HUMAN FACTORS AND SAFETY FOR SENIORS WHO COOK

BY

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THESIS

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Abstract

Maintaining independence as people age is an important factor which contributes to prolonging physical and emotional health. Preparing meals is one of these daily activities that becomes increasingly difficult and can contribute to loss of independence. For this project, research was done on the physical effects of aging, anthropometrics of seniors, and the difficulties that seniors face in the cooking process. Research was performed through interviews, observation, and academic sources. The scope of this project did not include the effects of cognitive decline.

Some of the biggest obstacles seniors face in the kitchen are due to diminished strength, dexterity, and energy. These effects of aging can be overwhelming since cooking often requires standing for long periods, lifting heavy items, and bending for items that are too high or low. A kitchen layout design is proposed which minimizes exertion required for cooking. The design allows the user to cook seated or standing and brings the most common tasks and tools to the height of the worksurface and within arm's reach. The features and dimensions of this design are based on insights gained after empathic modeling, interviews and observations, analyzing kitchen workflows, studying ergonomic guidelines. Models were built to then test the ergonomics and usability of the design concepts with seniors.
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Chapter 1: Introduction

Maintaining independence as people age can contribute to better life satisfaction and help prolong physical and emotional health (Oswald, Jopp, Rott, Wahl, 2010). Evidence suggests that remaining in a familiar home where seniors are attached to a community can be correlated to better quality of life and longer life expectancy. Loss of independence and moving to a ‘retirement home’ often feels like a loss of dignity and can be damaging to mental health which can then negatively impact physical health (Rowland, 1977; Gilleard, Hyde, Martin, Higgs, 2007).

Many daily habits that are taken for granted by younger or healthier people, can become more and more difficult as people age until eventually they are unable to perform these tasks on their own. Preparing meals is one of these daily activities that becomes increasingly more difficult. Losing the ability to cook for one’s self is a big contributor to losing independence and having to move into assisted living housing (Plastow, Atwal, Gihooly, 2015). In addition, the capacity to prepare meals directly affects one’s nutrition which can worsen all other negative effects of aging.

The cause of this loss of independence relies on a number of factors including cognitive ability, physical mobility, and family or community support (Fauth, Zarit, Malmberg, Johansson, 2007). One contributing factor, which will be the focus of this project, is the design of the environment and products that the person is surrounded by. Homes and appliances are generally designed for healthy users that are age 19 – 65 (Hrovatin, Sirok, 2012). Seniors have different capabilities and needs which are therefore often neglected. If more architects and product designers took the needs of seniors and people with limited mobility into consideration, more people would be able to continue to care for themselves. The kitchen in particular is an area which could have significant impact on their lives (Chen, 2014; Ibrahim & Davies, 2012).

Seniors (people over age 65) are a growing population. With the baby boomer generation aging, it is projected by 2030 over 20% of the US population will be over 65 (Mather, Jacobsen, Pollard, 2015). That is 1 out of 5 people which translates to over 70 million people in the US. That is a significant portion of the population who’s needs are often being neglected to the point where it is impacting their quality of life and perhaps contributing to shorter lifespan.

This project aims to find solutions to help seniors maintain their independence longer by understanding the factors which hinder their abilities to cook or create risks for injury while cooking and from those findings, identify design improvements that could help them overcome these difficulties and risks.
Chapter 2: Human factors

Effects of Aging

In studying the effects of aging, it is important to first understand that there is no one way that people age. Seniors are the most variable group as far as motor and cognitive abilities (Fauth, Zarit, Malmberg, Johansson, 2007). Some acquire dementia in their 60s yet maintain their physical capabilities decades afterward. And vice versa, some may never decline in their cognitive abilities but may experience loss of mobility much earlier. There is a wide range of medical conditions and capabilities as people age because there are many factors involved and therefore people do not follow reliable timelines. But research was done on the most common physical declines which are most impactful on maintaining independence in the kitchen. To narrow the scope of the project, issues relating to cognitive decline were not pursued.

Arthritis

Arthritis affects 50% of adults over 65 (Arthritis Foundation, 2018). Arthritis is a general term for many types of joint pain and joint disease which reduce the dexterity of joints and make common movements painful. It can therefore can impact most aspects of daily life. Most commonly affected joints are in the hands, knees, and back. Arthritis may be one of the most common reasons for seniors to reduce the frequency and complexity of their cooking habits or stop cooking entirely (Stuparu, Barsan, 2012). It can be difficult to hold thin or smaller handled utensils. Tasks which require strong grip are too painful such as opening and sealing containers. Arthritis in the legs makes it painful to stand or walk for long periods. The back pain makes it difficult to do any kind of bending or twisting which is frequently required for cooking. For example, traditionally using an oven requires significant amount of bending to reach inside (see figure 1). Pulling out items from lower cabinets or reaching items on top shelves are fundamental tasks which gradually become unbearable.
Muscle strength

