher's exact test agreed with the significance (p = 0.005). Another test was administered to assess the relationship between difficulty in opening food jars and the jar's characteristics, such as the size (small or large) and the slipperiness of the jar lids. No association was observed from the trial data.

3.7.5.4 Housekeeping

Two housekeeping tasks, bending the body downward (e.g., for vacuuming) and reaching upward (e.g., for dusting), showed statistically significant correlations with difficulty in performing housekeeping tasks. Their correlations were 0.70 and 0.65, respectably, as shown in Table 3-22. Fisher's exact test (p = 0.01 and p = 0.16

respectably) also confirmed the statistical association. Furthermore, the study investigated whether the characteristics of cleaning equipment, such as weight and size, affect how older adults foresee difficulty in bending the body downward to perform vacuuming. Spearman's correlations and Fisher's exact test identified a significant relationship ($r = 0.65$, $p = 0.002$) between the heaviness of the cleaning equipment and the level of difficulty in bending the body downward to perform vacuuming. Therefore, the result may imply that the weight of cleaning equipment is an important ergonomic design element that should be considered to ease housekeeping tasks for older adults.

Table 3-22: Correlation Table for Housekeeping

| | Q29: Housekeeping | Q32: Bend downward (vacuuming) | Q33: Reach upward (dusting) | Q34: Reach forward (picking up) | Q35: Maintain balance on ladders |
|---|---|---|---|---|---|
| Q29: Housekeeping | 1.00 | 0.70 | 0.65 | 0.57 | 0.44 |
| Q32: Bend downward | 0.70 | 1.00 | 0.90 | 0.75 | 0.35 |
| Q33: Reach upward | 0.65 | 0.90 | 1.00 | 0.81 | 0.32 |
| Q34: Reach forward | 0.57 | 0.75 | 0.81 | 1.00 | 0.42 |
| Q35: Maintain balance | 0.44 | 0.35 | 0.32 | 0.42 | 1.00 |

Qx presents question ID in the questionnaire

#### 3.7.5.5 Medication Adherence

To assess statistically significant factors between taking medication and associated tasks, the study selected five tasks: four that are related to fine motor skills and one that is related to cognition. The tasks that required fine motor skills are: 1) gripping a medicine bottle and turning its cap to open it, 2) gripping a medicine bottle and turning its cap to close it, 3) gripping a pill wrapper and tearing it open with fingers, and 4) picking up a pill with fingers. All the questions used the same scale from 1 being "not difficult" and 5 being "extremely difficult". The task that requires cognitive skills was addressed with a question pertaining to the frequency with which the survey participants forget to take their medication in correct dosages at the correct time. None of the above tasks showed a significant correlation with difficulty in taking medication; however,

Fisher's extract test indicated that there was a significant factor between difficulty in picking up pills with fingers and difficulty in taking medication ($p = 0.004$). The study further examined with Spearman's correlations and Fisher's exact test to determine whether there was a relationship between the frequency of improper medication adherence (Q43) and the design of the medicine bottle, such as the font size of the medicine label (Q44) and the instructions of a medicine label (Q45). The tests did not reveal evidence of a significant relationship.

3.7.5.6 Using a Computer

The level of difficulty encountered while using a computer was evaluated against four associated tasks: 1) using a keyboard or mouse, 2) understanding manuals/instructions depicted on a computer screen, 3) reading contents of a computer screen, and 4) troubleshooting a computer problem. A significant relationship was observed between difficulty in troubleshooting a computer problem and difficulty in reading the contexts of a computer screen ($p = 0.02$, and $p = 0.004$ respectively).

To assess the ergonomic factors that are associated with using a computer, the study selected four questions: 1) degree of pain in neck/shoulders/arms when or after using a computer, 2) frequency of pain in back/legs when or after using a computer, 3) usage of an adjustable chair, and 4) frequency of pain in fingers when or after using a computer. None of these ergonomic factors showed any significant correlation, according to the Spearman's correlations and Fisher's exact test. Additionally, no significant relationship was observed between difficulty in using a keyboard or mouse and frequency of pain in fingers when or after using a computer.

3.7.5.7 Using a Cellphone

All the participants confirmed that they use a cellphone. The study chose three tasks to determine whether there is a relationship with difficulty in using a cellphone: 1)

carrying around a cellphone, 2) using a keypad, and 3) troubleshooting a cellphone. To assess how the human factors design impacts difficulty with cellphone use, four tasks were selected: 1) position of wrist when taking pictures, 2) slipperiness of the cellphone, 3) size of the cellphone being small, and 4) size of the cellphone being large. The study also assessed whether a correlation exists between the frequency of texting on a cellphone and its slipperiness. No specific cellphone tasks or design elements were significantly correlated with difficulty in using it. Although it was not statistically significant, a relatively high correlation ($r = 0.56$) was identified between difficulty in using a cellphone and troubleshooting a cellphone problem.

3.7.5.8 Influence of Gender and Health Status

The Mann Whitney U test was used to compare gender-related differences for seven daily activities: bathing/showering, dressing, preparing meals, housekeeping, taking medication, using a computer, and using a cellphone. Significant gender differences were found for: 1) grip strength to open a jar lid ($p = 0.03$), 2) frequency of improper medication adherences ($p = 0.007$), and 3) level of difficulty in hearing ($p = 0.02$). The results showed that females experienced that they need more strength to open jar lids while males have more difficulty hearing and adhering proper medication. Further investigation with a larger sample of the population is necessary before conclusions can be considered valid.

# Chapter 4

## Results and Discussions

### 4.1 Online Questionnaire

This section describes the results of the data and findings from the online survey.

#### *4.1.1 Participants*

Of the three hundred and fifty-three (353) older adults who attempted to respond to the online survey, three hundred and seventeen (317) had successfully completed. The average time to complete the survey was 14 minutes; the longest time was 27 minutes. The majority of the participants were female Caucasians who were less than 75 years old. Table 4-1 summarizes the characteristics of the participants.

Table 4-1 Online Questionnaire Participant Characteristics (n = 317)

| Variable | Categories | N | % |
|---|---|---|---|
| Age | 70 or below | 155 | 48.9 |
| | 71-75 | 93 | 29.3 |
| | 76-80 | 46 | 14.5 |
| | 81 or over | 23 | 7.3 |
| Sex | Female | 216 | 68.1 |
| | Male | 101 | 31.9 |
| Race | Caucasian | 282 | 89.0 |
| | African American | 16 | 5.0 |
| | Other | 19 | 6.0 |
| Marital Status | Single | 33 | 10.4 |
| | Married | 152 | 47.9 |
| | Widowed or separated | 62 | 19.6 |
| | Divorced | 70 | 22.1 |
| Employment Status | Retired | 263 | 83.0 |
| | Full-time | 20 | 6.3 |
| | Part-time | 13 | 4.1 |
| | Self-employed | 9 | 2.8 |
| | Out of work or other | 12 | 3.8 |

| Variable | Categories | N | % |
|---|---|---|---|
| Housing | House | 229 | 72.2 |
| | Apartment or condominium | 76 | 24.0 |
| | Other | 12 | 3.8 |
| Self-Health Rating | Poor | 12 | 3.8 |
| | Fair | 69 | 21.8 |
| | Good | 130 | 41.0 |
| | Very Good | 91 | 28.7 |
| | Excellent | 15 | 4.7 |
| Self-perceived successful aging | Not at all | 9 | 2.8 |
| | Slightly | 45 | 14.2 |
| | Moderately | 139 | 43.8 |
| | Very | 101 | 31.9 |
| | Extremely | 23 | 7.3 |

The participants were not all from the same dwelling community. Roughly 96% of them reported that they live in a residential building such as a house or apartment, and among those who selected “other” type of housing, two indicated that they live a mobile home and one person mentioned living in a cabin.

*4.1.2 Difficulty in Daily Activity*

Table 4-2 and Figure 4-1 show the frequency distribution of difficulty levels for seven daily activities: bathing or showering, dressing, preparing meals, housekeeping, taking medication, using a computer, and using a cellphone. Among all the participants (n=317), more than 65% reported having no difficulty performing any of the daily activities, except housekeeping, with which approximately 61% of them reported having some level of difficulty in performing housekeeping. Only 10% of the participants found it difficult to take their medications correctly. It could be inferred that the respondents found daily tasks that require dynamic physical strength more difficult; however, more evidence and research would be required to verify other factors associated with this result.

Table 4-2 Difficulty in Daily Activities

| Activity | Not at all | Slightly | Moderately | Very | Extremely | *Others |
|---|---|---|---|---|---|---|
| Bathing or Showering | 74.8% | 19.6% | 3.8% | 1.3% | 0.6% | 0.0% |
| Dressing | 79.2% | 17.0% | 2.8% | 0.9% | 0.0% | 0.0% |
| Preparing meals | 70.0% | 17.7% | 7.3% | 3.2% | 1.9% | 0.0% |
| Housekeeping | 39.1% | 38.2% | 15.1% | 6.0% | 1.6% | 0.0% |
| Taking medication | 89.9% | 6.3% | 2.5% | 1.3% | 0.0% | 0.0% |
| Using computer | 67.2% | 17.0% | 5.0% | 0.9% | 0.0% | 9.8% |
| Using cellphone | 69.4% | 18.3% | 4.1% | 1.6% | 0.3% | 6.3% |

* Percentage of participants who did not use a computer or a cellphone

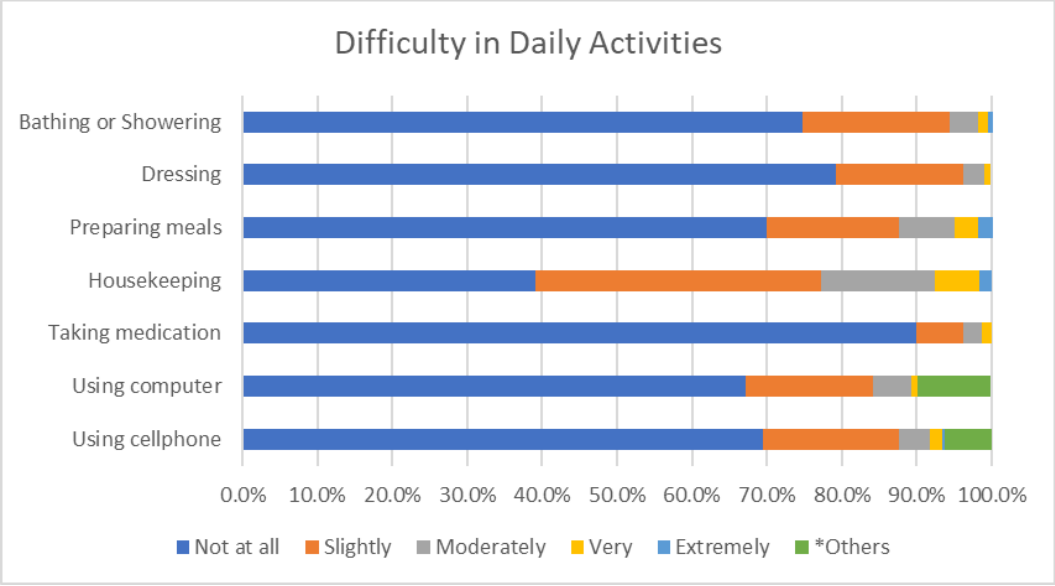


Figure 4-1 Difficulty in Daily Activities

Figure 4-2 indicates the gender-related differences in the percent of participants who reported some level difficulty in performing daily activities. The Mann Whitney U test was used to compare the differences between the genders (Table 4-3) and statistically significant difference was found in difficulty in dressing ($p < 0.05$). Even though the other activities also indicated some gender differences, they are not statistically significant.

Housekeeping was reported by both genders as the most difficult activities, followed by dressing by males (32.7%) and preparing meals by females (29.2%).

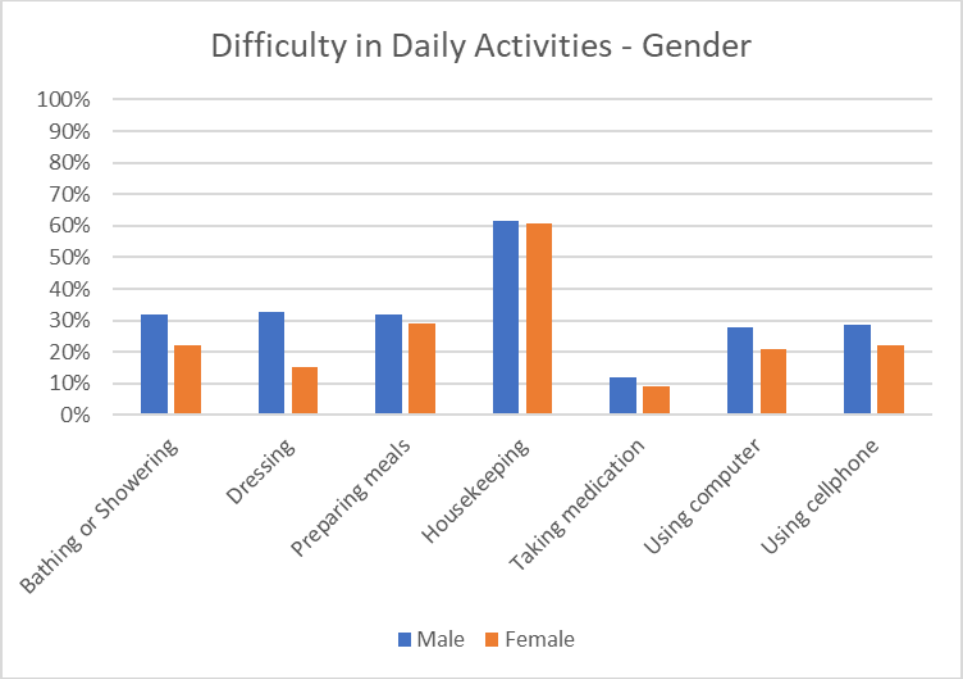


Figure 4-2 Difficulty in Daily Activities by Gender

Kruskal-Wallis test was utilized to understand whether the age of the elderly participants plays a role in their difficulty in performing daily activities, and Table 4-3 shows that no activity was significantly different among age groups ($p > 0.05$). Figure 4-3 represents the overall distribution of the participants, per age group, who experienced some level of difficulty in performing daily activities.

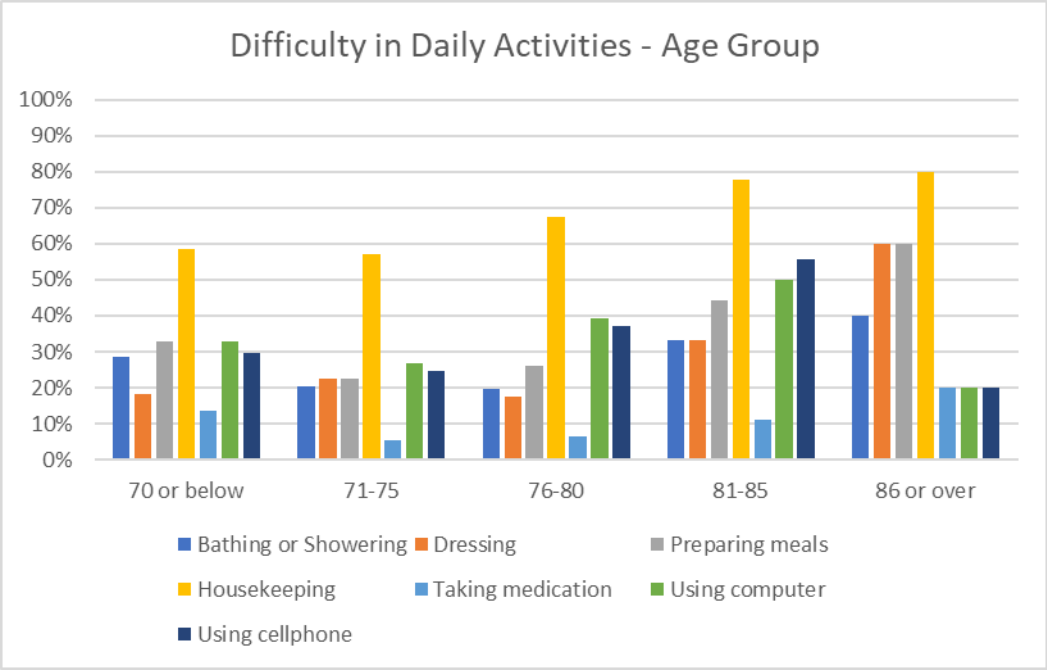


Figure 4-3 Difficulty in Daily Activities by Age

Table 4-3 Difficulty in Daily Activities: Gender and Age Differences (Test Statistic)

| Activity | Gender | | Age Group* | |
|---|---|---|---|---|
| | Test Statistic | p-value | Test Statistic | p-value |
| Bathing or showering | -1.626 | 0.10 | 4.78 | 0.31 |
| Dressing | -3.353 | 0.00 | 6.34 | 0.18 |
| Preparing meals | -0.40 | 0.69 | 7.35 | 0.12 |
| Housekeeping | -0.54 | 0.59 | 7.80 | 0.10 |
| Taking medication | -0.82 | 0.42 | 5.62 | 0.23 |
| Using computer | -1.41 | 0.16 | 7.76 | 0.10 |
| Using cellphone | -1.29 | 0.20 | 4.03 | 0.40 |

* Age groups are; 1 (70 or below), 2 (71-75), 3 (76-80), 4 (81-85), 5 (86 or over)

*4.1.4 Anthropometric*

An anthropometric category was used to assess whether body size/capacity and task demands/environmental conditions are associated with difficulties in performing daily

activities. The survey questions associated with this category are listed in Table 3-1. Table 4-4 shows the research hypotheses and the results from the Chi-square test of independence, which reveal associations between the specific anthropometric conditions and tasks under certain daily activities. A total of 317 individuals responded to the questionnaire and the contingency tables used to interpret their responses are shown in Appendix C.

Table 4-4 Hypotheses and Test Results: Anthropometric

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in bathing or showering is associated with the available space in the shower area.<br><br>(Q1 & Q8) | The association was significant; Chi-sq = 13.8; $p<0.05$. | Two hundred and thirty-seven (237) respondents had no difficulty with bathing or showering, among whom 57% found that the shower space was very comfortable or extremely comfortable for moving around in and 15% found that the space was moderately comfortable. Among those who reported some level of difficulty with bathing or showering (n=80), only 35% found the space was very comfortable or extremely comfortable, and 29% found it to be moderately comfortable. |
| Difficulty in dressing is associated with the space in the dressing area.<br><br>(Q9 & Q15) | The association was not significant; Chi-sq = 2.6; $p = 0.278 > 0.05$. | Two hundred and fifty-one (251) respondents found no difficulty with dressing, and sixty-six (66) finding it slightly difficult or more difficult. In these two categories, percentage of those found the dressing space small, just right, or too large, respectively, were comparable. |
| Difficulty in preparing meals is associated with the size of the jar lids to be gripped and turned.<br><br>(Q16 & Q18) | The association was significant; Chi-sq = 36.1; $p<0.05$. | Two hundred and twenty-two (222) respondents reported no difficulty in preparing meals, and most (70%) found the sizes of jar lids just right, with 21%, reported them as large or very large. Of the Ninety-five (95) who reported some level of difficulty in preparing meals, 52% found the lid size large or very large and 35% found it, just right. |
| Difficulty in preparing meals is associated with the height of the kitchen shelves/cabinets. | The association was significant; Chi-sq = 15.1; $p<0.05$. | Of the 222 respondents who found no difficulty in preparing meals, 75% found the height of the kitchen shelves/cabinets just right, and only 22% found it high or too high. Among those who reported some level of difficulty in preparing meals (n=95), 36% found it high or too high. |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| (Q16 & Q28) | | |
| Difficulty in preparing meals is associated with the heights of the work surfaces in the kitchen.<br><br>(Q16 & Q31) | The association was significant; Chi-sq = 10.5; p< 0.05. | Of the 222 respondents who reported having no difficulty in preparing meals, 92% found the height of work surfaces in the kitchen just right, and only 4.5% found it high or too high. However, of the 95 respondents who experienced some level of difficulty in preparing meals, 13.5% found the shelves high or too high. |
| Difficulty in preparing meals is associated with difficulty in reaching overhead in the kitchen.<br><br>(Q16 & Q32) | The association was significant; Chi-sq = 28.6; p<0.05. | Of the 222 respondents who reported no difficulty in preparing meals, 38% had no difficulty in reaching overhead, 40% found it slightly difficult, 13% moderately difficult, and 9% very difficult or extremely difficult. The corresponding percentages for those who reported some level of difficulty in preparing meals (n=95) were 19%, 32%, 23%, and 26%, respectively. |
| Difficulty in preparing meals is associated with difficulty in reaching forward or sideways for things that are not directly in front of you (e.g., pots, stove).<br><br>(Q16 & Q33) | The association was significant; Chi-sq = 81.2; p<0.05. | Of the 222 respondents who reported no difficulty in preparing meals, 82% experienced no difficulty in reaching forward or sideways, 15% found it slightly difficult, and 3% at least moderate difficulty. The corresponding percentages for those who reported some level of difficulty in preparing meals (n=95) were 33%, 41%, and 26%, respectively. |
| Difficulty in preparing meals is associated with difficulty in holding large kitchen objects (e.g., pots).<br><br>(Q16 & Q34) | The association was significant; Chi-sq = 78.3; p<0.05. | Of the 222 respondents who reported no difficulty in preparing meals, 70% had no difficulty holding large kitchen objects, and only 6% found it at least moderately difficult. However, of the 95 respondents who experienced some level of difficulty in preparing meals, 36% found holding large objects at least moderately difficult. |
| Difficulty in preparing meals is associated with difficulty in coping | The association was significant; Chi-sq = 91.2; p<0.05. | Of the 222 respondents who reported no difficulty in preparing meals, 73% had no difficulty in coping with the heat from pots when moving them, and only 4.5% found it at least moderately difficult. However, of the 95 |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| with the heat from pots when moving them.<br><br>(Q16 & Q35) | | respondents who experienced some level of difficulty in preparing meals, 51% found coping with the heat from pots at least moderately difficult. |
| Difficulty in housekeeping is associated with difficulty in moving furniture due to its weight<br><br>(Q36 & Q45) | The association was significant; Chi-sq = 100.0; $p<0.05$. | One hundred and twenty-four (124) respondents reported no difficulty in performing housekeeping duties, among whom 47% reported no difficulty in moving furniture due to its weight, and 17% finding it at least moderately difficult. One hundred and ninety-three (193) respondents had some level of difficulty in performing housekeeping duties, among whom 65% reported moving furniture at least moderately difficult and only 5%, did not find it difficult. |
| Difficulty in housekeeping is associated with difficulty in bending the body while moving furniture or things when cleaning.<br><br>(Q36 & Q46) | The association was significant; Chi-sq = 134.7; $p<0.05$. | Of the 124 respondents who reported no difficulty in performing housekeeping duties, 57% had no difficulty in bending while moving furniture or other things when cleaning, and only 5% found it at least moderately difficult. However, of the 193 respondents who found some level of difficulty with housekeeping, 60% found bending at least moderately difficult. |

Nearly 75% of the total respondents (n=237) did not find bathing or showering difficult, but those who indicated the difficulty is associated with the size of the shower space ($p<0.05$). Those who had some level of difficulty with bathing or showering (n=80) felt the size of shower space less comfortable than those who had no difficulty. Additionally, sixty-nine (69) of the 80 respondents (86%) also found it difficult to walk or maintain their balance (Table 4-5); thirty-seven (37) of them (46%) responded that they sometimes or often required mobility support (Table 4-6). Therefore, bathrooms for the elderly should be large enough for them to be able to move around in comfortably, with or without the mobility support, to make it easier for them to bathe or shower. The study did not find a need to consider dressing space since the results did not indicate a correlation

between the difficulty in dressing and the space in dressing areas. Over 65% of the participants, regardless of their level of difficulty in dressing, found their dressing space adequate (Appendix C).

Table 4-5 Contingency Table – Bathing or Showering vs. Walking

| | | Walking or maintaining balance (Q80) | | |
|---|---|---|---|---|
| | | No difficulty | Some difficulty | Total |
| Bathing or showering (Q1) | No difficulty | 133 | 104 | 237 |
| | Some difficulty | 11 | 69 | 80 |
| | Total | 144 | 173 | 317 |

Table 4-6 Contingency Table – Bathing of Showering vs. Mobility Support

| | | Level of mobility support (Q81) | | |
|---|---|---|---|---|
| | | Never or seldom | Sometimes or more | Total |
| Bathing or showering (Q1) | No difficulty | 223 | 14 | 237 |
| | Some difficulty | 43 | 37 | 80 |
| | Total | 266 | 51 | 317 |

A significant association was found between difficulty in preparing meals and: 1) the size of jar lids, 2) height of kitchen shelves/cabinets or work surfaces, and 3) movements required to reach or hold objects, etc. Kitchens seem to be in need of a lot of design improvements. As for the consumer products, almost 52% of the 95 respondents reported having some level of difficulty in preparing meals and indicated that the sizes of jar lids are either large or too large; only 35% of them found them to be just right. This result also agreed with research conducted by Wenk et al. (2016), who found that elderly participants perceive the diameter of jar lids large (Wenk, Brombach, Artigas, Jarvenpaa, Steinemann, Ziesemer, & Yildirim, 2016.) Unfortunately, it is not possible to compare the actual size of jar lids and the hand size of the respondents since this study did not capture those measurements. Based on their study, Yen, Flinn, Sommerich, Lavender, &

Sanders (2013) concluded that medium-sized lids (35 to 65 mm in diameter and 15 to 25 mm high) are the best for elderly females with hand pain. According to Carse, Thompson, & Stansfield (2011), older adults tend to use lower squeeze and higher compressive forces on jar lids. Nevertheless, the design suggestion is that the size of jar lids should be compatible with the size of hands, as discussed by Imrhan in detail (1994). Considering that manufacturers have other elements to evaluate when selecting jar size, it is suggested that opening aids be used when the lid size does not fit the hands properly (for maximal force or torque exertion), and that they should be made available in all kitchens designed for the elderly. Older adults should also be advised to avoid purchasing large jars.