Sarcopenia is a similar ailment in that it can affect the whole body and make all activities more difficult. Sarcopenia is the gradual loss of muscle mass with age. Around 1-2% of muscle mass is lost each year after around age 50 and accelerates after 70 (Phillips, 2015). Over time, this results in gradual loss of muscle strength that cannot be easily recovered. This leads to seniors having difficulty lifting heavy items which they were previously capable of lifting. In the cooking process, plenty of lifting is often required. Large glass or metal dishes can be uncomfortably heavy especially when full of water and food. Bulk ingredients like a gallon of milk can become too cumbersome. Large appliances that could make a recipe easy are too heavy to get out of storage. Back muscles are weaker so bending to lift things from the lower storage or the oven is even more difficult. But this does not just affect how much weight one is capable of lifting. All muscles in the body are affected so all activities take more effort and energy than they used to so seniors tire more quickly. Just walking or standing for long periods of time can be prohibitively tiring. The kitchen is designed for standing so this contributes greatly to the loss of desire to cook.

Seated cooking

As stated earlier many cannot remain standing for long periods of time and prefer to sit to cook. Additionally, about one quarter of seniors use some form of mobility assistive device such as wheelchair
or walker (Gell, Wallace, LaCroix, Mroz, & Patel, 2015) and have no other option but to be seated to cook. Some tasks are easily done at the kitchen table such as chopping or mixing ingredients. But using the rest of the kitchen while seated is more difficult since the kitchen is designed for standing use. Research was done on the many problems seniors face when trying to cook while seated, both those in wheelchairs and those who simply prefer to sit. Many online videos were found which document the whole cooking process for both groups and screenshots were taken of these videos to illustrate the findings.

First of all, the height of the kitchen counter is designed for standing use. The standard counter height is around 36” which is uncomfortably high for typical seat height which is about 18” for standard kitchen chairs and 19” for adult wheelchairs. Also, there is no space under the counter for leg room which means the user is sitting in an awkward twisted posture to be able to reach over the counter at all (figure 2). Using a higher chair like a bar stool helps with the height problem but still requires the uncomfortable twisted posture otherwise the counter is too far away to be of any use (figure 3). But many do not have bar stools or are using wheelchairs. This means during the whole process the arms need to be held uncomfortably high while working on the counter which is quickly tiring for the arms and shoulders. Often the contents of the stove cannot be seen into because the side of the pot is about eye level (figure 4). Stirring the inside of a pot requires the arms to be raised even more. The unnatural posture and tired arms increases the risk of spilling the pot off the stove.

Figure 2: Counter height discomfort for cooking from a seated position
The oven is especially poorly designed for wheelchairs users. The open door blocks the space in front of the oven so the user is forced to twist and bend in uncomfortable positions just to reach inside the oven (Figure 5). In some cases, they are reaching so far that they can only use one hand to lift the dish because the other is helping offset the balance just to avoid tipping over and into the oven. Even if the oven is at a convenient height, it is often designed so that they must keep their arms raised to avoid touching the hot oven door.
Senses

All senses gradually diminish over time. Each of these affect the ability to cook and can contribute to risk of injury or poor food safety. Perhaps most impactful is poor vision. There is a wide range of vision impairments but the likelihood of some level vision loss increases with age. This leads to difficulty finding ingredients, knowing when food is cooked, and increases likelihood of spills. Diminished hearing can increase risk of fires or burns due to not being able to hear timers or smoke alarms. Diminished smell also contributes to risk of fires as they may not be able to smell smoke. Diminished smell and taste can lead to poor nutrition or food poisoning because they are less able to detect spoiled or uncooked food.

Anthropometrics

Much has been done for anthropometric data on human dimensions and recommended interaction distances for optimal ergonomics. Detailed recommendations on fundamental workstation dimensions have been documented and change depending on sex, age, and type of workstation as shown in figure 6. Anthropometric data on seniors was consulted and recommendations for ergonomic reach heights and optimal workspace distances were studied to understand ideal kitchen design dimensions for seniors (Kothiyal & Tettey, 2001; Pressman, 2007). For example, there are two ‘zones’ to take into consideration for an ergonomically designed workstation: the reach distance and the optimal work zone (Figure 7). The reach distance is the maximum radius a person can comfortably reach from one location without bending or reaching. Within a smaller radius and directly in front of the user is the optimal work
zone. This is the most comfortable area to work in and therefore where the most frequent tasks should take place. Less common tasks can be placed outside of this space but within the reach distance.

Figure 6: Seated workstation dimension recommendations from Architectural Graphic Standards (Pressman, 2007).
Risk of injury

Safety was a priority for this project so research was done to find what would be the highest risk of severe injury. It was found that burns are reported to be the 2\textsuperscript{nd} or 3\textsuperscript{rd} leading cause of fatal home accidents among adults over age 65 and vulnerability increases with age (Davidge, 2008; Grant, 2013). This surprising statistic is due to a few factors. Slower reaction times and lower strength results in being less able to avoid a burn in the case of an accident. In the case of a spill or a fall, they are less able to escape or remove the cause of the burn quickly. An older body is less able to recover and regenerate tissue as fast as a younger body. Due to these factors scalds burn deeper and damage more than they often do for other demographics which is why they more often lead to mortality (Davidge, 2008) and are a serious threat to seniors.

The kitchen is often reported to be the number 1 most likely place where burn accidents occur for seniors and the 3 most common mechanisms for these burns are scalds, flame, and hot surfaces, the majority of which being scalds (Davidge, 2008; Wong, Choy, 2007; Redlick, Cooke, Gomez, Banfield, Cartotto, Fish, 2002; Lewandowski, Pegg, Fortier, Skimmings, 1993).
Hot surfaces and flames

The reported contributing factors for receiving burns from hot surfaces include forgetting that items or burners are hot, and reaching through/over/near hot items such as the stovetop or pot (Grant, 2013). Reported contributing factors for kitchen fires and flame related burns are grease fires, flammable materials such as papers being too close to the stovetop catching fire, or loose clothing touching the stove top as the user reaches over the burners (Grant, 2013; Wong, 2007; Ahrens, Hall, Comoletti, Gamache, Lebeau, 2007). Exacerbating that problem is not knowing how to extinguish a grease fire and attempting to add water which actually increases the flame. These issues are dangerous but a majority of people that were interviewed reported being aware of these dangers and felt that they were always cognizant of these risks and how to avoid them.

Scalds

As stated above, the most common mechanism for serious burns is scalding due to hot liquid. The highest contributing factors include falling or tripping while carrying a container of hot liquid, knocking a pot off the stove, dropping it while transporting it, and one of the most common factors is due to errors when pouring the hot liquids (Burn Foundation, 2018; Grant, 2013; Washington State Department of Labor & Industries, 2009; Wong, 2007) These dangers related to scalds seemed less top of mind for those who were interviewed. And, since it is the highest risk of fatality, scalds became one of the priorities for safety in this project.
Chapter 3: Market research

Research was done to understand the existing products and other solutions in development that attempt to address the needs of seniors who cook. There are some appliances with features that can help, and there are many still in development for the near future. There is an abundance of concepts for using technology and the Internet of Things to assist in some of the cognitive or sensory problems but as far as addressing the physical limitations what was found was not satisfactory.

Smart kitchens

There are many newer products and research studies which attempt improve the safety of elderly in the kitchen with technology (Yamaguchi, Foloppe, Richard, Allain, 2012; Blasco, Marco, Casas, Cirujano, Picking, 2014; Johansson, Lundberg, Borell, 2011; Higgins, Glasgow, 2012; Iglesias, Ugalde, Coello, 2010; Wai, Devi, Biswas, 2011). There are ‘smart appliances’ like ovens and stovetops that can sense if they are being used or not and can automatically shut-off when not being used or produce audio reminders that they should be turned off. Some attempt to address the risk of burns due to touching surfaces that are hot by reminding or emphasizing to the user what objects are hot with visual or audio alerts as the user gets too close.

Some are attempting to connect smart appliances like these to each other so that the whole kitchen can share data and work together to assist in cooking. Smart kitchen system concepts present the possibility of projecting recipes and instructions on the counter or use a virtual assistant to help walk the user through the recipe. The system could keep track of inventory in the cupboards and in the fridge and when a recipe or user requires an ingredient the shelf can light up the item to help the user find it. Then while cooking, the oven or stove top could be programmed with specific settings for the specific recipe or user.

These solutions all help with those with diminished senses or early dementia to maintain independence. They also help prevent kitchen fires to flame and prevent burns from touching hot surfaces. But less concepts were found that address the simple physical difficulties identified in the research due to limited mobility.

Burn prevention

Several products do exist to help prevent burns. There are automatic fire extinguishers which drop powder onto the stove so they can extinguish grease fires (figure 8a). There are some products which can be placed on hot surfaces such as inside the oven to prevent the cook from touching the hot racks
And there are many simple tools which help fix a pot or pan to the burner so that it can’t easily be knocked off or spill over (Figure 8c).

(Figure 8b).  And there are many simple tools which help fix a pot or pan to the burner so that it can’t easily be knocked off or spill over (Figure 8c).