Among those who reported having some level of difficulty in preparing meals (n=95), approximately 36% found the height of kitchen shelves high or too high, and nearly 14% found the height of the worksurfaces high or too high. The general recommendation is that the shelf height for older adults should be below 1600 mm, and it should not be lower than 300 mm from the floor (Kirvesoja, Vayrynen, & Haikio, 2000; Pinto, Medici, Sant, Bianchi, Zlotnicki, & Napoli, 2000). Research by Kirvesoja et al. (2000) also determined that work surfaces for elderly should be between 800 mm and 900 mm. It should, however, be noted that according to ergonomics research, the appropriate heights of the shelves/worksurfaces are determined by the users' body size and physical needs (Kirvesoja et al., 2000; Hrovatin, Sirok, Jevsnik, Oblak, & Berginc, 2012). Therefore, shelves with adjustable heights between 300 mm and 1600 mm and worksurfaces with adjustable heights between 800 mm and 900 mm may be most useful for older adults preparing their meals in the kitchen.

Nearly 67% of those who had some level of difficulty preparing meals found it difficult to reach forward or sideways in the kitchen. Similarly, about 51% of them

perceived coping with heat from pots a challenge, while at least 36% of them found holding large cooking objects (e.g., pots) difficult. Improving the kitchen workflow and the arrangement of the appliances may be helpful in addressing these challenges. A better kitchen layout could minimize the amount of motion required for reaching and shorten the distance that heavy or hot pots have to be carried. A carefully planned arrangement, including the size and/or shape of the appliances and the floor space layout, can enhance accessibility and usability without increasing physical demands (Hrovatin et al., 2012; Kang & Lee, 2016).

Housekeeping is the only daily activity that the majority (61%) of participants (n=317) found somewhat difficult to perform. Of the 193 respondents who had some level of difficulty in performing housekeeping activities, approximately 65% of them found it difficult to move furniture, and nearly 60% of them found it hard to bend over. In other words, the test results revealed that the physical demands, such as moving furniture or bending, are significantly associated with difficulty in performing housekeeping duties ($p<0.05$). Although further assessments would be necessary to understand the individual living conditions where housekeeping takes place, rearranging the furniture may be a good first step. It is also critical to consider other options such as task delegation (e.g., hiring a commercial housekeeper) and utilizing proper assistive technology (e.g., an ergonomic vacuum cleaner or a cleaning robot).

*4.1.4 Posture and Balance*

The “Posture and Balance” category of the function assesses whether maintaining one’s posture or balance is associated with difficulty in performing tasks for daily living. Examples of tasks associated with posture and balance are walking on an uneven floor surface, climbing ladders, and getting in or out of the bath tub without proper support. The survey questions associated with this category are listed in Table 3-2. Table

4-7 shows the hypotheses and the results from the Chi-square test of independence to observe associations between certain activities of daily living and specific tasks that demand maintaining balance or posture. A total of 317 respondents completed the questionnaire. The contingency tables used to interpret their responses are shown in Appendix D.

Table 4-7 Hypotheses and Test Results: Posture and Balance

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in bathing or showering is associated with the slipperiness of the shower floor.<br><br>(Q1 &Q3) | The association was significant; Chi-sq = 19.6; $p<0.05$. | Two hundred and thirty-seven (237) respondents reported having no difficulty bathing or showering. Most (63%) did not find the bathroom floor slippery, 13% found it at least moderately slippery. Eighty (80) reported some level of difficulty bathing or showering, with 25% reporting that they found the bathroom floor at least moderately slippery, 35% did not find it slippery. |
| Difficulty in walking or maintaining balance is associated with the slipperiness of the shower floor.<br><br>(Q80 & Q3) | The association was significant; Chi-sq = 21.7; $p<0.05$. | One hundred and forty-four (144) respondents reported no difficulty walking or maintaining balance. Most (68%) did not find the bathroom floor slippery, 11% found it at least moderately slippery. One hundred and four (104) respondents reported slight difficulty walking or maintaining balance. Sixty-nine (69) reported having at least moderate difficulty. Among these who found at least moderate difficulty, 26% found the bathroom floor at least moderately slippery; 35% did not find it slippery. |
| Difficulty in bathing or showering is associated with the location of the grab bars.<br><br>(Q1 & Q4) | The association was not significant; Chi-sq = 7.3; $p=0.063 > 0.05$. | Two hundred and thirty-seven (237) respondents reported having no difficulty in bathing or showering. Eighty (80) found it slightly or more difficult. In these two categories, percentage of those reported the location of the grab bars (e.g., no handles, improper location, neutral, or proper location, respectively) were comparable. |

In summary, the results indicate significant associations between the slipperiness of the bathroom floor and difficulty in bathing or showering, and difficulty in walking or maintaining balance. However, almost 75% of the participants reported no difficulty in

bathing/showering and nearly 45% reported no difficulty with walking. Notably, almost 65% of those who found bathing or showering difficult (n=80) felt the bathroom floor was slippery and about 55% of those who had difficulty walking or maintaining balance (n=177) felt the bathroom floor was slippery. The slipperiness of the bathroom floor seems to be one of the factors that would affect those who experience difficulty bathing or showering, even though they may be minority.

No significant association was found between difficulty in bathing or showering and the location of the grab bars ($p = 0.063 > 0.05$). However, the table shown in Appendix D shows that, almost 36% of the participants (n=317) did not have a grab bar in their bathroom. Among those who did have grab bars (n=202), close to 72% reported having no difficulty bathing or showering. Nearly 73% of those who had no difficulty bathing or showering felt that their grab bars were appropriately located, while over 45% of those who had some level of difficulty in bathing or showering felt that their grab bars were improperly located.

Some researchers suggested the use of non-slip bath mats to mitigate the slipperiness of the floors and to improve balance and posture stability (Sveistrup et al., 2006; King & Novak, 2017). Although the results show no significant association between the difficulty of bathing or showering and the location of the grab bars, there does appear to be a relationship between difficulty in getting in/out of the bath tub and the location of the grab bars ($p=0.02<0.05$ – shown under the “mobility” section). Therefore, it seems clear that grab bars should be installed in the bathroom to provide mobility support and posture stability.

*4.1.5 Whole Body Strength*

The “Whole Body Strength” category of the function assesses whether whole-body strength is associated with the level of difficulty in performing specific daily

activities. Examples of tasks associated with this category are opening kitchen cabinets or a refrigerator door and handling cleaning equipment. The survey questions associated with whole body strength are listed in Table 3-3. Table 4-8 shows the hypotheses and the results from the Chi-square test of independence that were used to determine whether certain activities of daily living are associated with specific tasks that require whole body strength. For example, “Is the difficulty in preparing meals associated with difficulty in opening the kitchen cabinets?” A total of 317 individuals responded to the questionnaire. Contingency tables that were used to interpret the responses are shown in Appendix E.

Table 4-8 Hypotheses and Test Results: Whole Body Strength

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in preparing meals is associated with the weight of pots.<br><br>(Q16 &Q25) | The association was significant; Chi-sq = 114.7; $p<0.05$. | Two hundred and twenty-two (222) respondents reported no difficulty with preparing meals, and 69% reported no difficulty with lifting pots; only 6% found it at least moderately difficult. Fifty-six (56) respondents reported having slight difficulty with preparing meals; thirty-nine (39) reported having at least moderate difficulty. Among those who reported at least moderate difficulty, 67% reported moderate difficulty handling the weight of pots, and 15% reported having no difficulty. |
| Difficulty in preparing meals is independent of difficulty in opening the kitchen cabinets.<br><br>(Q16 &Q29) | The association was significant; Chi-sq = 44.7; $p<0.05$. | Of the 222 respondents who reported having no difficulty preparing meals, 97% had no difficulty opening the kitchen cabinets, and only 3% found it at least slightly difficult. However, of the 95 respondents who found some level of difficulty in preparing meals, 28% found opening the kitchen cabinets at least slightly difficult. |
| Difficulty in preparing meals is associated with difficulty in opening the refrigerator door. | The association was significant; Chi-sq = 25.5; $p<0.05$. | Of the 222 respondents who reported having no difficulty preparing meals, 96% had no difficulty opening the refrigerator door, and only 4% found it at least slightly difficult. However, of the 95 respondents who found some level of difficulty in preparing meals, 23% found opening the refrigerator door at least slightly difficult. |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| (Q16 &Q30) | | |
| Difficulty in housekeeping is associated with difficulty in moving around the cleaning equipment.<br><br>(Q36 &Q43) | The association was significant; Chi-sq = 195.6; p<0.05. | One hundred and twenty-four (124) respondents reported having no difficulty in performing housekeeping tasks, among whom 85% found no difficulty with moving the cleaning equipment. No one reported having at least moderately difficulty. One hundred and twenty-one (121) respondents found performing housekeeping tasks slightly difficult, and seventy-two (72) reported having at least moderate difficulty. Among those 72 respondents, 67% found moving the cleaning equipment at least moderately difficult; only 6% reported no difficulty. |
| Difficulty in housekeeping is associated with the size of the equipment used for cleaning.<br><br>(Q36 &Q44) | The association was significant; Chi-sq = 152.3; p<0.05. | Of the 124 respondents who found no difficulty in performing housekeeping tasks, 83% reported having no difficulty in handling the cleaning equipment; only 1% reported finding it moderately difficult. However, of the 72 respondents who found at least moderate difficulty with housekeeping tasks, 25% found handling cleaning equipment moderately difficult. |

The test found a significant relationship between difficulty in preparing meals and difficulty with handling heavy pots ($p<0.05$). Among those who did not find preparing meals difficult (n=222), only 6% found handling pots difficult, while approximately 67% of those who reported having at least moderate difficulty with preparing meals found the heavy pots difficult to handle. Declining physical strength is one of the issues that makes it difficult for the elderly to open doors (Leung, Famakin, & Kwok, 2017) although other elements such as the characteristics of the door and its location must also be considered as influential factors. The test results indicate a significant association between difficulty in preparing meals and difficulty in opening kitchen cabinets or refrigerator doors ($p<0.05$). Among those who reported having difficulty preparing meals (n=95), almost 30% of them found the doors to kitchen cabinets or the refrigerator hard to open. In

contrast, barely 4% of the respondents who reported having no difficulty preparing meals (n=222) considered kitchen cabinets or refrigerator doors hard to open.

The evidence supports Imrhan's (1994) conclusion that some elderly people find it hard to use home appliances because they require greater push/pull strength. To correct this, it is suggested that manufacturers change their designs to fit older consumers' needs, such as the amount of torque needed to open appliance doors, and possibly touchless mechanism that open kitchen cabinets and refrigerator doors.

The data suggests that the weight and size of cleaning equipment is associated with the level of difficulty in performing housekeeping tasks ($p<0.05$). Moreover, the tables in Appendix E show that more than 55% of those who reported having moderate difficulty performing housekeeping tasks (n=75) found it hard to handle cleaning equipment, while roughly 67% of them found cleaning equipment too heavy to easily lift or move around. These results were anticipated, as it is well known that declining physical strength is one of the characteristics of aging, and some cleaning tasks, such as vacuuming, put a physical load on muscles in the upper body (Choi & Shin, 2018; Bak, D'Souza, Shin, 2019). It is recommended that older adults use an ergonomic and lightweight vacuum cleaner, some of which are now targeting elderly consumers in their advertising campaigns. Other options to consider are task delegation (e.g., hiring a commercial housekeeper) and utilizing proper assistive technology (e.g., cleaning robot).

*4.1.6 Segmental Strength*

The "Segmental Strength" category of the function assesses whether the segmental strength, such as arm strength, is associated with difficulty in performing specific tasks for daily activities. Examples of tasks associated with this category are turning on/off the faucet when showering and opening/closing medicine bottles. The survey questions associated with segmental strength are listed in Table 3-4. Table 4-9

shows the hypotheses and the results from the Chi-square test of independence that were used to determine whether certain activities of daily living are associated with specific tasks that require segmental strength. For example, “Is difficulty in using fingers or hands associated with difficulty in opening a medicine bottle?” A total of 317 individuals responded to the questionnaire. Contingency tables used to interpret the responses are shown in Appendix F.

Table 4-9 Hypotheses and Test Results: Segmental Strength

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in using fingers or hands is associated with difficulty in turning faucets on/off without pain.<br><br>(Q82 &Q5) | The association was significant; Chi-sq = 24.5; $p<0.05$. | One hundred and ninety-one (191) respondents reported no difficulty in using their fingers or hands and most (93%) did not find it painful or uncomfortable to turn faucets on or off; only 7% considered it at least slightly painful. One hundred and twenty-six (126) respondents reported some level of difficulty with using their fingers or hands, with 27% of these finding it at least slightly painful or uncomfortable to turn faucets on and off, 73% finding it not painful. |
| Difficulty in using fingers or hands is associated with difficulty in opening jar lids without tools.<br><br>(Q82 &Q17) | The association was significant; Chi-sq = 56.8; $p<0.05$. | Of the 191 respondents who found no difficulty in using their fingers or hands, 39% reported having no difficulty in opening jar lids without tools, and only 7% found it very or extremely difficult. However, of the 36 respondents who found at least moderate difficulty in using their fingers or hands, 67% found opening jar lids without tools very or extremely difficult. |
| Difficulty in using fingers or hands is associated with difficulty in opening new jar lids.<br><br>(Q82 &Q21) | The association was significant; Chi-sq = 44.4; $p<0.05$. | Of the 191 respondents who reported no difficulty with using their fingers or hands, 30% seldom or ever found opening new jar lids difficult, and only 7% very often found it difficult. However, of the 36 respondents who reported at least moderate difficulty with using their fingers or hands, 44% very often found opening new jar lids difficult. |
| Difficulty in using fingers or hands is associated with difficulty in opening previously opened jar lids. | The association was significant; Chi-sq = 50.5; $p<0.05$. | Of the 191 respondents who reported no difficulty with using their fingers or hands, 37% seldom or every found opening previously opened jar lids difficult, and 19% sometimes or often found it difficult. However, of the 36 respondents who reported at least moderate difficulty with using their fingers or |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| (Q82 &Q22) | | hands, 72% sometimes or often found opening previously opened jar lids difficult. |
| Difficulty in using fingers or hands is associated with difficulty in opening a medicine bottle.<br><br>(Q82 &Q48) | The association was significant; Chi-sq = 51.9; $p<0.05$. | Of the 191 respondents who reported no difficulty in using their fingers or hands, 79% had no difficulty gripping a medicine bottle and turning the cap to open it; only 4% found it at least moderately difficult. However, of the 126 respondents who reported at least slight difficulty with using their fingers or hands, 21% found opening a medicine bottle at least moderately difficult. |
| Difficulty in using fingers or hands is associated with difficulty in closing a medicine bottle.<br><br>(Q82 &Q49) | The association was significant; Chi-sq = 59.9; $p<0.05$. | Of the 191 respondents who reported having no difficulty in using their fingers or hands, 91% had no difficulty gripping a medicine bottle and turning the cap to open it; only 2% found it at least moderately difficult. However, of the 126 respondents who experienced at least slight difficulty in using their fingers or hands, 13.5% found closing a medicine bottle at least moderately difficult. |

The results from all hypotheses tests associated with segmental strength (Table 4-9) show significant associations between difficulty with using fingers or hands and difficulty in performing specified tasks ($p<0.05$). Table 4-10 shows that of those who had some level of difficulty with using their fingers or hands (n=126), a significant number (close to 90%) found opening jar lids difficult. Regardless of the level of difficulty in using their fingers or hands, the data suggests that opening jar lids is a common challenge for older adults, as more than 70% of all participants (n=317) found it difficult. Opening or closing a medicine bottle appeared to be another obstacle for those who had difficulty in using their fingers or hands, as at least 45% reported finding it hard.

Table 4-10 Difficulty in Performing Tasks – Segmental Strength

| Area of Difficulty | Level of difficulty in using fingers or hands | | |
|---|---|---|---|
| | No difficulty (n = 191) | Some difficulty (n = 126) | Total (n = 317) |
| Turning a faucet on/off | 13 (7%) | 34 (27%) | 44 (14%) |
| Opening jar lids without tools | 116 (61%) | 120 (95%) | 236 (74%) |

| Area of Difficulty | Level of difficulty in using fingers or hands | | |
|---|---|---|---|
| | No difficulty (n = 191) | Some difficulty (n = 126) | Total (n = 317) |
| Opening new jar lids | 134 (70%) | 112 (89%) | 246 (78%) |
| Opening previously opened jar lids | 121 (63%) | 110 (87%) | 231 (73%) |
| Opening a medicine bottle | 40 (21%) | 75 (60%) | 115 (36%) |
| Closing a medicine bottle | 18 (9%) | 60 (48%) | 78 (25%) |

* Percentage shown in a parenthesis is relative to a column population.

The Mann Whitney U test was used to compare the differences between genders. A statistically significant difference was found in the level of difficulty in opening jars with hands alone ($p<0.05$), difficulty in opening new jar lids ($p=0.01<0.05$), and difficulty in opening previously opened jar lids ($p=0.03<0.05$). Table 4-11 presents the test results (p-value) for each task, and Figure 4-4 shows the frequency distribution of each difficulty level, per gender, for opening jar lids by hands alone (right) and opening new jar lids (left).

Table 4-11 Segmental Strength Tasks – Association with Gender

| Area of Difficulty | p-value |
|---|---|
| Turning a faucet on/off | 0.50 |
| Opening jar lids without tools | 0.00 |
| Opening new jar lids | 0.01 |
| Opening used jar lids | 0.03 |
| Opening a medicine bottle | 0.28 |
| Closing a medicine bottle | 0.51 |

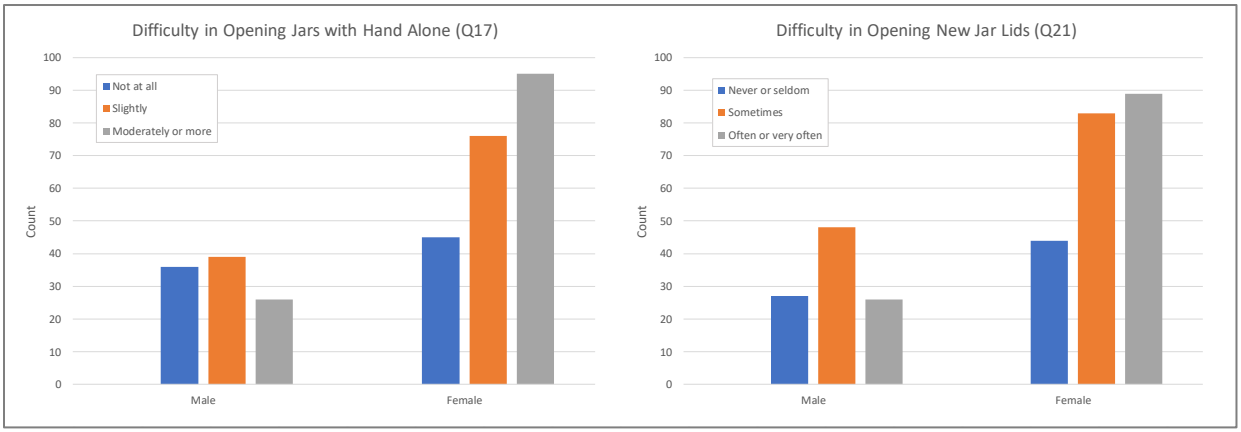


Figure 4-4 Difficulty in Opening Jar Lids by Gender

As shown in Table 4-11, significant gender-related differences were not observed for difficulty in performing other tasks: turning faucets on/off (p=0.50), opening a medicine bottle (p=0.28), or closing a medicine bottle (p=0.51). Unfortunately, this study lacked sufficient data to investigate reasons for the variabilities in the results above; however, they support the findings of the literature review - that there were inconsistent outcomes from the published studies associated with gender and grip strength among elderly people.

Recent studies reported various types of difficulty that older adults have in opening bottles/packaging (Beckman, Parker, & Thorslund, 2005; Sormunen, Nevala, & Sipila, 2014; Philbert, Notenboom, Bouvy, & Geffen, 2014; Wenk et al., 2016). They emphasized the urgent need to improve the design of the packaging to make it more user friendly for elderly consumers so that they can open the packaging and read the instruction easily. This is particularly important for medicine bottles. Additionally, Sormunen et al. (2014) discovered that a screw-cap opening mechanism is not suitable for people with motion restrictions, and most older adults prefer a bottle with a hinged cap. Consequently, Wenk et al. (2014) reported that frail elderly participants (average

cylindrical grip of 152.9N) found screw caps difficult to open. Furthermore, the opening mechanism must ensure the safety of elderly users (Duizer, Robertson, & Han, 2008; Wenk et al., 2014). It is suggested that the manufacturers of packaging products consider various ways to redesign lids for older adults.

*4.1.7 Physiological Endurance*

Physiological endurance refers to the ability to perform a task, such as computer work, for prolonged periods of time, and the physiological endurance category of the function assesses whether limitations in this ability are associated with difficulty in performing tasks for daily activities. Examples of tasks associated with this category are working on the computer or using a cellphone. The survey questions associated with the physiological endurance are listed in Table 3-5. Table 4-12 shows the hypotheses and results from the Chi-square test of independence that were used to determine whether certain activities of daily living are associated with specific tasks that require physiological endurance. For example, “Is the level of pain in the upper body when using a computer associated with how sharply the neck is bent or the shoulders and arms are raised?” Of the 317 individuals who responded to the questionnaire, 286 responded to the questions associated with computer use and 297 responded to the questions associated with cellphone use. Those who do not use either a computer or a cellphone did not answer the questions. Contingency tables used to determine to interpret the results are shown in Appendix G.

Table 4-12 Hypotheses and Test Results: Physiological Endurance

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| The level of pain in neck/shoulders/arms while/after using a computer is | The association was significant; Chi-sq =182.9; $p<0.05$. | One hundred and forty-eight (148) respondents reported having no pain in their neck/shoulders/arms while/after using a computer. Of them, 72% responded that they did not bend their neck or raise their |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| associated with how sharply the neck is bent or the shoulders/arms are raised.<br><br>(Q56 & Q57) | | shoulders/arms sharply, and only 1.4% said that they bent their neck or raised their shoulders/arms sharply at least moderately. Forty-four (44) reported at least moderate pain in neck/shoulders/arms while/after using a computer, among whom 61% said that they at least moderately bend their neck or raise their shoulders/arms sharply. Only 2.3% said they did not bend their neck or raise their shoulders/arms sharply. |
| The frequency of experiencing leg pain while/after using a computer is associated with the frequency of sitting in an adjustable char.<br><br>(Q58 &Q59) | The association was not significant; Chi-sq = 4.7; p = 0.10 > 0.05. | Two hundred and thirty-six (236) respondents did not experience leg pain while/after using a computer, and fifty (50) experienced slight or more pain. The results were comparable among those that never/seldom, sometimes, often/very often sat in an adjustable chair. |
| The frequency of experiencing pain in the fingers while/after using a computer is associated with the difficulty of using a keyboard or a mouse.<br><br>(Q60 &Q61) | The association was significant; Chi-sq = 60.6; p<0.05. | Two hundred and twenty-nine (229) respondents reported having no pain in their fingers while/after using a computer. Of those, 90% had no difficulty using a keyboard or a mouse, and only 10% found it slightly or more difficult. Fifty-seven (57) reported having pain in their fingers sometimes or more often while/after using a computer, and of those, 54% reported having slight or more difficulty in using a keyboard or a mouse; 46% reported having no difficulty. |
| The frequency of experiencing pain in the fingers while/after using a computer is associated with difficulty with using fingers or hands.<br><br>(Q60 &Q82) | The association was significant; Chi-sq = 51.9; p<0.05. | Of the 229 respondents who reported having no pain in their fingers while/after using a computer, 71% had no difficulty using their fingers or hands, and 29% found it at least slightly difficult. However, of the 42 respondents who sometimes experienced pain in their fingers while/after using a computer, 76% reported that using their fingers or hands was at least slightly difficult. |
| The frequency of bending a wrist sharply when using a cellphone is associated with the | The association was significant; Chi-sq = 17.4; p = 0.03 < 0.05. | One hundred and thirty (130) respondents reported that they do not bend their wrist sharply when using a cellphone, among whom 38% said that they never/seldom use it to take pictures, 62% said that they sometimes or more often use it to take pictures. Eighty-three (83) answered that they sometimes or more often |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| frequency of using it to take photos.<br><br>(Q71 & Q68) | | bend their wrist sharply when using a cellphone, among whom 18% said they never/seldom take pictures with it, 82% said they sometimes or more often use it to take pictures. |

The results show a significant relationship between the level of pain in one's neck/shoulder/arms and the posture of the neck/shoulder/arms ($p<0.05$), and between the frequency of experiencing pain in fingers and the level of difficulty in using a keyboard or mouse ($p<0.05$). No significant association was found between the frequency of leg pain and the frequency of using an adjustable chair ($p=0.10>0.05$). Approximately 61% of those who experienced at least moderate pain in their neck/shoulders/arms while/after using a computer (n=44) said that they bend their neck or raise their shoulders or arms to at moderately sharp angles, whereas barely 1.4% of those who had no pain in their upper body while/after using a computer (n=148) reported that they bend their neck or raise their shoulders/arms sharply. Similarly, close to 55% of those who experienced some level of pain in their fingers while/after using a computer (n=57) had some level of difficulty in using a keyboard or mouse, while only 10% of those who had no pain in their fingers while/after using a computer (n=229) reported some level of difficulty in using a keyboard or mouse. Therefore, it can be concluded that pain associated with computer use may be reduced by changing the design or layout of the workstation to eliminate the amount of stress on the body.