Accessibility

There are some clever kitchen designs for accessibility which assist those who use wheelchairs. These can definitely improve the cooking experience for elderly with limited mobility though they are not generally designed for seniors specifically. There are plenty of pull-out or pull-down storage mechanisms which make better use of cabinet space that is too high to reach (Figure 9a). Similarly, though not designed just for wheelchair users, there are storage mechanisms designed to assist the lifting of large heavy appliances up from lower storage (Figure 9b).

Renovation can be done to the kitchen to make room under the counter to allow a wheelchair to roll under it. This vastly improves the overall cooking process for those in wheelchairs but is then less usable for others in the household who may not need to use a wheelchair (Figure 10a) because the counter height is too low. There are some more expensive options where the height of the counter or sink is adjustable so it is usable from both a standing position and from a wheelchair (Figure 10b).
Unfortunately, one study found that only about 10% seniors with mobility difficulties choose to renovate (Hrovatin, Sirok, 2012). There are many reasons for this. First, most of these options are geared specifically for wheelchair use which is not always their need. If they do find options that fit their needs, the expense is commonly a large obstacle. Often, they are concerned that making the kitchen more
accessible for them will limit the usability for others in the residence. Also, aging is such a gradual
decline that people often just get accustomed to any new difficulties over time and don’t even realize
how much it is impacting them. So, it is hard to see at what point they really need assistance and when
to choose to make changes. Perhaps one of the greatest difficulties is the emotional choice of
acknowledging that they do, in fact, need the help. Most don’t want to admit to themselves that they
are declining in abilities or don’t want to be seen by others as disabled. So, while there are some great
solutions for some of the mobility concerns, most seniors are not adopting them.

Inspiration products
Inspiration was found in some products which are not necessarily marketed as assistive but are simply
innovative designs which make some tasks easier. These products improve the ergonomics of cooking
and therefore can be beneficial to seniors, but without any of the perceived stigma for being intended
for those with disabilities. Some of these are marketed for their luxury and convenience and are
therefore desirable to most everyone. Based on these products it was decided that that the goal of this
project’s final design should be that it is useful and desirable to a wider market. If seniors see it as an
innovative new product which makes cooking more convenient, and not as an assistive device, it may
have a greater chance of being adopted by those who need it, and have a better emotional impact on
the seniors who use it. Below are some of the products that ended up inspiring and influencing the final
design.

There are many kitchen trolleys, like the one in Figure 11a, that are simple and functional and
beautifully fit into different kitchen aesthetics. They provide a mobile workspace and add to the
counterspace in the kitchen. Though simple, there is a key usefulness a trolley like this could have for
seniors. It would reduce the amount of lifting and carrying they need to do, particularly for bringing
heavy items from the kitchen to the dinner table. If the surface of the trolley is the same height as the
counter, heavy items can easily slide onto the trolley and be transferred over to the table without
needing to be lifted.
Figure 11b shows a drawer-style dishwasher which was found installed in some of the Clark-Lindsey apartments. There are many drawer-style dishwasher products on the market. They are much easier to use than typical dishwashers since the user doesn’t need to bend down as much to reach into it so it is easier on the back and less lifting is required. Also, the door doesn’t get in the way of a user which is better for those in wheelchairs. The residents at Clark-Lindsey explained that they preferred this product to dishwashers they had used previously for these reasons.
Figure 12a shows a type of kitchen sink which is growing in popularity. The drain is in the corner and the bottom of the sink is much flatter than many sinks. This is so that the bottom can more easily be used as a worksurface as dishes set inside have more stability. A cutting board fits along a track on the top of the sink and can easily slide under the faucet or to the other side. The strainer similarly slides along a lower track. This set-up is beautiful and it streamlines the relationship between cutting, washing, and cleaning tasks. This makes many of the common cooking tasks more efficient and allows for more tasks to be done without the user moving from the central position.

Many products like the spice rack on Figure 12b exist that use circular lazy-susan type mechanisms which are simple and effective. They can make difficult to reach spaces convenient by rotating items around to the most accessible position.

These, among many other products, helped inform the projects on what solutions exist and what types of solutions are missing from the market. They helped guide the design to be simple, convenient, marketable to a wide audience, and effective for the needs of seniors.
Chapter 4: Interviews and Observational Research

The Center for Health, Aging, and Disability department on campus allowed the use of some resources for this project through the CHART program (Collaborations in Healthy Aging Research and Technology). CHART collaborates with Clark-Lindsey, a senior living facility in Champaign and has a designated apartment within Clark-Lindsey for research. This was used to recruit volunteer research participants and to install concept models and get feedback from residents. Through this process 15 residents were interviewed; 12 women and 3 men. Observational research was also done documenting the preparation of 5 meals by seniors in their own apartments. The focus of the interviews and observations was to better understand the habits, attitudes, and difficulties of seniors regarding meal preparation.

Interview process

After receiving IRB approval, research participants were recruited by posting flyers, and by approaching residents in-person during their regularly scheduled coffee meetup times (IRB documents can be found in Appendix A and recruitment materials found in Appendix B). The project was explained to them and they were told if they were interested in participating to contact the researcher. Gender imbalance in the participants was simply due to more women volunteering than men. Most men that were approached claimed they did not cook and were therefore not interested in participating. When volunteers approached the researcher to volunteer during the designated times, they were first asked to sign consent forms and then informally interviewed in a conversational format using a set of questions as a guide. Questions were focused on understanding how much experience interviewees had with cooking in the past, how much they desired to cook currently or how meaningful being able to cook for themselves was, what the difficulties they faced cooking, and how much they were aware and concerned with specific safety risks (the specific questions can be found in Appendix C).

Results

The most common complaints had to do with the physical human factors already found in earlier academic research. They explained that the whole process was just too tiring. Many commented that cooking required lifting heavy items, that too much bending was required which is too painful, and that reaching their highest shelves was impossible. Some mentioned that they were able to deal with some heavy items as long as they only needed to slide it from one place to another instead of having to
actually lift it. Many also mentioned that inadequate lighting in the kitchen made the whole process more difficult.

Another notable complaint was regarding the difficulty in the specific task of draining a pot of hot water. This participant said that a pot full of water was too heavy and the hand position was awkward and cumbersome and she no longer had the dexterity to do it without much difficulty. This problem stood out since it also overlapped with research findings regarding the high risk of scald injuries due to errors in pouring hot liquids.

**Target user**

The interviews helped narrow down the target user for this project. As noted earlier, there are options for renovating a traditional home to be more accessible for the elderly but people are averse to doing so for several reasons. It is expensive, people feel a stigma associated with the change, and due to the gradual change in abilities it difficult to decide when they really need it. Therefore, for this project it was decided that the target user would not be those looking to renovate their traditional home but those in senior living or assisted living apartments.

Most interviewees, however, felt that most residents in assisted living were not very interested in cooking. Most felt that, even if they used to love cooking, they were happy that they no longer needed to. They enjoyed the food and they enjoyed the benefit of having their meals provided for them. They gave the impression that most seniors in this population would not be very interested in being enabled to perform cooking tasks with greater ease and independence. This was a surprising attitude. It was assumed, even if a majority of their meals was provided for them, that they some would still occasionally want to do of their own cooking or baking.

Of course, this apparent apathy toward cooking could be due to a variety of factors. It is possible that as they lost the ability to cook for themselves it was discouraging to the point where they also lost the desire. It is possible that the attitude was a result of choosing to view their situation as a benefit instead of loss of independence. Perhaps if that had they not lost the ability in the first place they might still chose to cook for themselves occasionally if they had the option. Nevertheless, based on the discussions with them, it seemed that those in this assisted living community were not interested in increasing the amount of food preparation they were currently doing.
Discussions with seniors who were living in the more independent housing at Clark-Lindsey had different attitudes. Those who enjoyed cooking reported that one of the reasons to delay moving into an assisted living facility was the desire to cook. They said that they would miss needing to cook for themselves.

Based on these two populations it seems that the desire to cook, not just the ability to cook, is one of the dividing factors as to who is in assisted living and who is choosing to still live in more independent housing. Therefore, it was decided that the target user for the final design for this project were those in senior living apartments designed for aging in place.

There is a growing trend globally towards apartments and communities designed for aging adults to move into while they are still healthy and independent and where there are plenty of accommodations intended to make the aging process easier (Wiles, Leibing, Guberman, Reeve, & Allen, 2012). These are a positive alternative to simply moving into assisted living when it becomes a necessity. Instead, they can get as little assistance as they desire and over time as they need more assistance there is a system and well-designed environment already in place for them. They can stay where they are comfortable and can stay connected to the community they have developed. This type of forward-thinking senior living housing is the target market for this project.

**Observational research**

To better understand what is involved in the cooking process, after the interviews, observational research was performed by documenting 5 meals cooked by seniors at Clark-Lindsey. A variety of meals and tasks were observed and recorded including, 2 simple breakfasts, 2 simple dinners, and 1 three course dinner. Video was taken to document the process from preparation to clean-up. The participants were instructed to cook as they normally would and the researcher did not assist or interfere but did ask questions to understand their thoughts and methods. In addition to these in-person observations, dozens of online videos, (time-lapses, vlogs…) which showed the whole meal preparation process of seniors adequately, were also used.