With the 95% of confidence level, the results show the significant association between the frequency of taking pictures with a cellphone and the wrist posture (bending sharply) when using a cellphone ($p=0.03<0.05$). However, it is not statistically significant with 99% of confidence level. Among those who did not bend their wrist sharply when using a cellphone (n=130), roughly 62% said they sometimes or more often took pictures

with it. Among those who sometimes or more often bent their wrist sharply when using a cellphone (n=83), approximately 82% said they sometimes or more often use it to take pictures.

Pain and injuries that result from using a computer are caused by various factors such as stressful body posture, improper computer furniture, and a long duration of computer usage (Imrhan, 1996; Singh & Wadhwa, 2006; Zhu & Shin, 2011). Tablet computers, whose usage has drastically increased recent years, require substantial head and neck flexion (Vasavada, Nevins, Monda, Hughes, & Lin; 2015, Yoakum, Romero, Latham, Douglas, Gallagher & Terhune, 2019). Therefore, it is not surprising that the results showed an association between pain in the neck, shoulders, or arms and increased frequency of bending the neck or raising shoulders/arms when using a computer.

The ANSI/HFES standard (2007) specifies that the line-of-sight angle is between 0 degree (horizontal eye height) and 60 degrees below eye height. Although the recommended viewing distance varies from standard to standard (Woo, White & Lai, 2016), the ANSI/HFES standard (2007) suggests that the distance should be at least 50 cm. When armrests are too low, the user is put in an awkward posture, such as leaning to one side and using one arm at a time (Imrhan, 1996). Conversely, when armrests are too high, the user's shoulder and/or neck muscles work overtime (Zhu and Shin, 2011). Zhu & Shin (2011) suggested that armrests at resting elbow height could reduce the strain place on the shoulder and/or neck muscles. Further investigation is necessary before making design suggestions that would ease computer-related pain or fatigue; however, it is always wise to follow ergonomic standard/guidelines.

Keyboard height may be one of the areas to assess against the standard and adjust accordingly in order to ease difficulty. For instance, the ANSI/HFES standard

(2007) recommends that the keyboard height be between 59 cm and 75 cm. Many ergonomic keyboards and mice are available on the market, such as a vertical mouse that keeps the hand in a neutral position, a trackball mouse that reduces arm movement, and a split keyboard that allows hands to rest in a natural position (Builder, Adelson, & Pardilla, 2021).

Smartphone technology that allows pictures to be easily taken with a cellphone had made it a very common activity. To achieve the ideal “self” angle, the photo taker’s wrist is forced to hyper-flex inwards, which can cause an injury that is similar to Carpal Tunnel Syndrome and is called “selfie wrist” (Industry Safety & Hygiene News, 2019). It has not been determined whether this condition is applicable to elderly users, but it could explain why the results from this study indicate an association between the frequency of bending the wrist and the frequency of taking pictures with cellphones. Commercial selfie sticks that prevent “selfie wrist” are available; however, Kim & Lee (2017) warned that most commercial selfie sticks are not ergonomic and cause short-term fatigues. They further espoused that the ergonomic factors could be improved by design changes such as using lighter weight materials for the stick and installing a wider handle.

*4.1.8 Mobility*

The “mobility” category of the function assesses whether mobility is associated with difficulty in performing tasks for daily activities. Examples of tasks associated with this category are getting in/out of the bathtub, and bending to perform housekeeping activities. The survey questions associated with mobility are listed inTable 3-6. Table 4-13 shows the hypotheses and the results from the Chi-square test of independence that were used to determine whether certain activities of daily living were associated with specific tasks that require mobility. A total of 317 individuals responded to the

questionnaire. Contingency tables that were used to interpret the results are shown in Appendix H.

Table 4-13 Hypotheses and Test Results: Mobility

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in bathing or showering is associated with the frequency of bending the back due to the faucet being too low.<br><br>(Q1 &Q2) | The association was not significant; Chi-sq = 5.8; p = 0.054 >0.05. | Two hundred and thirty-seven (237) respondents reported no difficulty bathing or showering, and eighty (80) reported finding it at least slightly difficult. The results were comparable among those that never/seldom, sometimes, often/very often bent their neck/knees or back due to the faucet being low. |
| Difficulty in getting in/out of the tub is associated with the level of mobility support needed.<br><br>(Q7 & Q81) | The association was significant; Chi-sq = 44.8; p<0.05. | One hundred and eighty-four (184) respondents reported having no difficulty getting in/out of the bathtub, among whom 96% responded that they never/seldom use mobility support such as wheelchairs, walker, cane or crutches; only 3% said that they often or very often use mobility support. One hundred and thirty-three (133) reported having at least slight difficulty getting in/out of the bathtub, among whom 18% said they often or very often used mobility support; 68% said never/seldom used it. |
| Difficulty in getting in/out of the bathtub is associated with difficulty in bathing or showering.<br><br>(Q7 & Q1) | The association was significant; Chi-sq = 96.5; p<0.05. | Of the 184 respondents who reported having no difficulty getting in/out of the bathtub, 95% had no difficulty bathing or showering, and only 0.5% found it at least moderately difficult. However, of the 133 respondents who experienced at least slight difficulty in getting in/out of the bathtub, 13% found bathing or showering at least moderately difficult. |
| Difficulty in getting in/out of the bathtub is associated with the slipperiness of the shower floor.<br><br>(Q7 & Q3) | The association was significant; Chi-sq = 50.9; p<0.05. | Of the 184 respondents who experienced no difficulty in getting in/out of the bathtub, 72% reported the bathroom floor was not slippery, and only 9% reported that it was at least moderately slippery. However, of the 45 respondents who had at least moderate difficulty getting in/out of the bathtub, 47% considered the bathroom floor at least moderately slippery. |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in getting in/out of the bathtub is associated with the location of the grab bars in the bathtub area.<br><br>(Q7 & Q4) | The association was significant; Chi-sq = 10.3; p = 0.02 < 0.05.<br><br>(NOTE: not significant if alpha is 0.01). | Of the 184 respondents who reported having no difficulty getting in/out of the bathtub, 47% agreed that the grab bars were properly located for support, and only 4% felt they were located improperly properly. Of the 133 respondents who experienced at least slight difficulty in getting in/out of the bathtub, 13% considered that the grab bars to be placed improperly. |
| Difficulty in bending the neck, knees, and back (upper body) while dressing is associated with difficulty to move arms while dressing.<br><br>(Q10 &Q11) | The association was significant; Chi-sq =97.9; p<0.05. | Two hundred and forty-one (241) respondents reported having no difficulty moving their arms while dressing, among whom 69% reported having no difficulty bending their upper body while dressing; and 6% found it at least moderately difficult. Seventy-six (76) found moving their arms while dressing at least slightly difficult, 29% found bending their upper body at least moderately difficult, and only 5% found it not difficult. |
| Difficulty with housekeeping tasks is associated with difficulty in bending down to perform housekeeping.<br><br>(Q36 &Q39) | The association was significant; Chi-sq = 229.1; p<0.05. | One hundred and twenty-four (124) respondents reported that they have no difficulty performing housekeeping tasks, among whom 88% reported having no difficulty bending down. None (0%) of the respondents found it very or extremely difficult. Seventy-two (72) reported having at least moderate difficulty performing housekeeping tasks. Of those, 39% had moderate difficulty bending down, and only 4% did not find it difficult. |
| Difficulty with housekeeping tasks is associated with difficulty in reaching forward to perform housekeeping tasks.<br><br>(Q36 &Q41) | The association was significant; Chi-sq =194.3; p<0.05. | Of the 124 respondents who reported no difficulty performing housekeeping tasks, 92% had no difficulty reaching forward or sideways, and none (0%) found it very or extremely difficult. However, of the 72 respondents who experienced at least moderate difficulty performing housekeeping tasks, 28% found reaching forward or sideways very or extremely difficult. |

Difficulty with bathing or showering was not found to be associated with the height of the faucet (p = 0.054). Regardless of the level of difficulty in bathing or

showering, approximately 70% of the respondents (n=317) did not believe that the faucet's location caused them to bend their body. Thus, it can be concluded that the location of the faucet is not a factor in improving mobility. With a 99% confidence level, the location of the grab bar was not found to be associated with difficulty in bathing or showering (p=0.02).

The results also show that getting in/out of the bathtub is significantly associated with difficulty in bathing or showering and slipperiness of the floor. Those who found it difficult to get in/out of the bathtub were more likely to be those who needed a greater level of mobility support, found the bathtub floor slippery, found the location of the grab handles unsuitable, and/or had difficulty bathing and showering. These findings also confirm the bathroom negotiation issues that King & Novak (2017) addressed in their research. Many studies have also recommended installation of grab bars and bath mats to assist with bathroom negotiation and to prevent falls among older adults, yet further changes are needed in building codes or policies to reshape the construction of homes (Edwards, Dulai & Rahman, 2019). Meanwhile, removing environmental hazards (e.g., removing a bathtub or steps between the floor and a shower space) while implementing features to support balance and posture stability (e.g., grab bars and bath mats) have been proven effective.

Those who experienced difficulty in bending their neck/knees/back (upper body) while dressing are more likely to be those who find it difficult to move their arms or reach forward or sideways. Results indicated that specific dressing tasks and difficulty in moving arms and bending the upper body were associated. One of the approaches to easing this difficulty is to consider clothing design. According to Disable World (2015), specialized garments called "adaptive clothing" consist of clothing, garments, and footwear designed for people with physical limitations. According to Yeung & Hui (2020),

the need and demand for adaptive clothing is increasing. Examples of adaptive clothing are a dress with snaps on the shoulder or side, a shirt with magnetic closures, and non-slip socks.

Those who find difficulty in housekeeping tasks are more likely to be those who find it difficult to bending down to perform tasks. Therefore, it can be concluded that mobility limitations seem to affect housekeeping tasks. As was mentioned in an earlier section, one solution is to use a lightweight ergonomic vacuum cleaner. Other options are using a cleaning robot or delegating the tasks to others.

*4.1.9 Tactile Tasks*

Tactile tasks refer to holding slippery things. This category assesses whether tactile tasks are associated with difficulty in performing daily activities. Examples of tasks associated with this category are holding a cellphone and preventing it from slipping, and opening or closing smooth jar lids. The survey questions associated with tactile tasks are listed in Table 3-7. Table 4-14 shows the hypotheses and the results from the Chi-square test of independence that were used to determine whether certain activities of daily living were associated with specific tactile tasks. A total 317 individuals responded to the questionnaire. As mentioned in an earlier section, fewer respondents answered the questions associated with using a computer or a cellphone since some participants did not use either. Contingency tables used to interpret the results are shown in Appendix I.

Table 4-14 Hypotheses and Test Results: Tactile Tasks

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Slipperiness of jar lids is associated with difficulty in opening food jars with one's hands alone. | The association was significant; Chi-sq = 85.9; $p<0.05$. | One hundred and eight (108) respondents did not consider jar lids slippery at all, among whom 47% reported having no difficulty in opening them with their hands alone; 20% reported having at least moderate difficulty. Sixty-four (64) respondents considered jar lids moderately slippery; 59% of them found opening |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| (Q19 &Q17) | | jar lids with their hands alone at least moderately difficult; only 8% did not find it difficult. |
| Slipperiness of jar lids is associated with their size.<br><br>(Q19&Q18) | The association was significant; Chi-sq = 71.3; p<0.05. | Of the 108 respondents who did not find jar lids slippery at all, 86% found the size of most jar lids just right, 6.5% found it small/too small, and 7.4% found it large/too large. Among those who reported that jar lids are at least moderately slippery (n=88), 17% found it small/too small, and 56% found it large/too large. |
| Slipperiness of cellphone is associated with its size when holding it.<br><br>(Q72&Q73, Q72&Q74) | The association was significant; Chi-sq = 38.0; p<0.05 (size being small) Chi-sq = 27.5; p<0.05 (size being large). | Two hundred and thirty-six (236) respondents did not find the cellphone slippery at all, among whom 85% found the size of the cellphone just right, and 15% found it somewhat small. Sixty-one (61) respondents found the cellphone at least slightly slippery; 52% of those found it somewhat small, and only 48% found it just right.<br>Of the 236 respondents who did not find the cellphone slippery at all, 92% found the size of the cellphone just right, and 8% found it somewhat large. Of the 61 respondents who found cellphones at least slightly slippery, 33% found it somewhat large, and 67% found it just right. |
| Slipperiness of cellphone is associated with difficulty in carrying it around.<br><br>(Q72&Q75) | The association was significant; Chi-sq = 56.2; p<0.05. | Of the 236 respondents who did not consider the cellphone slippery at all, 86% found no difficulty in carrying it around, and 4% found it at least moderately difficult. Of the 61 respondents who found the cellphone at least slightly slippery, 31% found carrying the cellphone around at least moderately difficult. |
| Difficulty in using fingers or hands is associated with the level of slipperiness when holding objects.<br><br>(Q82&Q86) | The association was significant; Chi-sq = 65.3; p<0.05. | One hundred and ninety-one (191) respondents reported having no difficulty using their fingers or hands, among whom 85% found no slipperiness when holding objects, and 0.5% found at least moderate slipperiness. One hundred and twenty-six (126) respondents found at least slight difficulty using their fingers or hands, with 12% of them attributing at least moderate slipperiness when holding objects, and 44% reported finding no slipperiness. |

The test results revealed that the respondents who felt that their cellphones have some level of slipperiness (n=61) also felt that the phone size either too small or too large, which contributes to difficulty in carrying them around. Approximately 56% of participants who felt that jar lids are at least moderately slippery (n=88) considered them

either large or too large. Only 7% of the participants who felt that jar lids are not slippery (n=108) reported considering them either large or too large.

As older adults tend to use greater forces to prevent slipping due to age-related changes in skin properties (Cole, 1991; Kinoshita & Francis, 1996), they encounter greater difficulty in holding slippery items with their hands. Analyses show that difficulty gripping and opening jar lids and holding cell phones are associated with the (self-perceived) level of slipperiness of these objects. The slipperiness of the lids was also associated with those who found the lids either too small or too large. Research (Imrhan & Loo, 1988) has shown that lids that are too large or too small for the elderly hand cannot be gripped with as much muscular force as lids that fit comfortably in the hand (mid-size range). Interestingly, Cole, Rotella & Harper's (1999) investigation revealed that age-related differences in slip force were seen for objects with smooth surfaces, not those with rough surfaces. The recommendation for addressing this issue is to mitigate the slipperiness of the cellphone by using an anti-slip case since changing its size would require involving the manufacturers. Anti-slip cases are available from multiple vendors for different types of cellphones.

It is recommended that the designers of jar lids consider their size so that they are compatible with hand size. As this may not be the best solution for manufacturers, an alternative solution would be to consider using a non-slippery material for the lids. Otherwise, elderly users should apply opening aids such as a rubber jar lid gripper, an electric jar opener, or other device.

*4.1.10 Psychomotor Skills*

The psychomotor skills category of the function assesses whether the psychomotor skills are associated with difficulty in perform tasks for daily activities. Examples of tasks associated with this category are buttoning clothes, tying shoelaces,

and gripping food jars. The survey questions associated with the psychomotor skills are listed in Table 3-8. Table 4-15 shows the hypotheses and the results from the Chi-square test of independence that are used to determine whether certain activities of daily living are associated with specific tasks that require psychomotor skills. For example, “Is difficulty in using one’s fingers or hands associated with difficulty in picking up pills with fingers?” A total of 317 individuals responded to the questionnaire, but fewer respondents answered the questions associated with using a computer or a cellphone since some of them did not use either. Contingency tables used to interpret the results are shown in Appendix J.

Table 4-15 Hypotheses and Test Results: Psychomotor Skills

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in buttoning a shirt or tying shoelaces is associated with difficulty in using fingers or hands.<br><br>(Q13&Q82) | The association was significant; Chi-sq = 46.8; $p<0.05$. | One hundred and ninety-one (191) respondents found no difficulty in using their fingers or hands, among whom 87% had no difficulty buttoning a shirt or tying shoelaces, and 3.7% found it at least moderately difficult. One hundred and twenty-six (126) respondents found at least slight difficulty in using their fingers or hands; with 18% of them found buttoning a shirt or tying shoelaces at least moderately difficult, and 52% did not find it difficult. |
| Difficulty in opening food packages or boxes is associated with difficulty in using fingers or hands.<br><br>(Q23&Q82) | The association was significant; Chi-sq = 43.0; $p<0.05$. | Of the 191 respondents who found no difficulty in using their fingers or hands, 63% reported having no difficulty opening food packages or boxes, and only 3% found it very or extremely difficult. However, of the 126 respondents who considered it at least slight difficult to using their fingers or hands, 10% found opening food packages or boxes very or extremely difficult, and 30% did not find it difficult. |
| Difficulty with gripping a pill wrapper and tearing it open with fingers is associated with | The association was significant; Chi-sq = 74.0; $p<0.05$. | Of the 191 respondents who found no difficulty in using their fingers or hands, 59% had no difficulty gripping a pill wrapper and tearing it open with fingers, and only 4% found it very or extremely difficult. However, of the 126 respondents who had at least slight difficult using their fingers or hands, 21% found gripping a pill |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| difficulty in using fingers or hands.<br><br>(Q50&Q82) | | wrapper and tearing it open with their fingers very or extremely difficult, and 19% did not find it difficult. |
| Difficulty with picking up pills with fingers is associated with difficulty in using fingers or hands.<br><br>(Q51&Q82) | The association was significant; Chi-sq = 72.3; $p<0.05$. | Of the 191 respondents who found no difficulty in using their fingers or hands, 86% found no difficulty in picking up pills with fingers, and only 3% found it at least moderately difficult. However, of the 126 respondents who found at least slight difficulty in using their fingers or hands, 25% found picking up pills with fingers at least moderately difficult, and 42% did not find it difficult. |
| Difficulty in using a keyboard or mouse is associated with difficulty in using fingers or hands.<br><br>(Q61&Q82) | The association was significant; Chi-sq = 46.4; $p<0.05$. | One hundred and seventy-three (173) respondents found no difficulty in using their fingers or hands, among whom 94% had no difficulty using a keyboard or a mouse; none (0%) found it at least moderately difficult. One hundred and thirteen (113) respondents found at least slight difficulty in using their fingers or hands, with 12% of those found using a keyboard or a mouse at least moderately difficult, and 63% did not find it difficult. |
| Difficulty in using a cellphone keypad is associated with difficulty in using fingers or hands.<br><br>(Q76&Q82) | The association was significant; Chi-sq = 73.6; $p<0.05$. | One hundred and seventy-four (174) respondents found no difficulty in using their fingers or hands, among whom 90% found no difficulty in using a cellphone keypad, and 1% found it very or extremely difficult. One hundred and twenty-three (123) respondents found at least slight difficulty in using their fingers or hands, with 15% of these found using the cellphone keypad very or extremely difficult, and 46% did not find it difficult. |

Difficulty in buttoning a shirt, tying a shoe lace, opening food packages or boxes, gripping or tearing pill wrappers, picking up pills with the fingers, using a computer keyboard or mouse, and using a cellphone keypad are associated with having difficulty with using fingers or hands. Some researchers who identified older adults as having difficulty with opening blister packs urged manufacturers to develop a better blister packing design for drug products (Muhlfeld, Langguth, Hausler & Hangels, 2011; Philbert et al., 2014). The test results seem to agree with their findings, as close to 57% of the

respondents (n=317) reported having some level of difficulty with gripping a pill wrapper and tearing it with fingers. Moreover, Butlewski (2015) indicated that the main problems that older adults have with opening packaging are related to the excessive strength required to open it, the high precision of movement required, and information not being easily read or logical. He further discussed options to improve the design by reflecting on the anthropometric data of the elderly population, an opening mechanism that allows various grips to open, and the amount of physical effort required (lower demand for psychomotor skills).

To ease difficulty that some older adults have with buttoning a shirt or tying shoelaces, it is suggested that they wear adaptive clothing, such as a shirt with magnetic closures or a jacket that zips in the front, and shoes with hook-and-loop fasteners instead of shoelaces. Furthermore, ergonomic keyboards should be considered for the elderly who have difficulty using their hands or fingers. Examples of an ergonomic keyboard and a mouse are described in an earlier section. Alternatively, a voice assistant feature could be used for computer work or mobile phone.

*4.1.11 Cognitive*

The cognitive category of the function assesses whether the cognitive skills are associated with difficulty in performing tasks for daily activities. Examples of tasks associated with this category are turning on/off the wrong stove control, and understanding instructions for taking medication. The survey questions associated with the cognitive skills are listed in Table 3-9. Table 4-16 shows the hypotheses and the results from the Chi-square test of independence that were used to determine whether certain activities of daily living are associated with specific tasks that require cognitive skills. For example, “Is difficulty in bathing or showering” associated with difficulty in adjusting hot/cold water to get a comfortable temperature?” A total of 317 individuals

responded to the questionnaire. Fewer respondents answered the questions associated with using a computer or a cellphone, as some of them did not use either. Contingency tables used to interpret the results are shown in Appendix K.

Table 4-16 Hypotheses and Test Results: Cognitive

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in bathing or showering is associated with difficulty in adjusting hot/cold water.<br><br>(Q1&Q6) | The association was significant; Chi-sq = 24.9; p<0.05. | Two hundred and thirty-seven (237) respondents found no difficulty in bathing or showering, among whom 85% found no difficulty in adjusting hot/cold water, and 15% found it at least slightly difficult. Eighty (80) respondents had at least slight difficulty bathing or showering, with 41% of those found adjusting hot/cold water at least slightly difficult, and 59% did not find it difficult. |
| Difficulty in preparing meals is associated with the frequency of turning on/off the wrong stove control.<br><br>(Q16&Q26) | The association was significant; Chi-sq = 13.6; p = 0.001p<0.05. | Two hundred and twenty-two (222) respondents found no difficulty in preparing meals, among whom 62% answered that they never turned on/off the wrong stove control, and 8% answered that they sometimes or often turned on/off wrong stove control. Ninety-five (95) respondents had at least slight difficulty preparing meals, with 21% of them answered they sometimes or often turned on/off the wrong stove control, and 44% never did it. |
| Difficulty in preparing meals is associated with the frequency of forgetting to turn off the stove.<br><br>(Q16&Q27) | The association was significant; Chi-sq = 9.2; p = 0.01 < 0.05. | Of the 222 respondents who found no difficulty in preparing meals, 75% reported that they never forgot to turn off the stove, and only 5% said they sometimes or often forgot to turn off the stove. Of the 95 respondents who had at least slight difficulty preparing meals, 11% reported they sometimes or often forgot to turn off the stove, and 58% never did it. |
| Difficulty in taking medication is associated with the frequency of incorrect | The association was significant; Chi-sq = 29.4; p<0.05. | Two hundred and eighty-five (285) respondents had no difficulty taking medication, among whom 59% reported that they never forgot to take the proper dosage at the correct time, and 8% said they sometimes or often forget. Thirty-two (32) respondents found at least slight difficulty in taking medication, with 34% of them saying that they |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| medication adherence.<br><br>(Q47&Q52) | | sometimes or often forget to take it, and 19% saying that they never forget it. |
| Difficulty in taking medication is associated with difficulty in understanding instructions on medicine labels.<br><br>(Q47&Q54) | The association was significant; Chi-sq = 13.2; $p<0.05$. | Of the 285 respondents found no difficulty in taking medication, 79% found no difficulty in understanding instructions on medication labels, and 21% found it at least slightly difficult. Of the 32 respondents found at least slightly difficulty in taking medication, with 50% found some level of difficulty in understanding instructions on medication labels, and other 50% had no difficulty. |
| Difficulty in using a computer is associated with difficulty in solving a computer problem.<br><br>(Q55&Q65) | The association was significant; Chi-sq = 49.6; $p<0.05$. | Two hundred and thirteen (213) respondents found no difficulty in using a computer, among whom 42% had no difficulty solving a computer problem; 24% found it at least moderately difficult. Nineteen (19) respondents reported at least moderate difficulty with using a computer, with 84% of them found solving a computer problem at least moderately difficult, and 5% did not find it difficult. |
| Difficulty in using a cellphone is associated with difficulty in solving a cellphone problem.<br><br>(Q66&Q77) | The association was significant; Chi-sq = 65.4; $p<0.05$. | Two hundred and twenty-two (222) respondents found no difficulty in using a cellphone, among whom 55% found no difficulty in solving a cellphone problem, and 15% found it at least moderately difficult. Seventy-seven (77) respondents found at least slight difficulty in using a cellphone, with 58% of these found solving a cellphone problem at least moderately difficult, and 12% did not find it difficult. |

Difficulty in bathing and showering seems to be associated with those who have difficulty in adjusting the hot and cold water. The test results indicated that nearly half of the respondents who have some level of difficulty bathing (n=88) find difficult to adjust the water temperature for bathing or showering. Similarly, Naik, Concato & Gill (2004)

reported that approximately 31% of the elderly participants in their study (n=626) had a disability that affected their bathing, and close to 39% of them had a problem adjusting temperature of the water. This suggests that adjusting temperature of the water is one of the difficult subtasks associated with bathing or showering. Harvey, Mitchell, Brodaty, Draper & Close (2016) found in their burn risk assessment study that people with dementia were at high risk of being burned by hot tap water. The potential design recommendation for mitigating this problem may be sensatory controls that monitor the temperature of the water from faucets. This technology, however, needs to ensure user-friendly instructions and possibly training for the elderly.