From these observations, each step and task was recorded and categorized to try to find patterns of difficulties or types of tasks which were more frequently difficult. Over 40 distinct types of tasks were observed and were grouped into 9 categories. The grouped tasks of one meal observation can be seen below, in no particular order.
Heat
Getting desired temp
Flipping food
Assessing done ness
Putting the food in and out
Mixing while cooking
Sitting to cool

Storage
Large storage for dishes
Large storage for large ingredients/food
Smaller drawer storage for utensils and other tools
Misc storage for other materials, plastic wrap, bags...

Cold (Fridge)
Finding
Taking out and putting back
water/ice dispenser

Dealing with packaging
Wrapped in plastic wrap
Sealed in plastic, required scissors to open
Paper bag, rolled top
Cardboard box
Twist open and closed
Ziploc bag
Jar lid

Cutting / peeling
By hand, plucking
Knife, cutting on cutting board, or in hands
Peeler
Blend with food processor

Mixing / distributing
Hand mixing, electric mixer
Measuring
Cracking eggs
Pouring
Shaking
Moving from one dish to next: by hand, spoon, tongs

Information
Reading recipe
Determining if something is cooked
Timer

Water / sink / cleaning
Garbage can
Disposal sink
Rinse food
Wash dishes
Wash hands
Clean up with paper towel rag
Pour down sink

Space
Looking for tools / ingredients
Moving / Carrying from one location to next
Adjusting lights

Specialty appliances
Blender
Insta pot
Toaster
Electric kettle
Coffee machine
Movement tracking / workflow diagrams

It was noticed that there was a lot of wasted energy expended moving back and forth between different categories of tasks and different zones in the kitchen. This back and forth was noticeably more difficult for those with limited mobility due to advanced arthritis. Workflow diagrams were made using the in-person observations as well as some of the online videos. The diagrams show the different zones or worksites within the kitchen and show how many times the user moved between these worksites. This revealed different relationships between different categories of tasks and therefore opportunities for reducing the movement required in the cooking process. The zones used for the diagrams were based on the categories created in the previous section but modified to consider some of the physical separation between tasks. Some of these diagrams can be seen below.

For example, in the diagram for a simple eggs and toast breakfast, shown in Figure 13, the highest frequency node or worksite was the stovetop. This was the central workstation that the user would come back to and the bulk of the work was performed here. The other sites that the user most frequently moved to were from the stove to the sink and from the stove to a counter area where they handled cutting and mixing. The only counter appliances that were used were the toaster, and electric kettle.

Figure 14 shows a full dinner which involved 3 courses and dessert and in Figure 15 a breakfast which involved a more complicated recipe can be seen. This diagram also includes the clean-up and dishwasher process. In both cases the primary worksite appears to be a counterspace where the cutting and mixing took place. The highest frequency transitions were between this cutting/mixing area and the sink, followed by the storage, and the fridge.
Figure 13: Eggs and toast workflow diagram

Figure 14: Three course meal workflow diagram
Figure 16 shows a composite diagram which used combined data of in-person and online observations. This shows trends across a range of people and meal types. The ‘zone’ that was moved to most frequently was the storage but this referred to all forms of storage including cabinets, drawers, pantry, and counter space that was used for long term storage. Eventually this was divided into large and small storage (cabinets vs utensil drawers, for example) but the frequency of use for both types were about equal.

After several observations, and based on the composite diagram, it became clear that most often the strongest relationships were between the sink, the counter area used for cutting and mixing, and the stovetop. The highest frequency transitions were between these 3 (other than the various storage locations).
Using this analysis, it was conjectured that bringing these high frequency relationship zones closer together would minimize the amount of lifting and moving required by the user and would reduce the amount of exertion involved. This became one of the objectives of the final design solution. The top 3 worksites were prioritized to bring together because they would have the most impact on the user and secondary tasks were subsequently ranked based on the diagrams.
Chapter 5: Design Process

Objectives

Based on the research of the needs of seniors, directions for potential design opportunities were identified. The following are a few of the possibilities that were explored:

- Ways to know/remind users that a surface or dish is too hot to touch
- Ways to move heavy hot objects (from one work zone to another, from storage to work zone, from kitchen to table, taking hot dish out of the oven, etc)
- Ways to put out or prevent kitchen fires
- Ways to heat the contents of a pot but not the exterior
- Spill-proof cookware

Chosen objectives:

- Reduce the risk of spilling a pot of hot liquid
- Reduce amount of movement and lifting in the cooking process

Based on the research findings and explicit needs of the interviewees, the focus of the project was narrowed to two focuses 1) reducing the amount of exertion required by the user, specifically regarding lifting, bending, reaching, standing and walking. And 2) reducing the risk for burn injury by scalds. These 2 focuses were found to be complimentary. The less that a user needs to move and lift, the less they will be carrying and moving containers of hot liquid and therefore reduce opportunities to spill.

Ideation

With the goal of limiting movement and lifting, ideation began by focusing on features for individual appliances that might prevent burns or assist with lifting for specific tasks. After the cooking observations and diagraming the workflow and movement within the kitchen, ideation began to focus on how to reduce movement by designing a kitchen workstation. Because of the limitation on how long some seniors can stand, concepts were explored for seated workstations which could bring items and tasks to the user instead of requiring the user to move to them. The basic concept that began to be developed was that the sink be used as the center of the workstation with a cutting surface on one side of the sink and a cooktop on the other side, each of which could slide over the sink to be directly in front of the user. Brainstorming sketches can be seen in Figure 17.
Figure 17: Brainstorming sketches
Initially it was thought that focusing on just the top 3 (stove, cutting surface, and sink) would be a sufficient benefit to the cooking process. Even if users needed to stand up and walk a few steps for other tasks, that overall the exertion would still be reduced. But it was decided to expand on this idea and see how holistic this solution could be by exploring the whole kitchen layout and cooking process. So, after working through how to keep the 3 priority functions within the primary workspace, ideas were brainstormed to include secondary tasks like the refrigerator, oven, trash, and storage within the reach distance.

Based on the observations, it was noticed that quite a lot of different storage spaces were used to retrieve the various ingredients, tools, and dishes needed while cooking and that this was often the cause for most movement. Therefore, including some storage space became the 4th priority for the design followed by the oven, and a way to access other common countertop appliances. Many ideas were explored for how to maximize the amount of storage the user had access to. Different mechanisms for moving storage cabinets along tracks to slide closer to the user when needed were considered. Figure 18 shows a concept which intended to maximize the number of storage spaces that could fit around the user and that could easily be pulled down/forward to the optimal workspace (using existing pull-down type storage hardware).

![Figure 18: Exploring layouts for maximizing number of pull-down/pull-out storage units](image)
Figure 19 shows layout concept for a system with a long track or conveyor belt which could progress the workstation so that the user could have access to anything on the track. The track was intended to have modular sections, some of which could be used for closed cabinet-like storage and some could simply be mobile counter space. It was realized that this could also function to give access to the smaller appliances. If power could be run to the moving track sections the appliances could be left on the track, moved along the track electrically until it is within reach, and be used without having to be move them manually.

![Figure 19: Conveyor belt storage concept](image)

Complex conveyor type concepts evolved to incorporate more rotating carousels or ‘lazy-susans’ instead of belts or tracks because they are much simpler. Lazy-susan carousels were found to be the simplest type of movement that could maximize the amount of surface area a user could have access to. Concepts like the one shown in Figure 20 were explored which had a large carousel to the right of the sink for smaller storage, moving counter space, and a place where appliances could be plugged in and stored. The section to the left of the sink was for refrigerated storage space, which would replace a
refrigerator, which could also rotate around so the user had access to the whole unit from one position. Circular storage was placed above the sink and below the counter on each side.

![Figure 20: Rotating carousel themed concept](image)

Dozens of concepts were explored, some concepts in more detail than others. Each had benefits and disadvantages that had to be weighed. Each concept presented choices between pursuing simplicity or maximizing capacity, compromises between maximum surface area for usable counterspace or number of burners, and compromises between increasing storage space versus increasing the number of other lower priority functions.

**Models**

To quickly assess the usability and usefulness of concepts, simple ‘sketch models’ like the ones shown in Figure 21 were put together to interact with and get a realistic sense of reasonable dimensions. Similarly, experiments with pouring pots of water quickly lead to exploring simple methods for assisting that process. By resting the pot on two different elevations of scrap wood, with a gap in between, it was
found that the pot could be tipped with greater ease (Figure 21). These experiments produced surprisingly effective results. The successful geometry was noted to be pursued further.

![Figure 21: Sketch models for layout and pouring aid](image)

A workstation layout concept was chosen to develop and a rough but more robust model was built from foam and cardboard to test (Figure 22). This low fidelity model was used to test the concept by simulating meal preparation. Simple recipes were acted out as realistically as possible with the rough model. This proved that some of the features in the layout were quite usable and potentially beneficial. The idea that the stovetop (to the left of the sink) and a counter surface (to the right of the sink) could each slide over the sink so that the user did not have to move felt natural and convenient. In this concept, the refrigerator was directly behind the sink. In testing it was found that the doors and method for pulling out the contents of the refrigerator interfered with the usability of the sliding stove system. This functionality of the fridge also seemed complicated and less feasible so it was removed from the concept.