Difficulty in preparing meals is associated with those who forget to turn off the stove. Close to 50% of the respondents who sometimes have issues with stove control (either forget to turn it off or use the wrong stove control) reported some level of difficulty in preparing meals. Improper stove control was listed as one of the five features of mild dementia (Gurland, Dean, Copeland & Golden, 1982). Yared & Abulrazak (2018) described safety risks among elderly people that are associated with cooking and promoted interventions to reduce the risks. Many manufacturers offer an electric cooktop that has safety features such as automatically turning off the burners when a pot is removed. This design solution might remedy stove control issues.

Difficulty in taking medication is associated with those who forget to take medication or those who misunderstand the instruction on the medicine label. Cognitive performance influences medication-taking behavior (Insel et al., 2006; Bosworth & Ayotte, 2009); therefore, it was understandable that the test results showed an association between the difficulty in understanding medication instructions and difficulty in medication adherence. Marcum, Hanlon & Murray (2017) suggested multiple interventions to improve medication adherence, while other studies touted redesigning

drug labels (Gerhart, Spriggs, Hampton, Hoy, Strochlic, Proulx & Goetchius, 2015). Although they are still being investigated, additional visual aids for medication labels may also help elderly users distinguish between medication bottles (Caderelli, Mann, Fulda, Balyakina, Espinoza & Lurie,

Difficulty with using a computer or cell phone is associated with those who had difficulties with solving problems that occurred with them.

*4.1.12 Seeing*

The seeing category of the function assesses whether the visual skills are associated with difficulty in performing tasks for daily activities. Examples of tasks associated with this category are reading data on a cellphone, reading a medicine label, and reading data on a computer screen. The survey questions associated with vision are listed in Table 3-10. Table 4-17 shows the hypotheses and the results from the Chi-square test of independence that were used to determine whether certain activities of daily living were associated with specific tasks that require visual skills. A total of 317 individuals responded to the questionnaire. Fewer respondents answered the questions associated with using a computer or a cellphone since some of them did not use either. Contingency tables used to interpret the results are shown in Appendix L.

Table 4-17 Hypotheses and Test Results: Seeing

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in reading a medicine label is associated with difficulty in taking medication.<br><br>(Q53 &Q47) | The association was significant; Chi-sq = 10.4; $p<0.05$. | Two hundred and eighty-five (285) respondents found no difficulty in taking medication, among whom 45% found no difficulty in reading a medicine label, and 28% found it at least moderately difficult. Thirty-two (32) respondents found at least slight difficulty in taking medication, with 47% of these found reading a medicine label at least moderately difficult, and 16% did not find it difficult. |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in seeing is associated with difficulty in using a computer.<br><br>(Q83&Q55) | The association was significant; Chi-sq = 24.7; p<0.05. | Two hundred and thirteen (213) respondents found no difficulty in using a computer, among whom 27% found no difficulty in seeing things without glasses; 73% found it somewhat difficult. Seventy-three (73) respondents found at least slight difficulty in using a computer, with 90% of them found some level of difficulty in seeing things without glasses, and 10% did not find it difficult. |
| Difficulty in recognizing obstacles when walking or climbing stairs is associated with difficulty in seeing.<br><br>(Q87&Q83) | The association was significant; Chi-sq = 22.4; p<0.05. | Two hundred and forty-two (242) respondents found no difficulty in recognizing obstacles when walking or climbing stairs, among whom 27% found no difficulty in seeing things without glasses; 73% found it somewhat difficult. Seventy-five (75) respondents found at least slight difficulty in recognizing obstacles when walking or climbing stairs, with 93% of them found some level of difficulty in seeing things without glasses, and 7% did not find it difficult. |
| Difficulty in reading the contents on a computer screen is associated with the amount of lighting in the room.<br><br>(Q63&Q64) | The association was significant; Chi-sq = 45.2; p<0.05. | One hundred and ninety-six (196) respondents found no difficulty in reading the contents on a computer screen. Among them, 79% thought that there was adequate lighting in the room, and 21% considered the lighting inadequate. Ninety (90) respondents found at least slight difficulty in reading the contents on a computer screen, with 48% of them thought there was not adequate lighting in the room, and 52% thought the lighting adequate. |

Difficulty in taking medication is more prevalent among people who find it difficult to read medicine labels. Approximately 84% of those who had difficulty taking medication (n=32) found the lettering of the medicine label somewhat small. Smither & Braun (1994) reported that a 12-point font size is easy for most older adults to read. Large print, consistent layout, overall lowercase lettering, and some yellow highlighting could enhance the ease with which older adults read medication labels (Leat, Krishnamoorthy, Carbonara, Gold, & Rojas-Fernandez, 2016).

Difficulty in using a computer and difficulty in recognizing obstacles when walking are more prevalent among those who have difficulty seeing without glasses. Difficulty

with reading contents on a computer is associated with those who find the ambient room lighting too dim. A good visual design of cellphones for elder users that computer manufacturers should consider include a large font, an adjustable contrast setting, a larger screen size, bigger text on keys, and better color contrast (Faisal, Romli & Yosof, 2014). Jayroe & Wolfram (2012) described useability challenges for senior users with computer tablets, such as identifying links on the displayed page, and confusion caused by sudden and unexpected appearance/disappearance of the keyboard. Many different computers and tablets with features that include large and adjustable font size and simplified functions are available for senior users.

*4.1.13 Hearing*

The hearing category of the function assesses whether the hearing skills are associated with difficulty in performing tasks for daily activities. The survey questions associated with the hearing skills are listed inTable 3-11. Table 4-18 shows the hypotheses and the results from the Chi-square test of independence that were used to determine whether certain activities of daily living were associated with specific tasks that require hearing skills. A total of 317 individuals responded to the questionnaire. Fewer respondents answered the questions associated with using a computer or a cellphone since some of them did not use either. Contingency tables used to interpret the results are shown in Appendix M.

Table 4-18 Hypotheses and Test Results: Hearing

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| Difficulty in hearing is associated with difficulty in using a computer. | The association was significant; Chi-sq = 28.1; $p<0.05$. | Two hundred and thirteen (213) respondents found no difficulty in using a computer, among whom 57% had no hearing difficulty; 17% found it at least moderately difficult. Seventy-three (73) respondents found at least slight difficulty in using a computer, with 44% of them |

| Hypothesis | Results | Results Interpretation (5% of Significance Level) |
|---|---|---|
| (Q84&Q55) | | found hearing at least moderately difficult, and 33% did not find it difficult. |
| Difficulty in hearing is associated with difficulty in using a cellphone.<br><br>(Q84&Q66) | The association was significant; Chi-sq = 14.0; $p<0.05$. | Two hundred and twenty (220) respondents found no difficulty in using a cellphone, among whom 56% found no difficulty in hearing, and 20% found it at least moderately difficult. Seventy-seven (77) respondents found at least slight difficulty in using a cellphone, with 38% of them found hearing at least moderately difficult, and 33% did not find it difficult. |
| Difficulty in hearing is associated with difficulty in talking on a cellphone when there is background noise.<br><br>(Q84&Q78) | The association was significant; Chi-sq = 66.0; $p<0.05$. | One hundred and sixteen (116) respondents found no difficulty in talking on a cellphone when there was background noise, among whom 72% found no difficulty in hearing, and 10% found it at least moderately difficult. Eighty (80) respondents found at least moderate difficulty in talking on a cellphone when there was background noise, with 51% of these found hearing at least moderately difficult, and 21% did not find it difficult. |

Difficulty in using a computer or cell phone, including talking amid background noise, is more prevalent among those who have difficulty hearing. The results show an association between hearing difficulties and difficulty with using a computer or a cellphone. Although the modern computer technologies employ useful features for hearing impaired users, challenges remain for elderly users with hearing difficulties (Jerram, Kent & Searchfield, 2010). Jerram et al. (2010) argued that cellphone designs should be simpler, have more user-friendly instructions, and have a less complicated visual format so that senior users can more easily operate their phones. Kbar, Bhatia, Abidi, & Alsharawy (2017) suggested that a mobile phone with an added text-to-speech conversion feature would allow users to type their message in a noisy environment. They

also stated the need for further research to provide haptic feedback and technical support.

## 4.2 Focus Group Study

This section describes the results and findings from the focus group study. After coding was accomplished, three themes emerged: 1) participants' frustration due to the mismatch between task demand and capacity, 2) design changes that participants have initiated or suggested, and 3) assistive technologies that participants commonly used to support their daily living. Supplementally, the last section discusses potential mechanisms that older adults apply to compensate for their functional limitations. All the findings are summarized per functional category in the following sub-sections.

### *4.2.1 Participants*

Prior to conducting a focus group interview, a consent form was mailed to each participant, who signed it and mailed it back to the researcher. Due to the corona virus pandemic, the study utilized the virtual meeting environment, Zoom, to facilitate the focus group. All the participants used the video so that their faces were visible and the interview was recorded for the transcription purpose with permission of the participants. Five older adults whose mean age was 78 participated the focus group interview. Two of them self-reported mild short-term memory issues and two others claimed that they were very healthy. The interview lasted for one hour, with two ten-minute breaks between sessions that were no included in the interview time. Table 4-19 summarizes the characteristics of the participants.

Table 4-19 Focus Group Participant Characteristics (n = 5)

| Variable | Categories | N |
|---|---|---|
| Age | 70 or below | 1 |
| | 71-75 | 1 |

| Variable | Categories | N |
|---|---|---|
| | 76-80 | 1 |
| | 81 or over | 2 |
| Sex | Female | 3 |
| | Male | 2 |
| Race | Caucasian | 5 |
| Marital Status | Single | 1 |
| | Married | 4 |
| Employment Status | Retired | 4 |
| | Full-time | 1 |
| Housing | House | 4 |
| | Senior community apartment | 1 |

*4.2.2 Anthropometric*

Bathrooms seem to be the environments that require high task demand such lifting legs (to get in/out of a bathtub), and maintaining posture and balance. Participants' fear of falling contributes to their perceived challenges of bathing or showering, and the participants all agreed that grab bars are necessary for bathing or showering. Those who resided in a house remodeled their bathroom by removing a bathtub and installing grab bars when they recognized their functional limitations, and a married couple installed handicap toilet seats to facilitate getting up or down and mentioned that they carry portable toilet seats with them when they travel. Participants also considered it hard to get dressed as it requires specific physical motions such as bending the upper body to put on socks or buttoning shirts. One participant regularly utilized a tool to assist with putting on socks and shoes.

Similar to the findings from the questionnaire, the participants found the lids of jars or bottle very tight and hard to open, and all of them admitted to frequently using a

tool to open them. They also found it hard to reach higher or lower cabinets, as it requires raising their arms high or to bending down, respectively. The depth of cabinets was also mentioned as being problematic by one elder, as she said that she could not reach items at the back of the lower cabinet. Drawer-type cabinets were discussed as an alternative design that would make their kitchens more user-friendly.

*4.2.3 Posture and Balance*

Two participants repeatedly mentioned that their limited gross motor skills cause them to have poor balance and posture. They reported trying to move slowly, assess consequences of physical demands before acting, and act cautiously in everything they do. Both participants were married, and their spouses often perform some tasks for them including grocery shopping, and cooking. All the participants understood that their lack of balance makes them vulnerable to accidents and reported that it is no longer safe for them to use a step stool.

*4.2.4 Body Strength*

A female participant related that she has difficulty getting things down from the top of the kitchen shelf – not because she cannot reach the shelf, but because she does not have enough strength to hold onto the items without dropping off. The same person reported that the motion of pushing vacuum cleaner back and forth is exhausting, and it is getting harder to make the bed as she gets older. Human factors design for bed making may be an area that needs further study. Another female participant used to pound ice bags to break up ice, but quit performing this task due to her declined physical strength. She instead purchased an ice maker.

*4.2.5 Physiological Endurance*

Only a few activities related to physiological endurance were discussed. All the participants reported to use a cellphone, but one participant said he has never used a

computer. One person mentioned that reading a book on the tablet computer makes her eyes tired and another participant reported that holding a cellphone for a prolonged time makes her fingers hurt. No one reported physical pain when or after using a computer; however, they did not seem to use a computer for a long period time on a regular basis.

*4.2.6 Mobility*

Mobility was one of the major concerns of all the participants. Any activities that require bending down, stretching up, and raising arms or legs, were perceived as the most difficult tasks. These include bathing or showering (e.g., getting in/out of bathtub, washing legs), dressing (putting on socks/shoes), accessing higher and lower cabinets, vacuuming, and bedmaking. None of the participants used a bathtub, as they perceived it as an obstacle. These findings may be associated with problems with lower extremity strength and mobility discussed in Chapter 2. Designs for elderly people should require fewer demands for mobility and ensure support to stabilize balance or posture.

*4.2.7 Psychomotor Skills*

Opening a medicine bottle with a child-lock is one of the daily living tasks that all participants reported as difficult. One participant said, “A lot of that (child-lock) is to try to keep children out of it, but it also keeps the person in need out of it”. Pill wrappers are another type of medication packaging that older adults find hard to tear open. One participant mentioned that she uses scissors to open the pill wrapper and then transferers the pills to a bottle to avoid frustration. The problems experienced by elderly adults in opening medicine packages have been studied for decades (Roger et al., 1998; Beckman, Bernsten, Parker, Thorslund, & Fastbom, 2005; Beckman et al., 2005; Kroemer, 2006); yet, it remains a challenge for older adults. Opening jar lids is considered difficult by genders. Participants expressed that zippers can present a challenge while dressing, as psychomotor skills are needed to connect both ends.

Alternatively, a few participants selected clothes or shoes with a fastening tape instead of buttons or zippers.

*4.2.8 Cognitive*

Most participants addressed using a pill organizer to help them take their medications as prescribed. One participant said that he had been depending on his spouse for last 30 years for his medication adherence, and some participants admitted to getting too busy or distracted and forgetting to take their medication. These findings align with the studies shown in the literature review section. An inability to pay attention and/or being easily distracted are cognitive characteristics that commonly appear with aging. One participant shared her experience of forgetting to turn off the stove control while she was multi-tasking; another shared that she has a stove control with a timer that that automatically turns itself off and makes her feel safe.

All the participants expressed difficulty in using a computer. They compared themselves with younger adults (e.g., their children or grandchildren) and especially talked about instructions for using technology devices as being “simple to young people but not simple to us.” They especially expressed negative comments about the software interfaces that often change to accommodate software updates. They said that they had tried to learn the features of their computer, but when updates occur and some of the features change, they become discouraged at the thought of having to start the learning process all over again.

*4.2.9 Seeing*

All the participants preferred larger font sizes on medicine labels and screens of the computers and cellphones and admitted to adjusting the font size on their computer and cellphone screens to enhance legibility. Some participants mentioned using a magnifying glass to read medication labels.

*4.2.10 Strategies to Overcome Functional Limitations*

Although this subject was not specifically discussed during the focus group, the results from the interview led to consideration of three different philosophies that older adults seem to apply to their daily tasks. The first stage is a “compromising” phase, where they either reduce the frequency with which they perform tasks or take more time to complete them. Examples of this stage cited by a female participant are making the bed and housekeeping. The second might be an “assistive technology” phase, in which older adults find assistive tools beneficial for enabling them to continue to perform tasks by themselves. Examples are toileting (using handicap toilet seats), bathing (employing grab bars), and opening jar lids. The third stage seems to be a “delegation” phase, in which older adults depend on others to perform a task. Examples are housekeeping (using a commercial service), and medication adherence. Older adults who participated in the focus group used all three strategies to overcome functional mitigations, but in individual ways that worked specifically for them. The strategies did not seem to be consistent to a specific task; rather, it seems to depend on personal justifications or preferences. These findings support the research done by Roger et al. (1998).

# Chapter 5

# Conclusions

## 5.1 Summary of Research Findings

This study identifies many of the tasks that make daily activities difficult for older adults, based upon responses from the questionnaire research and the focus group interviews. Getting in/out of a bathtub and adjusting the hot and cold water are two of the tasks that older adults find difficult while bathing or showering, and difficulty in dressing is attributed to the flexibility required by bending upper body. Several tasks such as opening jar lids, reaching cabinets, moving forward or sideways to reach objects, holding large objects, coping with the heat from pots when moving them, and opening cabinets or refrigerator doors are considered difficult tasks associated with preparing meals. Participants of this study found housekeeping the most difficult task of six daily activities, and bending over to vacuum, moving around a vacuum cleaner, and reaching forward were consistently mentioned as problems. Opening and closing a medicine bottle, picking up pills with their fingers, and tearing a pill wrapper open were tasks identified as difficult for medication adherence among those who had difficulty using their fingers and hands. Solving a computer or cellphone problem was associated with difficulty of using them.

Physical features of the living environment that are associated with mismatches between task demands and the functional capabilities of older adults include the bathroom environment, kitchen flow, furniture, and layout, consumer products such as jar lids, vacuum cleaners, and medicine bottles or packages; and workstation environments that are conducive to inadequate posture. Older adults who have difficulty in bathing or showering need adequate space, and a bathtub seems to be considered an obstacle for them, as it forces them to raise their legs and causes potential balance issues. The location of kitchen cabinets requires older adults to stretch up or bend down, which could

constrain older adults to move their body beyond their capacity limitations. Opening jar lids and bottle caps is often identified as a difficult task, since it requires more strength than they can generate.

The results from several research hypotheses and the focus group interview showed potential changes that could be made in the design of the environments and products to minimize the difficulties that older adults experience in performing daily tasks. To improve conditions for bathing or showering, several changes are recommended such as evaluating whether the space is adequate; removing a bathtub; installing grab bars in a proper location; using flooring that is not slippery, or alternatively, installing an anti-slip mat; and utilizing a sensory control to achieve a comfortable water temperature. The kitchen was deemed the area that needs the most design improvements. The height of cabinets and worksurfaces should be adjustable to accommodate the mobility limitations of aging, and touchless mechanisms should be considered for opening and closing cabinets and appliances doors, such as refrigerators. Computer work environments and the arrangement of computer equipment should be assessed to optimize comfort and reduce pain. Consumer products, including jar lids and medicine bottles/packages, need to be much better designed to ease difficulty in opening them and maintain safety. Better instructions and representations of the computer software in general could encourage the elderly to use electronic devices properly and more often.

Through a focus group interview, this study recognized that some assistive devices are already used frequently by older adults. Tools for opening jar lids seem to be a commonly used device, and grab bars in the bathroom were referred to as “musts” for mobility and balance. Other tools such as handicap toilet seats and a lightweight vacuum cleaner were mentioned as useful.

## 5.2 Limitations and Future Work

The findings of this study were limited by a lack of biomechanical data and were based on the online survey and virtual interviews. Another limitation may be unknown variables of participants' health conditions such as arthurites that could have influenced their answers to certain questions, rather than aging factor alone. The study also did not have diversified participants in ethnic background. Future studies are necessary to further investigate the findings of this study, potentially with biomechanical data and a wider range of population characteristics.

## 5.3 Final Conclusions

It is clear that many of the findings in this study on the difficulties in activities of daily living, based on their physiological capabilities, are not new; but despite the accumulated knowledge and efforts to improve the living environment over the decades, these problems are still prevalent. It is possible that an attempt to eliminate a problem of ADL/IADL may create new problems within a new environment or new product, or that the problems have not been seriously addressed. The new contributions of this study are 1) it elucidates the difficulties people face in their actual living environment from their own point of view, and 2) it shows specific relationships or associations between activities or tasks rated as difficult, by the elderly, and their physical and mental capabilities. While most of the older adults seem to be satisfied with their environment a small, but significant, percentage find the environment still too challenging. This study shows where those challenges may be met, with greater focus directed at this minority. This would require involvement of policy makers or/and government. Future research should have a stronger focus on the design of the living environment and implements needed for activities of daily living.

Overall, this study holistically analyzed the compatibility between the perceived functional capacities of older adults and task demands, and gave more practical implications to the better design for living environments for older adults.

Appendix A

Consent Form

## The University of Texas at Arlington (UTA)

## Informed Consent for Minimal Risk Studies with Adults

My name is Megumi Hice, and I am asking you to participate in a UT Arlington research study titled, "Design for Older Adults – Functional Limitations and Human Factors Engineering." This research study is about understanding how older adults interact with their living environment to perform activities of daily living. You can choose to participate in this research study if you are at least 65 years old and capable of performing daily activities such bathing, dressing, and housekeeping.

Reasons why you might want to participate in this study include to share your experience so that I can evaluate the design of living environment for older adults, but you might not want to participate if you are not able to commit to taking a survey about 30 minutes in one sitting. Your decision about whether to participate is entirely up to you. If you decide not to be in the study, there won't be any punishment or penalty; whatever your choice, there will be no impact on any benefits or services that you would normally receive. Even if you choose to begin the study, you can also change your mind and quit at any time without any consequences.

If you decide to participate in this research study, I will ask you to complete the one-time survey that should take about 30 minutes. The survey is not expected to pose any additional risks beyond those that you would normally experience in your regular everyday life.

You will not be paid for completing this study. There are no alternative options to this research project.

The research team is committed to protecting your rights and privacy as a research subject. We may publish or present the results, but your name will not be used. While absolute confidentiality cannot be guaranteed, the research team will make every effort to protect the confidentiality of your records as described here and to the extent permitted by law. If you have questions about the study, you can contact me at 817-657-0974 or megumi.hice@mavs.uta.edu For questions about your rights or to report complaints, contact the UTA Research Office at 817-272-3723 or regulatoryservices@uta.edu.

You are indicating your voluntary agreement to participate by signing on the line below.

Name of Person (Please print):_____

Signature of Person:_____

Date:_____

Appendix B

Questionnaire

## Living Environment for Older Adults

This questionnaire is a part of a Ph.D. dissertation research by the student at UTA (University of Texas, Arlington).

The purpose of this survey is to evaluate how older adults interact with their living environment to conduct activities of daily living. The results will be used only for the student's research. Outcome of the survey will be analyzed to determine what features of the living environment should be redesigned and what other living conditions should be modified.

This survey is anonymous and does not ask personal identifiable questions.

Instructions:

1. Answers are scaler based: 1 to 5 (e.g., disagree to agree)

2. Select only one box for an answer to each question (e.g., do not check two boxes for the same question)

**Bathing or Showering**

**Examples: getting in/out or slipping in the tub**

1. How hard is it for you to bathe or shower?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

2. How often do you bend your neck, knees, or back because the bathroom faucet is too low?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

3. How slippery is the shower (or bathtub) floor?

| Not slippery | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

4. Do you think the handles in your bathroom are properly located for you to hold to help maintain your balance?
   Answer if your shower or bathtub area has grab handles

| Totally Disagree | Disagree | Neutral | Agree | Totally Agree |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

5. How painful or uncomfortable is it for you to turn the faucet on and off?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

6. How hard is it for you to adjust hot and cold water to get a comfortable temperature?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

7. How hard is it for you to get in or out of the tub or shower?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

8. How comfortable do you feel moving around in your shower area because of the amount of space available?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Dressing**

**Examples: buttoning or raising arms**

9. How hard is it for you to dress yourself?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

10. How hard is it for you to bend your neck, knees, or back (upper body) while dressing?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

11. How hard is it for you to move your arms while dressing?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

12. How hard is it for you to maintain balance while dressing?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

13. How hard is it for you to button a shirt or tie shoelaces?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

14. How often do you sit or lean on furniture while dressing?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

15. How do you consider the space where you dress?

| Too small | Small | Just Right | Large | Too Large |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

**Cooking or Preparing Meals**

**Examples: cutting food, using oven, reaching shelves, or opening jars**

16.How hard is it for you to cook or prepare meals?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

17.How hard is it for you to open food jars with your hands alone (not with tools or opening aids)?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

18.How do you consider the size of the most jar lids for you to grip and turn?

| Too small | Small | Just right | Large | Too large |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

19.How slippery do you find jar lids when trying to open or close them?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

20.In general, how much hand strength do you apply to open or tighten jar lids?

| Slight | Moderate | High | Very high | Extremely high |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

21.How often do you find new jar lids (that have never opened before) difficult to open?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

22.How often do you find used jar lids (that have been opened) difficult to open or tighten?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

23.How difficult is it for you to open food packages or boxes (e.g., meat, cookies)?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

24. How often do you find packages or boxes difficult to open?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

25. In general, how difficult is it to handle the weights of pots when cooking or serving meals?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

26. How often do you turn on or off the wrong stove control for a particular heating surface?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

27. How often do you forget to turn off the stove?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

28. How do you consider the height of kitchen shelves/cabinets that you use most frequently?

| Too low | low | Just right | high | Too high |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

29. How hard is it for you to open the kitchen cabinets (because of hand strength)?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

30. How hard is it for you to open the refrigerator door (because of hand strength)?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

31. In general, how comfortable are the heights of the work surfaces in your kitchen?

| Too Low | Low | Just Right | High | Too High |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

32. How difficult is it for reaching into cupboards and shelves above your head in your kitchen?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

33. How difficult is it to reach forward or sideways for things that are not directly in front of you; for example, reaching for pots on a stove?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

34. How difficult is it to hold large objects in your home because of their size; for example, pots in the kitchen?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

35. How difficult is it to cope with the heat from hot pots in the kitchen when moving them?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Housekeeping**

**Examples: vacuuming, cleaning floors, dusting, or making bed**

36. How physically hard is it for you to do housekeeping?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

37. How crowded are various objects, such as books, papers, boxes and shoes, found on your floors that might obstruct walking?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

38. How difficult is it to walk on any of your floors due to uneven or loose rugs or carpet?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

39. How hard is it for you to bend your body downward to perform housekeeping such as vacuuming and mopping floors?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

40. How hard is it for you to reach upward to perform housekeeping such as dusting shelves?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

41. How hard is it for you to reach forward or sideways to perform housekeeping such as picking up or moving things?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

42. How hard is it for you to maintain balance when climbing stepladders or other step-up aids to reach, clean or clear high shelves?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

43. How heavy is it to lift or move around the cleaning equipment you use in your residence?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

44. How hard is it for you to handle cleaning equipment, in general, due to its size?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

45. How difficult is it to move around your furniture due to their weight?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

46. How hard is it on your body due to bending while moving around furniture or other things in your home when cleaning or doing other forms of housekeeping?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Taking Medication**

**Examples: understanding label, or remembering doses**

47.How hard is it for you to take medication?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

48.How hard is it to grip a medicine bottle and turn its cap for opening?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

49.How hard is it to grip a medicine bottle and turn its cap for closing?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

50.How hard is it to grip a pill wrapper and tear it with your fingers?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

51.How hard is it to pick up pills with your fingers?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

52.How often do you forget to take medication in the correct dosage or at the correct time?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

53.How hard is it for you to read a medicine label because lettering is too small?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

54.How hard is it for you to understand a medicine label because instructions are too complicated?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

**Computer**

**Examples: typing, using a mouse, reading screen contents, searching the internet, or sitting**

◯ **Check this circle if you do not use a computer**

55. How difficult is it for you to use a computer?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

56. What level of pain do you experience in your neck, shoulders, or arms when/after using a computer?

| None | Slight | Moderate | Very | Extreme |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

57. How sharply do you bend your neck or raise shoulders/arms when using a computer?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

58. How often do you experience pain in your legs when/after using a computer?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

59. How often do you sit on an adjustable chair when using a computer?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

60. How often do you experience pain in your fingers when/after using a computer?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

61. How hard is it for you to use a keyboard or a mouse?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

62. How hard is it for you to understand a user manual or instructions on a computer screen?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

63. How hard is it for you to read the contents on a computer screen?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

64. Do you think the lighting in the room is bright enough for you to work with your computer?

| Totally Disagree | Disagree | Neutral | Agree | Totally Agree |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

65. How difficult is it for you to solve or diagnose a computer problem when printing a document, emailing, or installing software?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

**Cellphone**

**Examples: telephoning, texting, reading screen contents, or searching the internet**

◯ **Check this circle if you do not use a cellphone**

66.How difficult is it for you to use a cellphone?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

67.How often do you text messages with your cellphone?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

68.How often do you take pictures with your cellphone?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

69.How often do you read, write or send emails with your cellphone?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

70.How often do you use a cellphone only for the telephoning purpose?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

71.How often do you bend your wrist sharply when using a cellphone?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

72.How slippery is your cellphone when you hold it?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

73.How small does your cellphone feel when holding and using it?

| Just right | Slightly small | Small | Very small | Too small |
|---|---|---|---|---|
| □ | □ | □ | □ | □ |

74. How large does your cellphone feel when holding and using it?

| Just right | Slightly large | Large | Very large | Too large |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

75. How difficult is it for you to carry your cellphone around?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

76. How difficult is it for you to use a keypad on your cellphone because of difficulty in bending or moving your fingers?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

77. How difficult is it for you to solve or diagnose a cellphone problem such as calling, emailing, or installing applications?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

78. How difficult is it for you to talk over the cellphone with background noise?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

79. How hard is it to read the contents on a cellphone?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**General Daily Function**

80. What level of difficulty do you have in walking or maintaining balance?

| None | Slight | Moderate | Very | Extreme |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

81. How often do you use wheelchairs, walker, cane or crutches to support your mobility?

| Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

82. What level of difficulty do you have in using fingers or hands?

| None | Slight | Moderate | Very | Extreme |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

83. What level of difficulty do you have in seeing things around you or reading without glasses?

| None | Slight | Moderate | Very | Extreme |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

84. What level of difficulty do you have in hearing?

| None | Slight | Moderate | Very | Extreme |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

85. What level of difficulty do you have in remembering things?

| None | Slight | Moderate | Very | Extreme |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

86. How slippery do you find things, in general, when holding them?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

87. How hard is it for you to walk or climbing stairs because of difficulty recognizing obstacles?

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Demographic Questions**

**Gender:**

| Male | Female | Decline to answer |
|---|---|---|
| ☐ | ☐ | ☐ |

**Age:**

| 70 or below | 71 - 75 | 76 - 80 | 81 - 85 | 86 or over |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Ethnicity:**

| White | Hispanic or Latino | Black or African American | Native Indian | Asian | Other |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Marital Status:**

| Single | Married | Widowed | Divorced | Separated |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Employment Status:**

| Retired | Employed – full time | Employed – part time | Self-employed | Out of work | Decline to answer |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Type of Home:**

| House | Apartment or Condominium | Senior Living Community | Care Facility | Others |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Self-Rated Health Status:**

| Poor | Fair | Good | Very Good | Excellent |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**How successfully are you aging?**

| Not at all | Slightly | Moderately | Very | Extremely |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Comments:**

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# Appendix C

## Contingency Tables - Anthropometric

| | | | Q8 - 8. How comfortable do you feel moving around in your shower area because of the amount of space available? | | | | |
|---|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately | Very or extremely | Total |
| Q1 - 1. How hard is it for you to bathe or shower? | Not at all | Count | 40 | 27 | 36 | 134 | 237 |
| | | Expected Count | 40.4 | 31.4 | 44.1 | 121.1 | 237.0 |
| | | % within Q1 | 16.9% | 11.4% | 15.2% | 56.5% | 100.0% |
| | | % within Q8 | 74.1% | 64.3% | 61.0% | 82.7% | 74.8% |
| | | % of Total | 12.6% | 8.5% | 11.4% | 42.3% | 74.8% |
| | Slightly or more | Count | 14 | 15 | 23 | 28 | 80 |
| | | Expected Count | 13.6 | 10.6 | 14.9 | 40.9 | 80.0 |
| | | % within Q1 | 17.5% | 18.8% | 28.7% | 35.0% | 100.0% |
| | | % within Q8 | 25.9% | 35.7% | 39.0% | 17.3% | 25.2% |
| | | % of Total | 4.4% | 4.7% | 7.3% | 8.8% | 25.2% |
| Total | | Count | 54 | 42 | 59 | 162 | 317 |
| | | Expected Count | 54.0 | 42.0 | 59.0 | 162.0 | 317.0 |
| | | % within Q1 | 17.0% | 13.2% | 18.6% | 51.1% | 100.0% |
| | | % within Q8 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 17.0% | 13.2% | 18.6% | 51.1% | 100.0% |

| | | | Q15 - 15. How do you consider the space where you dress? | | | |
|---|---|---|---|---|---|---|
| | | | Small or too small | Just right | Large or too large | Total |
| Q9 - 9. How hard is it for you to dress yourself? | Not at all | Count | 24 | 194 | 33 | 251 |
| | | Expected Count | 26.9 | 189.2 | 34.8 | 251.0 |
| | | % within Q9 | 9.6% | 77.3% | 13.1% | 100.0% |
| | | % within Q15 | 70.6% | 81.2% | 75.0% | 79.2% |
| | | % of Total | 7.6% | 61.2% | 10.4% | 79.2% |
| | Slightly or more | Count | 10 | 45 | 11 | 66 |
| | | Expected Count | 7.1 | 49.8 | 9.2 | 66.0 |
| | | % within Q9 | 15.2% | 68.2% | 16.7% | 100.0% |
| | | % within Q15 | 29.4% | 18.8% | 25.0% | 20.8% |
| | | % of Total | 3.2% | 14.2% | 3.5% | 20.8% |
| Total | | Count | 34 | 239 | 44 | 317 |
| | | Expected Count | 34.0 | 239.0 | 44.0 | 317.0 |
| | | % within Q9 | 10.7% | 75.4% | 13.9% | 100.0% |
| | | % within Q15 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 10.7% | 75.4% | 13.9% | 100.0% |

| | | | Q18 - 18. How do you consider the size of the most jar lids for you to grip and turn? | | | |
|---|---|---|---|---|---|---|
| | | | Small or too small | Just right | Large or too large | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 21 | 155 | 46 | 222 |
| | | Expected Count | 23.8 | 131.7 | 66.5 | 222.0 |
| | | % within Q16 | 9.5% | 69.8% | 20.7% | 100.0% |
| | | % within Q18 | 61.8% | 82.4% | 48.4% | 70.0% |
| | | % of Total | 6.6% | 48.9% | 14.5% | 70.0% |
| | Slightly or more | Count | 13 | 33 | 49 | 95 |
| | | Expected Count | 10.2 | 56.3 | 28.5 | 95.0 |
| | | % within Q16 | 13.7% | 34.7% | 51.6% | 100.0% |
| | | % within Q18 | 38.2% | 17.6% | 51.6% | 30.0% |
| | | % of Total | 4.1% | 10.4% | 15.5% | 30.0% |
| Total | | Count | 34 | 188 | 95 | 317 |
| | | Expected Count | 34.0 | 188.0 | 95.0 | 317.0 |
| | | % within Q16 | 10.7% | 59.3% | 30.0% | 100.0% |
| | | % within Q18 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 10.7% | 59.3% | 30.0% | 100.0% |

| | | | Q28 - 28. How do you consider the height of kitchen shelves/cabinets that you use most frequently? | | | |
|---|---|---|---|---|---|---|
| | | | Low or too low | Just right | High or too high | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 8 | 166 | 48 | 222 |
| | | Expected Count | 12.6 | 152.0 | 57.4 | 222.0 |
| | | % within Q16 | 3.6% | 74.8% | 21.6% | 100.0% |
| | | % within Q28 | 44.4% | 76.5% | 58.5% | 70.0% |
| | | % of Total | 2.5% | 52.4% | 15.1% | 70.0% |
| | Slightly or more | Count | 10 | 51 | 34 | 95 |
| | | Expected Count | 5.4 | 65.0 | 24.6 | 95.0 |
| | | % within Q16 | 10.5% | 53.7% | 35.8% | 100.0% |
| | | % within Q28 | 55.6% | 23.5% | 41.5% | 30.0% |
| | | % of Total | 3.2% | 16.1% | 10.7% | 30.0% |
| Total | | Count | 18 | 217 | 82 | 317 |
| | | Expected Count | 18.0 | 217.0 | 82.0 | 317.0 |
| | | % within Q16 | 5.7% | 68.5% | 25.9% | 100.0% |
| | | % within Q28 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 5.7% | 68.5% | 25.9% | 100.0% |

| | | | Q31 - 31. In general, how comfortable are the heights of the work surfaces in your kitchen? | | | |
|---|---|---|---|---|---|---|
| | | | Low or too low | Just right | High or too high | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 7 | 205 | 10 | 222 |
| | | Expected Count | 9.1 | 196.8 | 16.1 | 222.0 |
| | | % within Q16 | 3.2% | 92.3% | 4.5% | 100.0% |
| | | % within Q31 | 53.8% | 73.0% | 43.5% | 70.0% |
| | | % of Total | 2.2% | 64.7% | 3.2% | 70.0% |
| | Slightly or more | Count | 6 | 76 | 13 | 95 |
| | | Expected Count | 3.9 | 84.2 | 6.9 | 95.0 |
| | | % within Q16 | 6.3% | 80.0% | 13.7% | 100.0% |
| | | % within Q31 | 46.2% | 27.0% | 56.5% | 30.0% |
| | | % of Total | 1.9% | 24.0% | 4.1% | 30.0% |
| Total | | Count | 13 | 281 | 23 | 317 |
| | | Expected Count | 13.0 | 281.0 | 23.0 | 317.0 |
| | | % within Q16 | 4.1% | 88.6% | 7.3% | 100.0% |
| | | % within Q31 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 4.1% | 88.6% | 7.3% | 100.0% |

| | | | Q32 - 32. How difficult is it for reaching into cupboards and shelves above your head in your kitchen? | | | | |
|---|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately | Very or extremely | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 83 | 92 | 28 | 19 | 222 |
| | | Expected Count | 70.7 | 85.4 | 35.0 | 30.8 | 222.0 |
| | | % within Q16 | 37.4% | 41.4% | 12.6% | 8.6% | 100.0% |
| | | % within Q32 | 82.2% | 75.4% | 56.0% | 43.2% | 70.0% |
| | | % of Total | 26.2% | 29.0% | 8.8% | 6.0% | 70.0% |
| | Slightly or more | Count | 18 | 30 | 22 | 25 | 95 |
| | | Expected Count | 30.3 | 36.6 | 15.0 | 13.2 | 95.0 |
| | | % within Q16 | 18.9% | 31.6% | 23.2% | 26.3% | 100.0% |
| | | % within Q32 | 17.8% | 24.6% | 44.0% | 56.8% | 30.0% |
| | | % of Total | 5.7% | 9.5% | 6.9% | 7.9% | 30.0% |
| Total | | Count | 101 | 122 | 50 | 44 | 317 |
| | | Expected Count | 101.0 | 122.0 | 50.0 | 44.0 | 317.0 |
| | | % within Q16 | 31.9% | 38.5% | 15.8% | 13.9% | 100.0% |
| | | % within Q32 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 31.9% | 38.5% | 15.8% | 13.9% | 100.0% |

| | | | Q33 - 33. How difficult is it to reach forward or sideways for things that are not directly in front of you; for example | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 182 | 34 | 6 | 222 |
| | | Expected Count | 149.2 | 51.1 | 21.7 | 222.0 |
| | | % within Q16 | 82.0% | 15.3% | 2.7% | 100.0% |
| | | % within Q33 | 85.4% | 46.6% | 19.4% | 70.0% |
| | | % of Total | 57.4% | 10.7% | 1.9% | 70.0% |
| | Slightly or more | Count | 31 | 39 | 25 | 95 |
| | | Expected Count | 63.8 | 21.9 | 9.3 | 95.0 |
| | | % within Q16 | 32.6% | 41.1% | 26.3% | 100.0% |
| | | % within Q33 | 14.6% | 53.4% | 80.6% | 30.0% |
| | | % of Total | 9.8% | 12.3% | 7.9% | 30.0% |
| Total | | Count | 213 | 73 | 31 | 317 |
| | | Expected Count | 213.0 | 73.0 | 31.0 | 317.0 |
| | | % within Q16 | 67.2% | 23.0% | 9.8% | 100.0% |
| | | % within Q33 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 67.2% | 23.0% | 9.8% | 100.0% |

| | | | Q34 - 34. How difficult is it to hold large objects in your home because of their size; for example, pots in the kitchen | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 156 | 52 | 14 | 222 |
| | | Expected Count | 122.6 | 65.8 | 33.6 | 222.0 |
| | | % within Q16 | 70.3% | 23.4% | 6.3% | 100.0% |
| | | % within Q34 | 89.1% | 55.3% | 29.2% | 70.0% |
| | | % of Total | 49.2% | 16.4% | 4.4% | 70.0% |
| | Slightly or more | Count | 19 | 42 | 34 | 95 |
| | | Expected Count | 52.4 | 28.2 | 14.4 | 95.0 |
| | | % within Q16 | 20.0% | 44.2% | 35.8% | 100.0% |
| | | % within Q34 | 10.9% | 44.7% | 70.8% | 30.0% |
| | | % of Total | 6.0% | 13.2% | 10.7% | 30.0% |
| Total | | Count | 175 | 94 | 48 | 317 |
| | | Expected Count | 175.0 | 94.0 | 48.0 | 317.0 |
| | | % within Q16 | 55.2% | 29.7% | 15.1% | 100.0% |
| | | % within Q34 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 55.2% | 29.7% | 15.1% | 100.0% |

| | | | Q35 - 35. How difficult is it to cope with the heat from hot pots in the kitchen when moving them? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 161 | 51 | 10 | 222 |
| | | Expected Count | 130.3 | 60.9 | 30.8 | 222.0 |
| | | % within Q16 | 72.5% | 23.0% | 4.5% | 100.0% |
| | | % within Q35 | 86.6% | 58.6% | 22.7% | 70.0% |
| | | % of Total | 50.8% | 16.1% | 3.2% | 70.0% |
| | Slightly | Count | 16 | 26 | 14 | 56 |
| | | Expected Count | 32.9 | 15.4 | 7.8 | 56.0 |
| | | % within Q16 | 28.6% | 46.4% | 25.0% | 100.0% |
| | | % within Q35 | 8.6% | 29.9% | 31.8% | 17.7% |
| | | % of Total | 5.0% | 8.2% | 4.4% | 17.7% |
| | Moderately or more | Count | 9 | 10 | 20 | 39 |
| | | Expected Count | 22.9 | 10.7 | 5.4 | 39.0 |
| | | % within Q16 | 23.1% | 25.6% | 51.3% | 100.0% |
| | | % within Q35 | 4.8% | 11.5% | 45.5% | 12.3% |
| | | % of Total | 2.8% | 3.2% | 6.3% | 12.3% |
| Total | | Count | 186 | 87 | 44 | 317 |
| | | Expected Count | 186.0 | 87.0 | 44.0 | 317.0 |
| | | % within Q16 | 58.7% | 27.4% | 13.9% | 100.0% |
| | | % within Q35 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 58.7% | 27.4% | 13.9% | 100.0% |

| | | | Q45 - 45. How difficult is it to move around your furniture due to their weight? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q36 - 36. How physically hard is it for you to do housekeeping? | Not at all | Count | 58 | 45 | 21 | 124 |
| | | Expected Count | 26.6 | 39.9 | 57.5 | 124.0 |
| | | % within Q36 | 46.8% | 36.3% | 16.9% | 100.0% |
| | | % within Q45 | 85.3% | 44.1% | 14.3% | 39.1% |
| | | % of Total | 18.3% | 14.2% | 6.6% | 39.1% |
| | Slightly or more | Count | 10 | 57 | 126 | 193 |
| | | Expected Count | 41.4 | 62.1 | 89.5 | 193.0 |
| | | % within Q36 | 5.2% | 29.5% | 65.3% | 100.0% |
| | | % within Q45 | 14.7% | 55.9% | 85.7% | 60.9% |
| | | % of Total | 3.2% | 18.0% | 39.7% | 60.9% |
| Total | | Count | 68 | 102 | 147 | 317 |
| | | Expected Count | 68.0 | 102.0 | 147.0 | 317.0 |
| | | % within Q36 | 21.5% | 32.2% | 46.4% | 100.0% |
| | | % within Q45 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 21.5% | 32.2% | 46.4% | 100.0% |

| | | | Q46 - 46. How hard is it on your body due to bending while moving around furniture or other things in your home when cleaning | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q36 - 36. How physically hard is it for you to do housekeeping? | Not at all | Count | 71 | 47 | 6 | 124 |
| | | Expected Count | 32.5 | 44.2 | 47.3 | 124.0 |
| | | % within Q36 | 57.3% | 37.9% | 4.8% | 100.0% |
| | | % within Q46 | 85.5% | 41.6% | 5.0% | 39.1% |
| | | % of Total | 22.4% | 14.8% | 1.9% | 39.1% |
| | Slightly or more | Count | 12 | 66 | 115 | 193 |
| | | Expected Count | 50.5 | 68.8 | 73.7 | 193.0 |
| | | % within Q36 | 6.2% | 34.2% | 59.6% | 100.0% |
| | | % within Q46 | 14.5% | 58.4% | 95.0% | 60.9% |
| | | % of Total | 3.8% | 20.8% | 36.3% | 60.9% |
| Total | | Count | 83 | 113 | 121 | 317 |
| | | Expected Count | 83.0 | 113.0 | 121.0 | 317.0 |
| | | % within Q36 | 26.2% | 35.6% | 38.2% | 100.0% |
| | | % within Q46 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 26.2% | 35.6% | 38.2% | 100.0% |

Appendix D

Contingency Tables - Posture and Balance

| | | | Q3 - 3. How slippery is the shower (or bathtub) floor? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q1 - 1. How hard is it for you to bathe or shower? | Not at all | Count | 150 | 56 | 31 | 237 |
| | | Expected Count | 133.1 | 65.8 | 38.1 | 237.0 |
| | | % within Q1 | 63.3% | 23.6% | 13.1% | 100.0% |
| | | % within Q3 | 84.3% | 63.6% | 60.8% | 74.8% |
| | | % of Total | 47.3% | 17.7% | 9.8% | 74.8% |
| | Slightly or more | Count | 28 | 32 | 20 | 80 |
| | | Expected Count | 44.9 | 22.2 | 12.9 | 80.0 |
| | | % within Q1 | 35.0% | 40.0% | 25.0% | 100.0% |
| | | % within Q3 | 15.7% | 36.4% | 39.2% | 25.2% |
| | | % of Total | 8.8% | 10.1% | 6.3% | 25.2% |
| Total | | Count | 178 | 88 | 51 | 317 |
| | | Expected Count | 178.0 | 88.0 | 51.0 | 317.0 |
| | | % within Q1 | 56.2% | 27.8% | 16.1% | 100.0% |
| | | % within Q3 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 56.2% | 27.8% | 16.1% | 100.0% |

| | | | Q3 - 3. How slippery is the shower (or bathtub) floor? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q80 - 80. What level of difficulty do you have in walking or maintaining balance? | Not at all | Count | 98 | 30 | 16 | 144 |
| | | Expected Count | 80.9 | 40.0 | 23.2 | 144.0 |
| | | % within Q80 | 68.1% | 20.8% | 11.1% | 100.0% |
| | | % within Q3 | 55.1% | 34.1% | 31.4% | 45.4% |
| | | % of Total | 30.9% | 9.5% | 5.0% | 45.4% |
| | Slightly | Count | 56 | 31 | 17 | 104 |
| | | Expected Count | 58.4 | 28.9 | 16.7 | 104.0 |
| | | % within Q80 | 53.8% | 29.8% | 16.3% | 100.0% |
| | | % within Q3 | 31.5% | 35.2% | 33.3% | 32.8% |
| | | % of Total | 17.7% | 9.8% | 5.4% | 32.8% |
| | Moderately or more | Count | 24 | 27 | 18 | 69 |
| | | Expected Count | 38.7 | 19.2 | 11.1 | 69.0 |
| | | % within Q80 | 34.8% | 39.1% | 26.1% | 100.0% |
| | | % within Q3 | 13.5% | 30.7% | 35.3% | 21.8% |
| | | % of Total | 7.6% | 8.5% | 5.7% | 21.8% |
| Total | | Count | 178 | 88 | 51 | 317 |
| | | Expected Count | 178.0 | 88.0 | 51.0 | 317.0 |
| | | % within Q80 | 56.2% | 27.8% | 16.1% | 100.0% |
| | | % within Q3 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 56.2% | 27.8% | 16.1% | 100.0% |

| | | | Q4 - 4. Do you think the handles in your bathroom are properly located for you to hold to help maintain your balance? | | | | |
|---|---|---|---|---|---|---|---|
| | | | No grad handles in my shower or bathtub area | Disagree | Neutral | Agree | Total |
| Q1 - 1. How hard is it for you to bathe or shower? | Not at all | Count | 92 | 13 | 27 | 105 | 237 |
| | | Expected Count | 86.0 | 17.9 | 26.2 | 106.9 | 237.0 |
| | | % within Q1 | 38.8% | 5.5% | 11.4% | 44.3% | 100.0% |
| | | % within Q4 | 80.0% | 54.2% | 77.1% | 73.4% | 74.8% |
| | | % of Total | 29.0% | 4.1% | 8.5% | 33.1% | 74.8% |
| | Slightly or more | Count | 23 | 11 | 8 | 38 | 80 |
| | | Expected Count | 29.0 | 6.1 | 8.8 | 36.1 | 80.0 |
| | | % within Q1 | 28.7% | 13.8% | 10.0% | 47.5% | 100.0% |
| | | % within Q4 | 20.0% | 45.8% | 22.9% | 26.6% | 25.2% |
| | | % of Total | 7.3% | 3.5% | 2.5% | 12.0% | 25.2% |
| Total | | Count | 115 | 24 | 35 | 143 | 317 |
| | | Expected Count | 115.0 | 24.0 | 35.0 | 143.0 | 317.0 |
| | | % within Q1 | 36.3% | 7.6% | 11.0% | 45.1% | 100.0% |
| | | % within Q4 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 36.3% | 7.6% | 11.0% | 45.1% | 100.0% |

Appendix E

Contingency Tables - Whole Body Strength

| | | | Q25 - In general, how difficult is it to handle the weights of pots when cooking or serving meals? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 153 | 56 | 13 | 222 |
| | | Expected Count | 119.8 | 61.6 | 40.6 | 222.0 |
| | | % within Q16 | 68.9% | 25.2% | 5.9% | 100.0% |
| | | % within Q25 | 89.5% | 63.6% | 22.4% | 70.0% |
| | | % of Total | 48.3% | 17.7% | 4.1% | 70.0% |
| | Slightly | Count | 12 | 25 | 19 | 56 |
| | | Expected Count | 30.2 | 15.5 | 10.2 | 56.0 |
| | | % within Q16 | 21.4% | 44.6% | 33.9% | 100.0% |
| | | % within Q25 | 7.0% | 28.4% | 32.8% | 17.7% |
| | | % of Total | 3.8% | 7.9% | 6.0% | 17.7% |
| | Moderately or more | Count | 6 | 7 | 26 | 39 |
| | | Expected Count | 21.0 | 10.8 | 7.1 | 39.0 |
| | | % within Q16 | 15.4% | 17.9% | 66.7% | 100.0% |
| | | % within Q25 | 3.5% | 8.0% | 44.8% | 12.3% |
| | | % of Total | 1.9% | 2.2% | 8.2% | 12.3% |
| Total | | Count | 171 | 88 | 58 | 317 |
| | | Expected Count | 171.0 | 88.0 | 58.0 | 317.0 |
| | | % within Q16 | 53.9% | 27.8% | 18.3% | 100.0% |
| | | % within Q25 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 53.9% | 27.8% | 18.3% | 100.0% |

| | | | Q29 - 29. How hard is it for you to open the kitchen cabinets (because of hand strength)? | | |
|---|---|---|---|---|---|
| | | | Not at all | Slightly or more | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 215 | 7 | 222 |
| | | Expected Count | 198.2 | 23.8 | 222.0 |
| | | % within Q16 | 96.8% | 3.2% | 100.0% |
| | | % within Q29 | 76.0% | 20.6% | 70.0% |
| | | % of Total | 67.8% | 2.2% | 70.0% |
| | Slightly or more | Count | 68 | 27 | 95 |
| | | Expected Count | 84.8 | 10.2 | 95.0 |
| | | % within Q16 | 71.6% | 28.4% | 100.0% |
| | | % within Q29 | 24.0% | 79.4% | 30.0% |
| | | % of Total | 21.5% | 8.5% | 30.0% |
| Total | | Count | 283 | 34 | 317 |
| | | Expected Count | 283.0 | 34.0 | 317.0 |
| | | % within Q16 | 89.3% | 10.7% | 100.0% |
| | | % within Q29 | 100.0% | 100.0% | 100.0% |
| | | % of Total | 89.3% | 10.7% | 100.0% |

| | | | Q30 - 30. How hard is it for you to open the refrigerator door (because of hand strength)? | | |
|---|---|---|---|---|---|
| | | | Not at all | Slightly or more | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 212 | 10 | 222 |
| | | Expected Count | 199.6 | 22.4 | 222.0 |
| | | % within Q16 | 95.5% | 4.5% | 100.0% |
| | | % within Q30 | 74.4% | 31.3% | 70.0% |
| | | % of Total | 66.9% | 3.2% | 70.0% |
| | Slightly or more | Count | 73 | 22 | 95 |
| | | Expected Count | 85.4 | 9.6 | 95.0 |
| | | % within Q16 | 76.8% | 23.2% | 100.0% |
| | | % within Q30 | 25.6% | 68.8% | 30.0% |
| | | % of Total | 23.0% | 6.9% | 30.0% |
| Total | | Count | 285 | 32 | 317 |
| | | Expected Count | 285.0 | 32.0 | 317.0 |
| | | % within Q16 | 89.9% | 10.1% | 100.0% |
| | | % within Q30 | 100.0% | 100.0% | 100.0% |
| | | % of Total | 89.9% | 10.1% | 100.0% |

| | | | Q43 - 43. How heavy is it to lift or move around the cleaning equipment you use in your residence? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q36 - 36. How physically hard is it for you to do housekeeping? | Not at all | Count | 106 | 18 | 0 | 124 |
| | | Expected Count | 57.5 | 39.5 | 27.0 | 124.0 |
| | | % within Q36 | 85.5% | 14.5% | 0.0% | 100.0% |
| | | % within Q43 | 72.1% | 17.8% | 0.0% | 39.1% |
| | | % of Total | 33.4% | 5.7% | 0.0% | 39.1% |
| | Slightly | Count | 37 | 63 | 21 | 121 |
| | | Expected Count | 56.1 | 38.6 | 26.3 | 121.0 |
| | | % within Q36 | 30.6% | 52.1% | 17.4% | 100.0% |
| | | % within Q43 | 25.2% | 62.4% | 30.4% | 38.2% |
| | | % of Total | 11.7% | 19.9% | 6.6% | 38.2% |
| | Moderately or more | Count | 4 | 20 | 48 | 72 |
| | | Expected Count | 33.4 | 22.9 | 15.7 | 72.0 |
| | | % within Q36 | 5.6% | 27.8% | 66.7% | 100.0% |
| | | % within Q43 | 2.7% | 19.8% | 69.6% | 22.7% |
| | | % of Total | 1.3% | 6.3% | 15.1% | 22.7% |
| Total | | Count | 147 | 101 | 69 | 317 |
| | | Expected Count | 147.0 | 101.0 | 69.0 | 317.0 |
| | | % within Q36 | 46.4% | 31.9% | 21.8% | 100.0% |
| | | % within Q43 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 46.4% | 31.9% | 21.8% | 100.0% |

| | | | Q44 - 44. How hard is it for you to handle cleaning equipment due to its size? | | | | |
|---|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately | Very or extremely | Total |
| Q36 - 36. How physically hard is it for you to do housekeeping? | Not at all | Count | 103 | 20 | 1 | 0 | 124 |
| | | Expected Count | 65.3 | 37.2 | 12.1 | 9.4 | 124.0 |
| | | % within Q36 | 83.1% | 16.1% | 0.8% | 0.0% | 100.0% |
| | | % within Q44 | 61.7% | 21.1% | 3.2% | 0.0% | 39.1% |
| | | % of Total | 32.5% | 6.3% | 0.3% | 0.0% | 39.1% |
| | Slightly | Count | 55 | 52 | 12 | 2 | 121 |
| | | Expected Count | 63.7 | 36.3 | 11.8 | 9.2 | 121.0 |
| | | % within Q36 | 45.5% | 43.0% | 9.9% | 1.7% | 100.0% |
| | | % within Q44 | 32.9% | 54.7% | 38.7% | 8.3% | 38.2% |
| | | % of Total | 17.4% | 16.4% | 3.8% | 0.6% | 38.2% |
| | Moderately or more | Count | 9 | 23 | 18 | 22 | 72 |
| | | Expected Count | 37.9 | 21.6 | 7.0 | 5.5 | 72.0 |
| | | % within Q36 | 12.5% | 31.9% | 25.0% | 30.6% | 100.0% |
| | | % within Q44 | 5.4% | 24.2% | 58.1% | 91.7% | 22.7% |
| | | % of Total | 2.8% | 7.3% | 5.7% | 6.9% | 22.7% |
| Total | | Count | 167 | 95 | 31 | 24 | 317 |
| | | Expected Count | 167.0 | 95.0 | 31.0 | 24.0 | 317.0 |
| | | % within Q36 | 52.7% | 30.0% | 9.8% | 7.6% | 100.0% |
| | | % within Q44 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 52.7% | 30.0% | 9.8% | 7.6% | 100.0% |

Appendix F

Contingency Tables - Segmental Strength

| | | | Q5 - 5. How painful or uncomfortable is it for you to turn the faucet on and off? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 178 | 9 | 4 | 191 |
| | | Expected Count | 162.7 | 19.9 | 8.4 | 191.0 |
| | | % within Q82 | 93.2% | 4.7% | 2.1% | 100.0% |
| | | % within Q5 | 65.9% | 27.3% | 28.6% | 60.3% |
| | | % of Total | 56.2% | 2.8% | 1.3% | 60.3% |
| | Slightly or more | Count | 92 | 24 | 10 | 126 |
| | | Expected Count | 107.3 | 13.1 | 5.6 | 126.0 |
| | | % within Q82 | 73.0% | 19.0% | 7.9% | 100.0% |
| | | % within Q5 | 34.1% | 72.7% | 71.4% | 39.7% |
| | | % of Total | 29.0% | 7.6% | 3.2% | 39.7% |
| Total | | Count | 270 | 33 | 14 | 317 |
| | | Expected Count | 270.0 | 33.0 | 14.0 | 317.0 |
| | | % within Q82 | 85.2% | 10.4% | 4.4% | 100.0% |
| | | % within Q5 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 85.2% | 10.4% | 4.4% | 100.0% |

| | | | Q17 - 17. How hard is it for you to open food jars with your hands alone (not with tools or opening aids)? | | | | |
|---|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately | Very or extremely | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | None | Count | 75 | 68 | 34 | 14 | 191 |
| | | Expected Count | 48.8 | 69.3 | 38.6 | 34.3 | 191.0 |
| | | % within Q82 | 39.3% | 35.6% | 17.8% | 7.3% | 100.0% |
| | | % within Q17 | 92.6% | 59.1% | 53.1% | 24.6% | 60.3% |
| | | % of Total | 23.7% | 21.5% | 10.7% | 4.4% | 60.3% |
| | Slight | Count | 5 | 42 | 24 | 19 | 90 |
| | | Expected Count | 23.0 | 32.6 | 18.2 | 16.2 | 90.0 |
| | | % within Q82 | 5.6% | 46.7% | 26.7% | 21.1% | 100.0% |
| | | % within Q17 | 6.2% | 36.5% | 37.5% | 33.3% | 28.4% |
| | | % of Total | 1.6% | 13.2% | 7.6% | 6.0% | 28.4% |
| | Moderate or more | Count | 1 | 5 | 6 | 24 | 36 |
| | | Expected Count | 9.2 | 13.1 | 7.3 | 6.5 | 36.0 |
| | | % within Q82 | 2.8% | 13.9% | 16.7% | 66.7% | 100.0% |
| | | % within Q17 | 1.2% | 4.3% | 9.4% | 42.1% | 11.4% |
| | | % of Total | 0.3% | 1.6% | 1.9% | 7.6% | 11.4% |
| Total | | Count | 81 | 115 | 64 | 57 | 317 |
| | | Expected Count | 81.0 | 115.0 | 64.0 | 57.0 | 317.0 |
| | | % within Q82 | 25.6% | 36.3% | 20.2% | 18.0% | 100.0% |
| | | % within Q17 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 25.6% | 36.3% | 20.2% | 18.0% | 100.0% |

| | | | Q21 - 21. How often do you find new jar lids (that have never opened before) difficult to open? | | | | |
|---|---|---|---|---|---|---|---|
| | | | Never or seldom | Sometimes | Often | Very often | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | None | Count | 57 | 92 | 28 | 14 | 191 |
| | | Expected Count | 42.8 | 78.9 | 42.2 | 27.1 | 191.0 |
| | | % within Q82 | 29.8% | 48.2% | 14.7% | 7.3% | 100.0% |
| | | % within Q21 | 80.3% | 70.2% | 40.0% | 31.1% | 60.3% |
| | | % of Total | 18.0% | 29.0% | 8.8% | 4.4% | 60.3% |
| | Slight | Count | 12 | 33 | 30 | 15 | 90 |
| | | Expected Count | 20.2 | 37.2 | 19.9 | 12.8 | 90.0 |
| | | % within Q82 | 13.3% | 36.7% | 33.3% | 16.7% | 100.0% |
| | | % within Q21 | 16.9% | 25.2% | 42.9% | 33.3% | 28.4% |
| | | % of Total | 3.8% | 10.4% | 9.5% | 4.7% | 28.4% |
| | Moderate or more | Count | 2 | 6 | 12 | 16 | 36 |
| | | Expected Count | 8.1 | 14.9 | 7.9 | 5.1 | 36.0 |
| | | % within Q82 | 5.6% | 16.7% | 33.3% | 44.4% | 100.0% |
| | | % within Q21 | 2.8% | 4.6% | 17.1% | 35.6% | 11.4% |
| | | % of Total | 0.6% | 1.9% | 3.8% | 5.0% | 11.4% |
| Total | | Count | 71 | 131 | 70 | 45 | 317 |
| | | Expected Count | 71.0 | 131.0 | 70.0 | 45.0 | 317.0 |
| | | % within Q82 | 22.4% | 41.3% | 22.1% | 14.2% | 100.0% |
| | | % within Q21 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 22.4% | 41.3% | 22.1% | 14.2% | 100.0% |

| | | | Q22 - 22. How often do you find used jar lids (that have been opened) difficult to open or tighten? | | | |
|---|---|---|---|---|---|---|
| | | | Never | Seldom | Sometimes or often | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | None | Count | 70 | 85 | 36 | 191 |
| | | Expected Count | 51.8 | 74.7 | 64.5 | 191.0 |
| | | % within Q82 | 36.6% | 44.5% | 18.8% | 100.0% |
| | | % within Q22 | 81.4% | 68.5% | 33.6% | 60.3% |
| | | % of Total | 22.1% | 26.8% | 11.4% | 60.3% |
| | Slight | Count | 13 | 32 | 45 | 90 |
| | | Expected Count | 24.4 | 35.2 | 30.4 | 90.0 |
| | | % within Q82 | 14.4% | 35.6% | 50.0% | 100.0% |
| | | % within Q22 | 15.1% | 25.8% | 42.1% | 28.4% |
| | | % of Total | 4.1% | 10.1% | 14.2% | 28.4% |
| | Moderate or more | Count | 3 | 7 | 26 | 36 |
| | | Expected Count | 9.8 | 14.1 | 12.2 | 36.0 |
| | | % within Q82 | 8.3% | 19.4% | 72.2% | 100.0% |
| | | % within Q22 | 3.5% | 5.6% | 24.3% | 11.4% |
| | | % of Total | 0.9% | 2.2% | 8.2% | 11.4% |
| Total | | Count | 86 | 124 | 107 | 317 |
| | | Expected Count | 86.0 | 124.0 | 107.0 | 317.0 |
| | | % within Q82 | 27.1% | 39.1% | 33.8% | 100.0% |
| | | % within Q22 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 27.1% | 39.1% | 33.8% | 100.0% |

| | | | Q48 - 48. How hard is it to grip a medicine bottle and turn its cap for opening? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 151 | 32 | 8 | 191 |
| | | Expected Count | 121.7 | 48.2 | 21.1 | 191.0 |
| | | % within Q82 | 79.1% | 16.8% | 4.2% | 100.0% |
| | | % within Q48 | 74.8% | 40.0% | 22.9% | 60.3% |
| | | % of Total | 47.6% | 10.1% | 2.5% | 60.3% |
| | Slightly or more | Count | 51 | 48 | 27 | 126 |
| | | Expected Count | 80.3 | 31.8 | 13.9 | 126.0 |
| | | % within Q82 | 40.5% | 38.1% | 21.4% | 100.0% |
| | | % within Q48 | 25.2% | 60.0% | 77.1% | 39.7% |
| | | % of Total | 16.1% | 15.1% | 8.5% | 39.7% |
| Total | | Count | 202 | 80 | 35 | 317 |
| | | Expected Count | 202.0 | 80.0 | 35.0 | 317.0 |
| | | % within Q82 | 63.7% | 25.2% | 11.0% | 100.0% |
| | | % within Q48 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 63.7% | 25.2% | 11.0% | 100.0% |

| | | | Q49 - 49. How hard is it to grip a medicine bottle and turn its cap for closing? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 173 | 14 | 4 | 191 |
| | | Expected Count | 144.0 | 34.3 | 12.7 | 191.0 |
| | | % within Q82 | 90.6% | 7.3% | 2.1% | 100.0% |
| | | % within Q49 | 72.4% | 24.6% | 19.0% | 60.3% |
| | | % of Total | 54.6% | 4.4% | 1.3% | 60.3% |
| | Slightly or more | Count | 66 | 43 | 17 | 126 |
| | | Expected Count | 95.0 | 22.7 | 8.3 | 126.0 |
| | | % within Q82 | 52.4% | 34.1% | 13.5% | 100.0% |
| | | % within Q49 | 27.6% | 75.4% | 81.0% | 39.7% |
| | | % of Total | 20.8% | 13.6% | 5.4% | 39.7% |
| Total | | Count | 239 | 57 | 21 | 317 |
| | | Expected Count | 239.0 | 57.0 | 21.0 | 317.0 |
| | | % within Q82 | 75.4% | 18.0% | 6.6% | 100.0% |
| | | % within Q49 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 75.4% | 18.0% | 6.6% | 100.0% |

Appendix G

Contingency Tables - Physiological Endurance

| | | | Q57 - 57. How sharply do you bend your neck or raise shoulders/arms when using a computer? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q56 - 56. What level of pain do you experience in your neck, shoulders, or arms when/after using a computer? | None | Count | 106 | 40 | 2 | 148 |
| | | Expected Count | 67.3 | 63.1 | 17.6 | 148.0 |
| | | % within Q56 | 71.6% | 27.0% | 1.4% | 100.0% |
| | | % within Q57 | 81.5% | 32.8% | 5.9% | 51.7% |
| | | % of Total | 37.1% | 14.0% | 0.7% | 51.7% |
| | Slight | Count | 23 | 66 | 5 | 94 |
| | | Expected Count | 42.7 | 40.1 | 11.2 | 94.0 |
| | | % within Q56 | 24.5% | 70.2% | 5.3% | 100.0% |
| | | % within Q57 | 17.7% | 54.1% | 14.7% | 32.9% |
| | | % of Total | 8.0% | 23.1% | 1.7% | 32.9% |
| | Moderate or more | Count | 1 | 16 | 27 | 44 |
| | | Expected Count | 20.0 | 18.8 | 5.2 | 44.0 |
| | | % within Q56 | 2.3% | 36.4% | 61.4% | 100.0% |
| | | % within Q57 | 0.8% | 13.1% | 79.4% | 15.4% |
| | | % of Total | 0.3% | 5.6% | 9.4% | 15.4% |
| Total | | Count | 130 | 122 | 34 | 286 |
| | | Expected Count | 130.0 | 122.0 | 34.0 | 286.0 |
| | | % within Q56 | 45.5% | 42.7% | 11.9% | 100.0% |
| | | % within Q57 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 45.5% | 42.7% | 11.9% | 100.0% |

| | | | Q59 - 59. How often do you sit on an adjustable chair when using a computer? | | | |
|---|---|---|---|---|---|---|
| | | | Never or seldom | Sometimes | Often or very often | Total |
| Q58 - 58. How often do you experience pain in your legs when/after using a computer? | Never or seldom | Count | 134 | 21 | 81 | 236 |
| | | Expected Count | 128.7 | 24.8 | 82.5 | 236.0 |
| | | % within Q58 | 56.8% | 8.9% | 34.3% | 100.0% |
| | | % within Q59 | 85.9% | 70.0% | 81.0% | 82.5% |
| | | % of Total | 46.9% | 7.3% | 28.3% | 82.5% |
| | Sometimes or more | Count | 22 | 9 | 19 | 50 |
| | | Expected Count | 27.3 | 5.2 | 17.5 | 50.0 |
| | | % within Q58 | 44.0% | 18.0% | 38.0% | 100.0% |
| | | % within Q59 | 14.1% | 30.0% | 19.0% | 17.5% |
| | | % of Total | 7.7% | 3.1% | 6.6% | 17.5% |
| Total | | Count | 156 | 30 | 100 | 286 |
| | | Expected Count | 156.0 | 30.0 | 100.0 | 286.0 |
| | | % within Q58 | 54.5% | 10.5% | 35.0% | 100.0% |
| | | % within Q59 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 54.5% | 10.5% | 35.0% | 100.0% |

| | | | Q61 - 61. How hard is it for you to use a keyboard or a mouse? | | |
|---|---|---|---|---|---|
| | | | Not at all | Slightly or more | Total |
| Q60 - 60. How often do you experience pain in your fingers when/after using a computer? | Never or seldom | Count | 207 | 22 | 229 |
| | | Expected Count | 186.6 | 42.4 | 229.0 |
| | | % within Q60 | 90.4% | 9.6% | 100.0% |
| | | % within Q61 | 88.8% | 41.5% | 80.1% |
| | | % of Total | 72.4% | 7.7% | 80.1% |
| | Sometimes or more | Count | 26 | 31 | 57 |
| | | Expected Count | 46.4 | 10.6 | 57.0 |
| | | % within Q60 | 45.6% | 54.4% | 100.0% |
| | | % within Q61 | 11.2% | 58.5% | 19.9% |
| | | % of Total | 9.1% | 10.8% | 19.9% |
| Total | | Count | 233 | 53 | 286 |
| | | Expected Count | 233.0 | 53.0 | 286.0 |
| | | % within Q60 | 81.5% | 18.5% | 100.0% |
| | | % within Q61 | 100.0% | 100.0% | 100.0% |
| | | % of Total | 81.5% | 18.5% | 100.0% |

| | | | Q60 - 60. How often do you experience pain in your fingers when/after using a computer? | | | |
|---|---|---|---|---|---|---|
| | | | Never or seldom | Sometimes | Often or very often | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 162 | 10 | 1 | 173 |
| | | Expected Count | 138.5 | 25.4 | 9.1 | 173.0 |
| | | % within Q82 | 93.6% | 5.8% | 0.6% | 100.0% |
| | | % within Q60 | 70.7% | 23.8% | 6.7% | 60.5% |
| | | % of Total | 56.6% | 3.5% | 0.3% | 60.5% |
| | Slightly or more | Count | 67 | 32 | 14 | 113 |
| | | Expected Count | 90.5 | 16.6 | 5.9 | 113.0 |
| | | % within Q82 | 59.3% | 28.3% | 12.4% | 100.0% |
| | | % within Q60 | 29.3% | 76.2% | 93.3% | 39.5% |
| | | % of Total | 23.4% | 11.2% | 4.9% | 39.5% |
| Total | | Count | 229 | 42 | 15 | 286 |
| | | Expected Count | 229.0 | 42.0 | 15.0 | 286.0 |
| | | % within Q82 | 80.1% | 14.7% | 5.2% | 100.0% |
| | | % within Q60 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 80.1% | 14.7% | 5.2% | 100.0% |

| | | | Q68 - 68. How often do you take pictures with your cellphone? | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Never | Seldom | Sometimes | Often | Very often | Total |
| Q71 - 71. How often do you bend your wrist sharply when using a cellphone? | Never | Count | 29 | 20 | 44 | 20 | 17 | 130 |
| | | Expected Count | 20.1 | 20.1 | 45.5 | 23.2 | 21.0 | 130.0 |
| | | % within Q71 | 22.3% | 15.4% | 33.8% | 15.4% | 13.1% | 100.0% |
| | | % within Q68 | 63.0% | 43.5% | 42.3% | 37.7% | 35.4% | 43.8% |
| | | % of Total | 9.8% | 6.7% | 14.8% | 6.7% | 5.7% | 43.8% |
| | Seldom | Count | 12 | 16 | 32 | 13 | 11 | 84 |
| | | Expected Count | 13.0 | 13.0 | 29.4 | 15.0 | 13.6 | 84.0 |
| | | % within Q71 | 14.3% | 19.0% | 38.1% | 15.5% | 13.1% | 100.0% |
| | | % within Q68 | 26.1% | 34.8% | 30.8% | 24.5% | 22.9% | 28.3% |
| | | % of Total | 4.0% | 5.4% | 10.8% | 4.4% | 3.7% | 28.3% |
| | Sometimes or more | Count | 5 | 10 | 28 | 20 | 20 | 83 |
| | | Expected Count | 12.9 | 12.9 | 29.1 | 14.8 | 13.4 | 83.0 |
| | | % within Q71 | 6.0% | 12.0% | 33.7% | 24.1% | 24.1% | 100.0% |
| | | % within Q68 | 10.9% | 21.7% | 26.9% | 37.7% | 41.7% | 27.9% |
| | | % of Total | 1.7% | 3.4% | 9.4% | 6.7% | 6.7% | 27.9% |
| Total | | Count | 46 | 46 | 104 | 53 | 48 | 297 |
| | | Expected Count | 46.0 | 46.0 | 104.0 | 53.0 | 48.0 | 297.0 |
| | | % within Q71 | 15.5% | 15.5% | 35.0% | 17.8% | 16.2% | 100.0% |
| | | % within Q68 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 15.5% | 15.5% | 35.0% | 17.8% | 16.2% | 100.0% |

Appendix H

Contingency Tables - Mobility

| | | | Q2 - 2. How often do you bend your neck, knees, or back because the bathroom faucet is too low? | | | |
|---|---|---|---|---|---|---|
| | | | Never or seldom | Sometimes | Often or very often | Total |
| Q1 - 1. How hard is it for you to bathe or shower? | Not at all | Count | 172 | 33 | 32 | 237 |
| | | Expected Count | 163.7 | 38.9 | 34.4 | 237.0 |
| | | % within Q1 | 72.6% | 13.9% | 13.5% | 100.0% |
| | | % within Q2 | 78.5% | 63.5% | 69.6% | 74.8% |
| | | % of Total | 54.3% | 10.4% | 10.1% | 74.8% |
| | Slightly or more | Count | 47 | 19 | 14 | 80 |
| | | Expected Count | 55.3 | 13.1 | 11.6 | 80.0 |
| | | % within Q1 | 58.8% | 23.8% | 17.5% | 100.0% |
| | | % within Q2 | 21.5% | 36.5% | 30.4% | 25.2% |
| | | % of Total | 14.8% | 6.0% | 4.4% | 25.2% |
| Total | | Count | 219 | 52 | 46 | 317 |
| | | Expected Count | 219.0 | 52.0 | 46.0 | 317.0 |
| | | % within Q1 | 69.1% | 16.4% | 14.5% | 100.0% |
| | | % within Q2 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 69.1% | 16.4% | 14.5% | 100.0% |

| | | | Q81 - 81. How often do you use wheelchairs, walker, cane or crutches to support your mobility? | | | |
|---|---|---|---|---|---|---|
| | | | Never or seldom | Sometimes | Often or very often | Total |
| Q7 - 7. How hard is it for you to get in or out of the tub or shower? | Not at all | Count | 176 | 3 | 5 | 184 |
| | | Expected Count | 154.4 | 12.8 | 16.8 | 184.0 |
| | | % within Q7 | 95.7% | 1.6% | 2.7% | 100.0% |
| | | % within Q81 | 66.2% | 13.6% | 17.2% | 58.0% |
| | | % of Total | 55.5% | 0.9% | 1.6% | 58.0% |
| | Slightly or more | Count | 90 | 19 | 24 | 133 |
| | | Expected Count | 111.6 | 9.2 | 12.2 | 133.0 |
| | | % within Q7 | 67.7% | 14.3% | 18.0% | 100.0% |
| | | % within Q81 | 33.8% | 86.4% | 82.8% | 42.0% |
| | | % of Total | 28.4% | 6.0% | 7.6% | 42.0% |
| Total | | Count | 266 | 22 | 29 | 317 |
| | | Expected Count | 266.0 | 22.0 | 29.0 | 317.0 |
| | | % within Q7 | 83.9% | 6.9% | 9.1% | 100.0% |
| | | % within Q81 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 83.9% | 6.9% | 9.1% | 100.0% |

| | | | Q1 - 1. How hard is it for you to bathe or shower? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q7 - 7. How hard is it for you to get in or out of the tub or shower? | Not at all | Count | 175 | 8 | 1 | 184 |
| | | Expected Count | 137.6 | 36.0 | 10.4 | 184.0 |
| | | % within Q7 | 95.1% | 4.3% | 0.5% | 100.0% |
| | | % within Q1 | 73.8% | 12.9% | 5.6% | 58.0% |
| | | % of Total | 55.2% | 2.5% | 0.3% | 58.0% |
| | Slightly or more | Count | 62 | 54 | 17 | 133 |
| | | Expected Count | 99.4 | 26.0 | 7.6 | 133.0 |
| | | % within Q7 | 46.6% | 40.6% | 12.8% | 100.0% |
| | | % within Q1 | 26.2% | 87.1% | 94.4% | 42.0% |
| | | % of Total | 19.6% | 17.0% | 5.4% | 42.0% |
| Total | | Count | 237 | 62 | 18 | 317 |
| | | Expected Count | 237.0 | 62.0 | 18.0 | 317.0 |
| | | % within Q7 | 74.8% | 19.6% | 5.7% | 100.0% |
| | | % within Q1 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 74.8% | 19.6% | 5.7% | 100.0% |

| | | | Q3 - 3. How slippery is the shower (or bathtub) floor? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q7 - 7. How hard is it for you to get in or out of the tub or shower? | Not at all | Count | 133 | 35 | 16 | 184 |
| | | Expected Count | 103.3 | 51.1 | 29.6 | 184.0 |
| | | % within Q7 | 72.3% | 19.0% | 8.7% | 100.0% |
| | | % within Q3 | 74.7% | 39.8% | 31.4% | 58.0% |
| | | % of Total | 42.0% | 11.0% | 5.0% | 58.0% |
| | Slightly | Count | 39 | 35 | 14 | 88 |
| | | Expected Count | 49.4 | 24.4 | 14.2 | 88.0 |
| | | % within Q7 | 44.3% | 39.8% | 15.9% | 100.0% |
| | | % within Q3 | 21.9% | 39.8% | 27.5% | 27.8% |
| | | % of Total | 12.3% | 11.0% | 4.4% | 27.8% |
| | Moderately or more | Count | 6 | 18 | 21 | 45 |
| | | Expected Count | 25.3 | 12.5 | 7.2 | 45.0 |
| | | % within Q7 | 13.3% | 40.0% | 46.7% | 100.0% |
| | | % within Q3 | 3.4% | 20.5% | 41.2% | 14.2% |
| | | % of Total | 1.9% | 5.7% | 6.6% | 14.2% |
| Total | | Count | 178 | 88 | 51 | 317 |
| | | Expected Count | 178.0 | 88.0 | 51.0 | 317.0 |
| | | % within Q7 | 56.2% | 27.8% | 16.1% | 100.0% |
| | | % within Q3 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 56.2% | 27.8% | 16.1% | 100.0% |

| | | | Q4 - 4. Do you think the handles in your bathroom are properly located for you to hold to help maintain your balance? | | | | |
|---|---|---|---|---|---|---|---|
| | | | No grab handles in my shower or bathtub area | Disagree | Neutral | Agree | Total |
| Q7 - 7. How hard is it for you to get in or out of the tub or shower? | Not at all | Count | 72 | 7 | 18 | 87 | 184 |
| | | Expected Count | 66.8 | 13.9 | 20.3 | 83.0 | 184.0 |
| | | % within Q7 | 39.1% | 3.8% | 9.8% | 47.3% | 100.0% |
| | | % within Q4 | 62.6% | 29.2% | 51.4% | 60.8% | 58.0% |
| | | % of Total | 22.7% | 2.2% | 5.7% | 27.4% | 58.0% |
| | Slightly or more | Count | 43 | 17 | 17 | 56 | 133 |
| | | Expected Count | 48.2 | 10.1 | 14.7 | 60.0 | 133.0 |
| | | % within Q7 | 32.3% | 12.8% | 12.8% | 42.1% | 100.0% |
| | | % within Q4 | 37.4% | 70.8% | 48.6% | 39.2% | 42.0% |
| | | % of Total | 13.6% | 5.4% | 5.4% | 17.7% | 42.0% |
| Total | | Count | 115 | 24 | 35 | 143 | 317 |
| | | Expected Count | 115.0 | 24.0 | 35.0 | 143.0 | 317.0 |
| | | % within Q7 | 36.3% | 7.6% | 11.0% | 45.1% | 100.0% |
| | | % within Q4 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 36.3% | 7.6% | 11.0% | 45.1% | 100.0% |

| | | | Q11 - 11. How hard is it for you to move your arms while dressing? | | |
|---|---|---|---|---|---|
| | | | Not at all | Slightly or more | Total |
| Q10 - 10. How hard is it for you to bend your neck, knees, or back (upper body) while dressing? | Not at all | Count | 166 | 4 | 170 |
| | | Expected Count | 129.2 | 40.8 | 170.0 |
| | | % within Q10 | 97.6% | 2.4% | 100.0% |
| | | % within Q11 | 68.9% | 5.3% | 53.6% |
| | | % of Total | 52.4% | 1.3% | 53.6% |
| | Slightly | Count | 61 | 50 | 111 |
| | | Expected Count | 84.4 | 26.6 | 111.0 |
| | | % within Q10 | 55.0% | 45.0% | 100.0% |
| | | % within Q11 | 25.3% | 65.8% | 35.0% |
| | | % of Total | 19.2% | 15.8% | 35.0% |
| | Moderately or more | Count | 14 | 22 | 36 |
| | | Expected Count | 27.4 | 8.6 | 36.0 |
| | | % within Q10 | 38.9% | 61.1% | 100.0% |
| | | % within Q11 | 5.8% | 28.9% | 11.4% |
| | | % of Total | 4.4% | 6.9% | 11.4% |
| Total | | Count | 241 | 76 | 317 |
| | | Expected Count | 241.0 | 76.0 | 317.0 |
| | | % within Q10 | 76.0% | 24.0% | 100.0% |
| | | % within Q11 | 100.0% | 100.0% | 100.0% |
| | | % of Total | 76.0% | 24.0% | 100.0% |

| | | | Q39 - 39. How hard is it for you to bend your body downward to perform housekeeping such as vacuuming and mopping floors | | | | |
|---|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately | Very or extremely | Total |
| Q36 - 36. How physically hard is it for you to do housekeeping? | Not at all | Count | 109 | 14 | 1 | 0 | 124 |
| | | Expected Count | 55.9 | 37.2 | 16.8 | 14.1 | 124.0 |
| | | % within Q36 | 87.9% | 11.3% | 0.8% | 0.0% | 100.0% |
| | | % within Q39 | 76.2% | 14.7% | 2.3% | 0.0% | 39.1% |
| | | % of Total | 34.4% | 4.4% | 0.3% | 0.0% | 39.1% |
| | Slightly | Count | 31 | 65 | 17 | 8 | 121 |
| | | Expected Count | 54.6 | 36.3 | 16.4 | 13.7 | 121.0 |
| | | % within Q36 | 25.6% | 53.7% | 14.0% | 6.6% | 100.0% |
| | | % within Q39 | 21.7% | 68.4% | 39.5% | 22.2% | 38.2% |
| | | % of Total | 9.8% | 20.5% | 5.4% | 2.5% | 38.2% |
| | Moderately or more | Count | 3 | 16 | 25 | 28 | 72 |
| | | Expected Count | 32.5 | 21.6 | 9.8 | 8.2 | 72.0 |
| | | % within Q36 | 4.2% | 22.2% | 34.7% | 38.9% | 100.0% |
| | | % within Q39 | 2.1% | 16.8% | 58.1% | 77.8% | 22.7% |
| | | % of Total | 0.9% | 5.0% | 7.9% | 8.8% | 22.7% |
| Total | | Count | 143 | 95 | 43 | 36 | 317 |
| | | Expected Count | 143.0 | 95.0 | 43.0 | 36.0 | 317.0 |
| | | % within Q36 | 45.1% | 30.0% | 13.6% | 11.4% | 100.0% |
| | | % within Q39 s | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 45.1% | 30.0% | 13.6% | 11.4% | 100.0% |

| | | | Q41 - 41. How hard is it for you to reach forward or sideways to perform housekeeping such as picking up or moving thing | | | | |
|---|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately | Very or extremely | Total |
| Q36 - 36. How physically hard is it for you to do housekeeping? | Not at all | Count | 114 | 10 | 0 | 0 | 124 |
| | | Expected Count | 66.5 | 35.6 | 12.9 | 9.0 | 124.0 |
| | | % within Q36 | 91.9% | 8.1% | 0.0% | 0.0% | 100.0% |
| | | % within Q41 | 67.1% | 11.0% | 0.0% | 0.0% | 39.1% |
| | | % of Total | 36.0% | 3.2% | 0.0% | 0.0% | 39.1% |
| | Slightly | Count | 51 | 56 | 11 | 3 | 121 |
| | | Expected Count | 64.9 | 34.7 | 12.6 | 8.8 | 121.0 |
| | | % within Q36 | 42.1% | 46.3% | 9.1% | 2.5% | 100.0% |
| | | % within Q41 | 30.0% | 61.5% | 33.3% | 13.0% | 38.2% |
| | | % of Total | 16.1% | 17.7% | 3.5% | 0.9% | 38.2% |
| | Moderately or more | Count | 5 | 25 | 22 | 20 | 72 |
| | | Expected Count | 38.6 | 20.7 | 7.5 | 5.2 | 72.0 |
| | | % within Q36 | 6.9% | 34.7% | 30.6% | 27.8% | 100.0% |
| | | % within Q41 | 2.9% | 27.5% | 66.7% | 87.0% | 22.7% |
| | | % of Total | 1.6% | 7.9% | 6.9% | 6.3% | 22.7% |
| Total | | Count | 170 | 91 | 33 | 23 | 317 |
| | | Expected Count | 170.0 | 91.0 | 33.0 | 23.0 | 317.0 |
| | | % within Q36 | 53.6% | 28.7% | 10.4% | 7.3% | 100.0% |
| | | % within Q41 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 53.6% | 28.7% | 10.4% | 7.3% | 100.0% |

# Appendix I

## Contingency Tables – Tactile Tasks

| | | | Q17 - 17. How hard is it for you to open food jars with your hands alone (not with tools or opening aids)? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q19 - 19. How slippery do you find jar lids when trying to open or close them? | Not at all | Count | 51 | 35 | 22 | 108 |
| | | Expected Count | 27.6 | 39.2 | 41.2 | 108.0 |
| | | % within Q19 | 47.2% | 32.4% | 20.4% | 100.0% |
| | | % within Q17 | 63.0% | 30.4% | 18.2% | 34.1% |
| | | % of Total | 16.1% | 11.0% | 6.9% | 34.1% |
| | Slightly | Count | 25 | 58 | 38 | 121 |
| | | Expected Count | 30.9 | 43.9 | 46.2 | 121.0 |
| | | % within Q19 | 20.7% | 47.9% | 31.4% | 100.0% |
| | | % within Q17 | 30.9% | 50.4% | 31.4% | 38.2% |
| | | % of Total | 7.9% | 18.3% | 12.0% | 38.2% |
| | Moderately | Count | 5 | 21 | 38 | 64 |
| | | Expected Count | 16.4 | 23.2 | 24.4 | 64.0 |
| | | % within Q19 | 7.8% | 32.8% | 59.4% | 100.0% |
| | | % within Q17 | 6.2% | 18.3% | 31.4% | 20.2% |
| | | % of Total | 1.6% | 6.6% | 12.0% | 20.2% |
| | Very or Extremely | Count | 0 | 1 | 23 | 24 |
| | | Expected Count | 6.1 | 8.7 | 9.2 | 24.0 |
| | | % within Q19 | 0.0% | 4.2% | 95.8% | 100.0% |
| | | % within Q17 | 0.0% | 0.9% | 19.0% | 7.6% |
| | | % of Total | 0.0% | 0.3% | 7.3% | 7.6% |
| Total | | Count | 81 | 115 | 121 | 317 |
| | | Expected Count | 81.0 | 115.0 | 121.0 | 317.0 |
| | | % within Q19 | 25.6% | 36.3% | 38.2% | 100.0% |
| | | % within Q17 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 25.6% | 36.3% | 38.2% | 100.0% |

| | | | Q18 - 18. How do you consider the size of the most jar lids for you to grip and turn? | | | |
|---|---|---|---|---|---|---|
| | | | Small or too small | Just right | Large or too large | Total |
| Q19 - 19. How slippery do you find jar lids when trying to open or close them? | Not at all | Count | 7 | 93 | 8 | 108 |
| | | Expected Count | 11.6 | 64.1 | 32.4 | 108.0 |
| | | % within Q19 | 6.5% | 86.1% | 7.4% | 100.0% |
| | | % within Q18 | 20.6% | 49.5% | 8.4% | 34.1% |
| | | % of Total | 2.2% | 29.3% | 2.5% | 34.1% |
| | Slightly | Count | 12 | 71 | 38 | 121 |
| | | Expected Count | 13.0 | 71.8 | 36.3 | 121.0 |
| | | % within Q19 | 9.9% | 58.7% | 31.4% | 100.0% |
| | | % within Q18 | 35.3% | 37.8% | 40.0% | 38.2% |
| | | % of Total | 3.8% | 22.4% | 12.0% | 38.2% |
| | Moderately or more | Count | 15 | 24 | 49 | 88 |
| | | Expected Count | 9.4 | 52.2 | 26.4 | 88.0 |
| | | % within Q19 | 17.0% | 27.3% | 55.7% | 100.0% |
| | | % within Q18 | 44.1% | 12.8% | 51.6% | 27.8% |
| | | % of Total | 4.7% | 7.6% | 15.5% | 27.8% |
| Total | | Count | 34 | 188 | 95 | 317 |
| | | Expected Count | 34.0 | 188.0 | 95.0 | 317.0 |
| | | % within Q19 | 10.7% | 59.3% | 30.0% | 100.0% |
| | | % within Q18 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 10.7% | 59.3% | 30.0% | 100.0% |

| | | | Q73 - 73. How small does your cellphone feel when holding and using it? | | | |
|---|---|---|---|---|---|---|
| | | | Just right | Slightly small | Small or very small | Total |
| Q72 - 72. How slippery is your cellphone when you hold it? | Not at all | Count | 200 | 26 | 10 | 236 |
| | | Expected Count | 182.0 | 33.4 | 20.7 | 236.0 |
| | | % within Q72 | 84.7% | 11.0% | 4.2% | 100.0% |
| | | % within Q73 | 87.3% | 61.9% | 38.5% | 79.5% |
| | | % of Total | 67.3% | 8.8% | 3.4% | 79.5% |
| | Slightly or more | Count | 29 | 16 | 16 | 61 |
| | | Expected Count | 47.0 | 8.6 | 5.3 | 61.0 |
| | | % within Q72 | 47.5% | 26.2% | 26.2% | 100.0% |
| | | % within Q73 | 12.7% | 38.1% | 61.5% | 20.5% |
| | | % of Total | 9.8% | 5.4% | 5.4% | 20.5% |
| Total | | Count | 229 | 42 | 26 | 297 |
| | | Expected Count | 229.0 | 42.0 | 26.0 | 297.0 |
| | | % within Q72 | 77.1% | 14.1% | 8.8% | 100.0% |
| | | % within Q73 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 77.1% | 14.1% | 8.8% | 100.0% |

| | | | Q74 - 74. How large does your cellphone feel when holding and using it? | | |
|---|---|---|---|---|---|
| | | | Just right | Somewhat large | Total |
| Q72 - 72. How slippery is your cellphone when you hold it? | Not at all | Count | 218 | 18 | 236 |
| | | Expected Count | 205.8 | 30.2 | 236.0 |
| | | % within Q72 | 92.4% | 7.6% | 100.0% |
| | | % within Q74 | 84.2% | 47.4% | 79.5% |
| | | % of Total | 73.4% | 6.1% | 79.5% |
| | Slightly or more | Count | 41 | 20 | 61 |
| | | Expected Count | 53.2 | 7.8 | 61.0 |
| | | % within Q72 | 67.2% | 32.8% | 100.0% |
| | | % within Q74 | 15.8% | 52.6% | 20.5% |
| | | % of Total | 13.8% | 6.7% | 20.5% |
| Total | | Count | 259 | 38 | 297 |
| | | Expected Count | 259.0 | 38.0 | 297.0 |
| | | % within Q72 | 87.2% | 12.8% | 100.0% |
| | | % within Q74 | 100.0% | 100.0% | 100.0% |
| | | % of Total | 87.2% | 12.8% | 100.0% |

| | | | Q75 - 75. How difficult is it for you to carry your cellphone around? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q72 - 72. How slippery is your cellphone when you hold it? | Not at all | Count | 204 | 22 | 10 | 236 |
| | | Expected Count | 183.6 | 29.4 | 23.0 | 236.0 |
| | | % within Q72 | 86.4% | 9.3% | 4.2% | 100.0% |
| | | % within Q75 | 88.3% | 59.5% | 34.5% | 79.5% |
| | | % of Total | 68.7% | 7.4% | 3.4% | 79.5% |
| | Slightly or more | Count | 27 | 15 | 19 | 61 |
| | | Expected Count | 47.4 | 7.6 | 6.0 | 61.0 |
| | | % within Q72 | 44.3% | 24.6% | 31.1% | 100.0% |
| | | % within Q75 | 11.7% | 40.5% | 65.5% | 20.5% |
| | | % of Total | 9.1% | 5.1% | 6.4% | 20.5% |
| Total | | Count | 231 | 37 | 29 | 297 |
| | | Expected Count | 231.0 | 37.0 | 29.0 | 297.0 |
| | | % within Q72 | 77.8% | 12.5% | 9.8% | 100.0% |
| | | % within Q75 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 77.8% | 12.5% | 9.8% | 100.0% |

| | | | Q86 - 86. How slippery do you find things, in general, when holding them? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 163 | 27 | 1 | 191 |
| | | Expected Count | 131.4 | 50.0 | 9.6 | 191.0 |
| | | % within Q82 | 85.3% | 14.1% | 0.5% | 100.0% |
| | | % within Q86 | 74.8% | 32.5% | 6.3% | 60.3% |
| | | % of Total | 51.4% | 8.5% | 0.3% | 60.3% |
| | Slightly or more | Count | 55 | 56 | 15 | 126 |
| | | Expected Count | 86.6 | 33.0 | 6.4 | 126.0 |
| | | % within Q82 | 43.7% | 44.4% | 11.9% | 100.0% |
| | | % within Q86 | 25.2% | 67.5% | 93.8% | 39.7% |
| | | % of Total | 17.4% | 17.7% | 4.7% | 39.7% |
| Total | | Count | 218 | 83 | 16 | 317 |
| | | Expected Count | 218.0 | 83.0 | 16.0 | 317.0 |
| | | % within Q82 | 68.8% | 26.2% | 5.0% | 100.0% |
| | | % within Q86 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 68.8% | 26.2% | 5.0% | 100.0% |

Appendix J

Contingency Tables – Psychomotor Skills

| | | | Q13 - 13. How hard is it for you to button a shirt or tie shoelaces? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 166 | 18 | 7 | 191 |
| | | Expected Count | 139.8 | 33.1 | 18.1 | 191.0 |
| | | % within Q82 | 86.9% | 9.4% | 3.7% | 100.0% |
| | | % within Q13 | 71.6% | 32.7% | 23.3% | 60.3% |
| | | % of Total | 52.4% | 5.7% | 2.2% | 60.3% |
| | Slightly or more | Count | 66 | 37 | 23 | 126 |
| | | Expected Count | 92.2 | 21.9 | 11.9 | 126.0 |
| | | % within Q82 | 52.4% | 29.4% | 18.3% | 100.0% |
| | | % within Q13 | 28.4% | 67.3% | 76.7% | 39.7% |
| | | % of Total | 20.8% | 11.7% | 7.3% | 39.7% |
| Total | | Count | 232 | 55 | 30 | 317 |
| | | Expected Count | 232.0 | 55.0 | 30.0 | 317.0 |
| | | % within Q82 | 73.2% | 17.4% | 9.5% | 100.0% |
| | | % within Q13 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 73.2% | 17.4% | 9.5% | 100.0% |

| | | | Q23 - 23. How difficult is it for you to open food packages or boxes (e.g., meat, cookies)? | | | | |
|---|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately | Very or extremely | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 121 | 53 | 11 | 6 | 191 |
| | | Expected Count | 95.8 | 59.6 | 24.1 | 11.4 | 191.0 |
| | | % within Q82 | 63.4% | 27.7% | 5.8% | 3.1% | 100.0% |
| | | % within Q23 | 76.1% | 53.5% | 27.5% | 31.6% | 60.3% |
| | | % of Total | 38.2% | 16.7% | 3.5% | 1.9% | 60.3% |
| | Slightly or more | Count | 38 | 46 | 29 | 13 | 126 |
| | | Expected Count | 63.2 | 39.4 | 15.9 | 7.6 | 126.0 |
| | | % within Q82 | 30.2% | 36.5% | 23.0% | 10.3% | 100.0% |
| | | % within Q23 | 23.9% | 46.5% | 72.5% | 68.4% | 39.7% |
| | | % of Total | 12.0% | 14.5% | 9.1% | 4.1% | 39.7% |
| Total | | Count | 159 | 99 | 40 | 19 | 317 |
| | | Expected Count | 159.0 | 99.0 | 40.0 | 19.0 | 317.0 |
| | | % within Q82 | 50.2% | 31.2% | 12.6% | 6.0% | 100.0% |
| | | % within Q23 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 50.2% | 31.2% | 12.6% | 6.0% | 100.0% |

| | | | Q50 - 50. How hard is it to grip a pill wrapper and tear it with fingers? | | | | |
|---|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately | Very or extremely | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 113 | 61 | 10 | 7 | 191 |
| | | Expected Count | 82.5 | 62.7 | 25.3 | 20.5 | 191.0 |
| | | % within Q82 | 59.2% | 31.9% | 5.2% | 3.7% | 100.0% |
| | | % within Q50 | 82.5% | 58.7% | 23.8% | 20.6% | 60.3% |
| | | % of Total | 35.6% | 19.2% | 3.2% | 2.2% | 60.3% |
| | Slightly or more | Count | 24 | 43 | 32 | 27 | 126 |
| | | Expected Count | 54.5 | 41.3 | 16.7 | 13.5 | 126.0 |
| | | % within Q82 | 19.0% | 34.1% | 25.4% | 21.4% | 100.0% |
| | | % within Q50 | 17.5% | 41.3% | 76.2% | 79.4% | 39.7% |
| | | % of Total | 7.6% | 13.6% | 10.1% | 8.5% | 39.7% |
| Total | | Count | 137 | 104 | 42 | 34 | 317 |
| | | Expected Count | 137.0 | 104.0 | 42.0 | 34.0 | 317.0 |
| | | % within Q82 | 43.2% | 32.8% | 13.2% | 10.7% | 100.0% |
| | | % within Q50 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 43.2% | 32.8% | 13.2% | 10.7% | 100.0% |

| | | | Q51 - 51. How hard is it to pick up pills with fingers? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 165 | 20 | 6 | 191 |
| | | Expected Count | 131.4 | 36.8 | 22.9 | 191.0 |
| | | % within Q82 | 86.4% | 10.5% | 3.1% | 100.0% |
| | | % within Q51 | 75.7% | 32.8% | 15.8% | 60.3% |
| | | % of Total | 52.1% | 6.3% | 1.9% | 60.3% |
| | Slightly or more | Count | 53 | 41 | 32 | 126 |
| | | Expected Count | 86.6 | 24.2 | 15.1 | 126.0 |
| | | % within Q82 | 42.1% | 32.5% | 25.4% | 100.0% |
| | | % within Q51 | 24.3% | 67.2% | 84.2% | 39.7% |
| | | % of Total | 16.7% | 12.9% | 10.1% | 39.7% |
| Total | | Count | 218 | 61 | 38 | 317 |
| | | Expected Count | 218.0 | 61.0 | 38.0 | 317.0 |
| | | % within Q82 | 68.8% | 19.2% | 12.0% | 100.0% |
| | | % within Q51 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 68.8% | 19.2% | 12.0% | 100.0% |

| | | | Q61 - 61. How hard is it for you to use a keyboard or a mouse? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 162 | 11 | 0 | 173 |
| | | Expected Count | 140.9 | 23.6 | 8.5 | 173.0 |
| | | % within Q82 | 93.6% | 6.4% | 0.0% | 100.0% |
| | | % within Q61 | 69.5% | 28.2% | 0.0% | 60.5% |
| | | % of Total | 56.6% | 3.8% | 0.0% | 60.5% |
| | Slightly or more | Count | 71 | 28 | 14 | 113 |
| | | Expected Count | 92.1 | 15.4 | 5.5 | 113.0 |
| | | % within Q82 | 62.8% | 24.8% | 12.4% | 100.0% |
| | | % within Q61 | 30.5% | 71.8% | 100.0% | 39.5% |
| | | % of Total | 24.8% | 9.8% | 4.9% | 39.5% |
| Total | | Count | 233 | 39 | 14 | 286 |
| | | Expected Count | 233.0 | 39.0 | 14.0 | 286.0 |
| | | % within Q82 | 81.5% | 13.6% | 4.9% | 100.0% |
| | | % within Q61 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 81.5% | 13.6% | 4.9% | 100.0% |

| | | | Q76 - 76. How difficult is it for you to use a keypad on your cellphone because of difficulty in bending or moving your | | | | |
|---|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately | Very or extremely | Total |
| Q82 - 82. What level of difficulty do you have in using fingers or hands? | Not at all | Count | 157 | 14 | 1 | 2 | 174 |
| | | Expected Count | 125.4 | 26.4 | 10.5 | 11.7 | 174.0 |
| | | % within Q82 | 90.2% | 8.0% | 0.6% | 1.1% | 100.0% |
| | | % within Q76 | 73.4% | 31.1% | 5.6% | 10.0% | 58.6% |
| | | % of Total | 52.9% | 4.7% | 0.3% | 0.7% | 58.6% |
| | Slightly or more | Count | 57 | 31 | 17 | 18 | 123 |
| | | Expected Count | 88.6 | 18.6 | 7.5 | 8.3 | 123.0 |
| | | % within Q82 | 46.3% | 25.2% | 13.8% | 14.6% | 100.0% |
| | | % within Q76 | 26.6% | 68.9% | 94.4% | 90.0% | 41.4% |
| | | % of Total | 19.2% | 10.4% | 5.7% | 6.1% | 41.4% |
| Total | | Count | 214 | 45 | 18 | 20 | 297 |
| | | Expected Count | 214.0 | 45.0 | 18.0 | 20.0 | 297.0 |
| | | % within Q82 | 72.1% | 15.2% | 6.1% | 6.7% | 100.0% |
| | | % within Q76 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 72.1% | 15.2% | 6.1% | 6.7% | 100.0% |

Appendix K

Contingency Tables – Cognitive

| | | | Q6 - 6. How hard is it for you to adjust hot and cold water to get a comfortable temperature? | | |
|---|---|---|---|---|---|
| | | | Not at all | Slightly or more | Total |
| Q1 - 1. How hard is it for you to bathe or shower? | Not at all | Count | 202 | 35 | 237 |
| | | Expected Count | 186.2 | 50.8 | 237.0 |
| | | % within Q1 | 85.2% | 14.8% | 100.0% |
| | | % within Q6 | 81.1% | 51.5% | 74.8% |
| | | % of Total | 63.7% | 11.0% | 74.8% |
| | Slightly or more | Count | 47 | 33 | 80 |
| | | Expected Count | 62.8 | 17.2 | 80.0 |
| | | % within Q1 | 58.8% | 41.3% | 100.0% |
| | | % within Q6 | 18.9% | 48.5% | 25.2% |
| | | % of Total | 14.8% | 10.4% | 25.2% |
| Total | | Count | 249 | 68 | 317 |
| | | Expected Count | 249.0 | 68.0 | 317.0 |
| | | % within Q1 | 78.5% | 21.5% | 100.0% |
| | | % within Q6 | 100.0% | 100.0% | 100.0% |
| | | % of Total | 78.5% | 21.5% | 100.0% |

| | | | Q26 - 26. How often do you turn on or off the wrong stove control for a particular heating surface? | | | |
|---|---|---|---|---|---|---|
| | | | Never | Seldom | Sometimes or often | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 138 | 66 | 18 | 222 |
| | | Expected Count | 126.1 | 69.3 | 26.6 | 222.0 |
| | | % within Q16 | 62.2% | 29.7% | 8.1% | 100.0% |
| | | % within Q26 | 76.7% | 66.7% | 47.4% | 70.0% |
| | | % of Total | 43.5% | 20.8% | 5.7% | 70.0% |
| | Slightly or more | Count | 42 | 33 | 20 | 95 |
| | | Expected Count | 53.9 | 29.7 | 11.4 | 95.0 |
| | | % within Q16 | 44.2% | 34.7% | 21.1% | 100.0% |
| | | % within Q26 | 23.3% | 33.3% | 52.6% | 30.0% |
| | | % of Total | 13.2% | 10.4% | 6.3% | 30.0% |
| Total | | Count | 180 | 99 | 38 | 317 |
| | | Expected Count | 180.0 | 99.0 | 38.0 | 317.0 |
| | | % within Q16 | 56.8% | 31.2% | 12.0% | 100.0% |
| | | % within Q26 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 56.8% | 31.2% | 12.0% | 100.0% |

| | | | Q27 - 27. How often do you forget to turn off the stove? | | | |
|---|---|---|---|---|---|---|
| | | | Never | Seldom | Sometimes or often | Total |
| Q16 - 16. How hard is it for you to cook or prepare meals? | Not at all | Count | 166 | 44 | 12 | 222 |
| | | Expected Count | 154.8 | 51.8 | 15.4 | 222.0 |
| | | % within Q16 | 74.8% | 19.8% | 5.4% | 100.0% |
| | | % within Q27 | 75.1% | 59.5% | 54.5% | 70.0% |
| | | % of Total | 52.4% | 13.9% | 3.8% | 70.0% |
| | Slightly or more | Count | 55 | 30 | 10 | 95 |
| | | Expected Count | 66.2 | 22.2 | 6.6 | 95.0 |
| | | % within Q16 | 57.9% | 31.6% | 10.5% | 100.0% |
| | | % within Q27 | 24.9% | 40.5% | 45.5% | 30.0% |
| | | % of Total | 17.4% | 9.5% | 3.2% | 30.0% |
| Total | | Count | 221 | 74 | 22 | 317 |
| | | Expected Count | 221.0 | 74.0 | 22.0 | 317.0 |
| | | % within Q16 | 69.7% | 23.3% | 6.9% | 100.0% |
| | | % within Q27 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 69.7% | 23.3% | 6.9% | 100.0% |

| | | | Q52 - 52. How often do you forget to take medication in the correct dosage or at the correct time? | | | |
|---|---|---|---|---|---|---|
| | | | Never | Seldom | Sometimes or often | Total |
| Q47 - 47. How hard is it for you to take medication? | Not at all | Count | 167 | 96 | 22 | 285 |
| | | Expected Count | 155.5 | 99.8 | 29.7 | 285.0 |
| | | % within Q47 | 58.6% | 33.7% | 7.7% | 100.0% |
| | | % within Q52 | 96.5% | 86.5% | 66.7% | 89.9% |
| | | % of Total | 52.7% | 30.3% | 6.9% | 89.9% |
| | Slightly or more | Count | 6 | 15 | 11 | 32 |
| | | Expected Count | 17.5 | 11.2 | 3.3 | 32.0 |
| | | % within Q47 | 18.8% | 46.9% | 34.4% | 100.0% |
| | | % within Q52 | 3.5% | 13.5% | 33.3% | 10.1% |
| | | % of Total | 1.9% | 4.7% | 3.5% | 10.1% |
| Total | | Count | 173 | 111 | 33 | 317 |
| | | Expected Count | 173.0 | 111.0 | 33.0 | 317.0 |
| | | % within Q47 | 54.6% | 35.0% | 10.4% | 100.0% |
| | | % within Q52 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 54.6% | 35.0% | 10.4% | 100.0% |

| | | | Q54 - 54. How hard is it for you to understand a medicine label because instructions are too complicated? | | |
|---|---|---|---|---|---|
| | | | Not at all | Slightly or more | Total |
| Q47 - 47. How hard is it for you to take medication? | Not at all | Count | 225 | 60 | 285 |
| | | Expected Count | 216.7 | 68.3 | 285.0 |
| | | % within Q47 | 78.9% | 21.1% | 100.0% |
| | | % within Q54 | 93.4% | 78.9% | 89.9% |
| | | % of Total | 71.0% | 18.9% | 89.9% |
| | Slightly or more | Count | 16 | 16 | 32 |
| | | Expected Count | 24.3 | 7.7 | 32.0 |
| | | % within Q47 | 50.0% | 50.0% | 100.0% |
| | | % within Q54 | 6.6% | 21.1% | 10.1% |
| | | % of Total | 5.0% | 5.0% | 10.1% |
| Total | | Count | 241 | 76 | 317 |
| | | Expected Count | 241.0 | 76.0 | 317.0 |
| | | % within Q47 | 76.0% | 24.0% | 100.0% |
| | | % within Q54 | 100.0% | 100.0% | 100.0% |
| | | % of Total | 76.0% | 24.0% | 100.0% |

| | | | Q65 - 65. How difficult is it for you to solve or diagnose a computer problem when printing a document, emailing, or ins | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q55 - 55. How difficult is it for you to use a computer? | Not at all | Count | 89 | 74 | 50 | 213 |
| | | Expected Count | 70.8 | 71.5 | 70.8 | 213.0 |
| | | % within Q55 | 41.8% | 34.7% | 23.5% | 100.0% |
| | | % within Q65 | 93.7% | 77.1% | 52.6% | 74.5% |
| | | % of Total | 31.1% | 25.9% | 17.5% | 74.5% |
| | Slightly | Count | 5 | 20 | 29 | 54 |
| | | Expected Count | 17.9 | 18.1 | 17.9 | 54.0 |
| | | % within Q55 | 9.3% | 37.0% | 53.7% | 100.0% |
| | | % within Q65 | 5.3% | 20.8% | 30.5% | 18.9% |
| | | % of Total | 1.7% | 7.0% | 10.1% | 18.9% |
| | Moderately or more | Count | 1 | 2 | 16 | 19 |
| | | Expected Count | 6.3 | 6.4 | 6.3 | 19.0 |
| | | % within Q55 | 5.3% | 10.5% | 84.2% | 100.0% |
| | | % within Q65 | 1.1% | 2.1% | 16.8% | 6.6% |
| | | % of Total | 0.3% | 0.7% | 5.6% | 6.6% |
| Total | | Count | 95 | 96 | 95 | 286 |
| | | Expected Count | 95.0 | 96.0 | 95.0 | 286.0 |
| | | % within Q55 | 33.2% | 33.6% | 33.2% | 100.0% |
| | | % within Q65 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 33.2% | 33.6% | 33.2% | 100.0% |

| | | | Q77 - 77. How difficult is it for you to solve or diagnose a cellphone problem when calling, emailing, or installing app | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q66 - 66. How difficult is it for you to use a cellphone? | Not at all | Count | 121 | 66 | 33 | 220 |
| | | Expected Count | 96.3 | 65.9 | 57.8 | 220.0 |
| | | % within Q66 | 55.0% | 30.0% | 15.0% | 100.0% |
| | | % within Q77 | 93.1% | 74.2% | 42.3% | 74.1% |
| | | % of Total | 40.7% | 22.2% | 11.1% | 74.1% |
| | Slightly or more | Count | 9 | 23 | 45 | 77 |
| | | Expected Count | 33.7 | 23.1 | 20.2 | 77.0 |
| | | % within Q66 | 11.7% | 29.9% | 58.4% | 100.0% |
| | | % within Q77 | 6.9% | 25.8% | 57.7% | 25.9% |
| | | % of Total | 3.0% | 7.7% | 15.2% | 25.9% |
| Total | | Count | 130 | 89 | 78 | 297 |
| | | Expected Count | 130.0 | 89.0 | 78.0 | 297.0 |
| | | % within Q66 | 43.8% | 30.0% | 26.3% | 100.0% |
| | | % within Q77 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 43.8% | 30.0% | 26.3% | 100.0% |

Appendix L

Contingency Tables – Seeing

| | | | Q53 - 53. How hard is it for you to read the medicine label because lettering is too small? | | | |
|---|---|---|---|---|---|---|
| | | | Not at all | Slightly | Moderately or more | Total |
| Q47 - 47. How hard is it for you to take medication? | Not at all | Count | 128 | 77 | 80 | 285 |
| | | Expected Count | 119.6 | 80.0 | 85.4 | 285.0 |
| | | % within Q47 | 44.9% | 27.0% | 28.1% | 100.0% |
| | | % within Q53 | 96.2% | 86.5% | 84.2% | 89.9% |
| | | % of Total | 40.4% | 24.3% | 25.2% | 89.9% |
| | Slightly or more | Count | 5 | 12 | 15 | 32 |
| | | Expected Count | 13.4 | 9.0 | 9.6 | 32.0 |
| | | % within Q47 | 15.6% | 37.5% | 46.9% | 100.0% |
| | | % within Q53 | 3.8% | 13.5% | 15.8% | 10.1% |
| | | % of Total | 1.6% | 3.8% | 4.7% | 10.1% |
| Total | | Count | 133 | 89 | 95 | 317 |
| | | Expected Count | 133.0 | 89.0 | 95.0 | 317.0 |
| | | % within Q47 | 42.0% | 28.1% | 30.0% | 100.0% |
| | | % within Q53 | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 42.0% | 28.1% | 30.0% | 100.0% |

| | | | Q83 - 83. What level of difficulty do you have in seeing things around you or reading without glasses? | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | None | Slight | Moderate | Very | Extreme | Total |
| Q55 - 55. How difficult is it for you to use a computer? | Not at all | Count | 57 | 59 | 54 | 25 | 18 | 213 |
| | | Expected Count | 47.7 | 51.4 | 61.1 | 34.3 | 18.6 | 213.0 |
| | | % within Q55 | 26.8% | 27.7% | 25.4% | 11.7% | 8.5% | 100.0% |
| | | % within Q83 | 89.1% | 85.5% | 65.9% | 54.3% | 72.0% | 74.5% |
| | | % of Total | 19.9% | 20.6% | 18.9% | 8.7% | 6.3% | 74.5% |
| | Slightly or more | Count | 7 | 10 | 28 | 21 | 7 | 73 |
| | | Expected Count | 16.3 | 17.6 | 20.9 | 11.7 | 6.4 | 73.0 |
| | | % within Q55 | 9.6% | 13.7% | 38.4% | 28.8% | 9.6% | 100.0% |
| | | % within Q83 | 10.9% | 14.5% | 34.1% | 45.7% | 28.0% | 25.5% |
| | | % of Total | 2.4% | 3.5% | 9.8% | 7.3% | 2.4% | 25.5% |
| Total | | Count | 64 | 69 | 82 | 46 | 25 | 286 |
| | | Expected Count | 64.0 | 69.0 | 82.0 | 46.0 | 25.0 | 286.0 |
| | | % within Q55 | 22.4% | 24.1% | 28.7% | 16.1% | 8.7% | 100.0% |
| | | % within Q83 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 22.4% | 24.1% | 28.7% | 16.1% | 8.7% | 100.0% |

| | | | Q83 - 83. What level of difficulty do you have in seeing things around you or reading without glasses? | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | None | Slight | Moderate | Very | Extreme | Total |
| Q87 - 87. How hard is it for you to walk or climbing stairs because of difficulty recognizing obstacles? | Not at all | Count | 66 | 61 | 56 | 35 | 24 | 242 |
| | | Expected Count | 54.2 | 56.5 | 66.4 | 40.5 | 24.4 | 242.0 |
| | | % within Q87 | 27.3% | 25.2% | 23.1% | 14.5% | 9.9% | 100.0% |
| | | % within Q83 | 93.0% | 82.4% | 64.4% | 66.0% | 75.0% | 76.3% |
| | | % of Total | 20.8% | 19.2% | 17.7% | 11.0% | 7.6% | 76.3% |
| | Slightly or more | Count | 5 | 13 | 31 | 18 | 8 | 75 |
| | | Expected Count | 16.8 | 17.5 | 20.6 | 12.5 | 7.6 | 75.0 |
| | | % within Q87 | 6.7% | 17.3% | 41.3% | 24.0% | 10.7% | 100.0% |
| | | % within Q83 | 7.0% | 17.6% | 35.6% | 34.0% | 25.0% | 23.7% |
| | | % of Total | 1.6% | 4.1% | 9.8% | 5.7% | 2.5% | 23.7% |
| Total | | Count | 71 | 74 | 87 | 53 | 32 | 317 |
| | | Expected Count | 71.0 | 74.0 | 87.0 | 53.0 | 32.0 | 317.0 |
| | | % within Q87 | 22.4% | 23.3% | 27.4% | 16.7% | 10.1% | 100.0% |
| | | % within Q83 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 22.4% | 23.3% | 27.4% | 16.7% | 10.1% | 100.0% |

| | | | Q64 - 64. Do you think the lighting in the room is bright enough for you to work with your computer? | | | | |
|---|---|---|---|---|---|---|---|
| | | | Disagree | Neutral | Agree | Totally agree | Total |
| Q63 - 63. How hard is it for you to read the contents on a computer screen? | Not at all | Count | 20 | 21 | 77 | 78 | 196 |
| | | Expected Count | 19.9 | 37.7 | 80.2 | 58.3 | 196.0 |
| | | % within Q63 | 10.2% | 10.7% | 39.3% | 39.8% | 100.0% |
| | | % within Q64 | 69.0% | 38.2% | 65.8% | 91.8% | 68.5% |
| | | % of Total | 7.0% | 7.3% | 26.9% | 27.3% | 68.5% |
| | Slightly or more | Count | 9 | 34 | 40 | 7 | 90 |
| | | Expected Count | 9.1 | 17.3 | 36.8 | 26.7 | 90.0 |
| | | % within Q63 | 10.0% | 37.8% | 44.4% | 7.8% | 100.0% |
| | | % within Q64 | 31.0% | 61.8% | 34.2% | 8.2% | 31.5% |
| | | % of Total | 3.1% | 11.9% | 14.0% | 2.4% | 31.5% |
| Total | | Count | 29 | 55 | 117 | 85 | 286 |
| | | Expected Count | 29.0 | 55.0 | 117.0 | 85.0 | 286.0 |
| | | % within Q63 | 10.1% | 19.2% | 40.9% | 29.7% | 100.0% |
| | | % within Q64 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 10.1% | 19.2% | 40.9% | 29.7% | 100.0% |

Appendix M

Contingency Tables – Hearing

| | | | Q84 - 84. What level of difficulty do you have in hearing? | | | | |
|---|---|---|---|---|---|---|---|
| | | | None | Slight | Moderate | Very or extreme | Total |
| Q55 - 55. How difficult is it for you to use a computer? | Not at all | Count | 122 | 55 | 20 | 16 | 213 |
| | | Expected Count | 108.7 | 53.6 | 33.5 | 17.1 | 213.0 |
| | | % within Q55 | 57.3% | 25.8% | 9.4% | 7.5% | 100.0% |
| | | % within Q84 | 83.6% | 76.4% | 44.4% | 69.6% | 74.5% |
| | | % of Total | 42.7% | 19.2% | 7.0% | 5.6% | 74.5% |
| | Slightly or more | Count | 24 | 17 | 25 | 7 | 73 |
| | | Expected Count | 37.3 | 18.4 | 11.5 | 5.9 | 73.0 |
| | | % within Q55 | 32.9% | 23.3% | 34.2% | 9.6% | 100.0% |
| | | % within Q84 | 16.4% | 23.6% | 55.6% | 30.4% | 25.5% |
| | | % of Total | 8.4% | 5.9% | 8.7% | 2.4% | 25.5% |
| Total | | Count | 146 | 72 | 45 | 23 | 286 |
| | | Expected Count | 146.0 | 72.0 | 45.0 | 23.0 | 286.0 |
| | | % within Q55 | 51.0% | 25.2% | 15.7% | 8.0% | 100.0% |
| | | % within Q84 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 51.0% | 25.2% | 15.7% | 8.0% | 100.0% |

| | | | Q84 - 84. What level of difficulty do you have in hearing? | | | | |
|---|---|---|---|---|---|---|---|
| | | | None | Slight | Moderate | Very or extreme | Total |
| Q66 - 66. How difficult is it for you to use a cellphone? | Not at all | Count | 122 | 53 | 28 | 17 | 220 |
| | | Expected Count | 108.9 | 56.3 | 35.6 | 19.3 | 220.0 |
| | | % within Q66 | 55.5% | 24.1% | 12.7% | 7.7% | 100.0% |
| | | % within Q84 | 83.0% | 69.7% | 58.3% | 65.4% | 74.1% |
| | | % of Total | 41.1% | 17.8% | 9.4% | 5.7% | 74.1% |
| | Slightly or more | Count | 25 | 23 | 20 | 9 | 77 |
| | | Expected Count | 38.1 | 19.7 | 12.4 | 6.7 | 77.0 |
| | | % within Q66 | 32.5% | 29.9% | 26.0% | 11.7% | 100.0% |
| | | % within Q84 | 17.0% | 30.3% | 41.7% | 34.6% | 25.9% |
| | | % of Total | 8.4% | 7.7% | 6.7% | 3.0% | 25.9% |
| Total | | Count | 147 | 76 | 48 | 26 | 297 |
| | | Expected Count | 147.0 | 76.0 | 48.0 | 26.0 | 297.0 |
| | | % within Q66 | 49.5% | 25.6% | 16.2% | 8.8% | 100.0% |
| | | % within Q84 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 49.5% | 25.6% | 16.2% | 8.8% | 100.0% |

| | | | Q84 - 84. What level of difficulty do you have in hearing? | | | | |
|---|---|---|---|---|---|---|---|
| | | | None | Slight | Moderate | Very or extreme | Total |
| Q78 - 78. How difficult is it for you to talk over the cellphone with background noise? | Not at all | Count | 84 | 21 | 8 | 3 | 116 |
| | | Expected Count | 57.4 | 29.7 | 18.7 | 10.2 | 116.0 |
| | | % within Q78 | 72.4% | 18.1% | 6.9% | 2.6% | 100.0% |
| | | % within Q84 | 57.1% | 27.6% | 16.7% | 11.5% | 39.1% |
| | | % of Total | 28.3% | 7.1% | 2.7% | 1.0% | 39.1% |
| | Slightly | Count | 46 | 33 | 16 | 6 | 101 |
| | | Expected Count | 50.0 | 25.8 | 16.3 | 8.8 | 101.0 |
| | | % within Q78 | 45.5% | 32.7% | 15.8% | 5.9% | 100.0% |
| | | % within Q84 | 31.3% | 43.4% | 33.3% | 23.1% | 34.0% |
| | | % of Total | 15.5% | 11.1% | 5.4% | 2.0% | 34.0% |
| | Moderately or more | Count | 17 | 22 | 24 | 17 | 80 |
| | | Expected Count | 39.6 | 20.5 | 12.9 | 7.0 | 80.0 |
| | | % within Q78 | 21.3% | 27.5% | 30.0% | 21.3% | 100.0% |
| | | % within Q84 | 11.6% | 28.9% | 50.0% | 65.4% | 26.9% |
| | | % of Total | 5.7% | 7.4% | 8.1% | 5.7% | 26.9% |
| Total | | Count | 147 | 76 | 48 | 26 | 297 |
| | | Expected Count | 147.0 | 76.0 | 48.0 | 26.0 | 297.0 |
| | | % within Q78 | 49.5% | 25.6% | 16.2% | 8.8% | 100.0% |
| | | % within Q84 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 49.5% | 25.6% | 16.2% | 8.8% | 100.0% |

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## Biographical Information

Megumi Sato Hice started a Ph.D. program at the University of Texas at Arlington in 2016 while she was working full-time in aviation industries. She had realized many areas in aviation industries where vulnerable people like older adults tried to fit into the environment rather than changing the design of the environment for them to comfortably live. This realization motivated her to pursue research in human factors engineering and gerontology. She hopes to continue more research in the airport environment to improve conditions for senior passengers.