This model was then modified and installed in the Clark-Lindsey CHART apartment to demonstrate to research participants in order to get their feedback (see Figure 23). The participants were then allowed to interact with the model to feel it for themselves. They also tested the pour assist device by draining a pot into the sink (Figure 23).
Feedback

The feedback was mostly positive. They unanimously felt that the general concept would make cooking take less effort and enable them to do more than they currently could do. They all were very intrigued by the pour assist device and expressed wanting one for their own home. They felt that using it gave them more control and made the task dramatically easier. Without being prompted, 2 of them automatically poured the pot with only one hand. This proved that the device was intuitive and useful.

The residents provided some useful suggestions. They felt that the refrigerator was an important feature to include in the workstation. The iteration of the concept that was demonstrated to them used the space behind the sink as basic cabinet storage and not as the refrigerator. They felt that the design
would be incomplete without considerations for the fridge. They also gave some insight on a more emotional aspect of using the kitchen regarding the window. Some of them had windows above the sink which provided a view outside. They explained that having this view to the outdoors made using the kitchen more enjoyable and they would be disappointed to lose that view with this design.

**Empathic modeling**

Empathic modeling was performed to better understand the experience of cooking as a senior by having a similar experience directly. To do this, a GERT suit (GERontologic Test suit) designed by (Wolfgang Mol) was used which simulated back pain, joint stiffness, tinnitus, low strength, and vision problems (see Figure 24). The researcher wore the suit and performed common tasks in a standard kitchen at Clark-Lindsey (Figure 25). This confirmed many of the research findings from early on. It was very painful to do any bending or twisting. Simple tasks took enormous effort. The most difficult was using the oven. It was difficult to read the settings on the knob and bending to insert a dish or take it out was too painful to be repeated.

![Figure 24: GERT age simulation suit](image)
The suit was then used to test the model for seated cooking (Figure 25). The same tasks were simulated and components were moved as they would be if the model was functional. This demonstrated to the researcher the benefits and problems with the design. Simply sitting was definitely an improvement to standing. Most of the tasks were placed at comfortable distances and positions so they felt much more feasible and less painful. The layout proved to be a good improvement on the ergonomics of cooking.

There were two problems that were identified from this experiment. In order to slide the stove top and cutting surface both hands were needed and some twisting of the torso was initially needed to reach the far side and pull. This was much more difficult than expected. After exploring this further it was found that if only one hand was used to pull at a position closer to the sink it was not uncomfortable. It was noted therefore that there should be a handle of some kind to make it easier to pull these sections. These handles should be as close to the user as possible to reduce the amount of twisting needed.

Also, just sliding the chair forward into position was unexpectedly difficult and painful. This action requires shifting your weight forward so that you are in a semi-squatting position while also bending the back to reach the seat and jerking the chair forward. This revealed that a chair might need to be designed as part of this workstation. Or at least, it would be necessary to recommend that a chair with wheels would be best to use with this design.
Final Model

After a satisfactory design was developed in greater detail, a higher fidelity model was built to reflect the dimensions and some of the functionality of the final design (see Figures 26, 27, and 28). The sliding section which contains the stovetop and appliance carousel functioned in that it could be comfortably pulled into the sink area and the lazy-susan was able to spin to access the different appliances placed on it. This model was used to again simulate a cooking process to test the ergonomics. It was then put on display in the museum of art where dozens of people were able to interact with it and provide more feedback. It proved to feel natural and comfortable and the general feedback was that it was appealing for both seniors and non-seniors.
Figure 27: Final model testing

Figure 28: Interactions with the final model
Chapter 6: Final design

This section will cover the details of the final concept that was chosen. This kitchen design minimizes exertion required for cooking. The design allows the user to cook seated or standing and brings the most common tasks and tools to the height of the worksurface and within arm’s reach. An overview of the functionality of the design can be seen below in Figure 29.

Figure 29: Final concept overview
The layout was designed using the workflow diagrams to assess the highest priority tasks (stove, sink, and cutting surface) and using ergonomic guidelines to put these tasks in the primary workspace and keep reach distances, angles, and heights optimal. Secondary needs (fridge/freezer, oven, dishwasher, small appliances) are also within recommended reach distances but off to the side of the main workspace. This vastly reduces the amount of movement required by the user. The design reduces the amount of lifting required by bringing most items to worksurface height and allowing for items to easily slide between worksurfaces.

It is not expected that the user will never have to get up or move from the primary workstation during the cooking process. The user will need to move to access additional storage spaces such as a pantry and to perform various less common tasks. But the majority of the cooking process should be able to be performed from the central position which vastly reduces the effort required therefore enabling seniors to do more than they otherwise could.

**Height**

The height of the counter can adjust from a standing height of 36” down to 32” which is low enough to be comfortably used from a wheelchair and high enough that wheelchair armrests can still slide under the sink. Figures 30 and 31 illustrate which components move.

![Figure 30: Height adjustment detail](image-url)
If none of the residents of the apartment are wheelchair users it may be easiest to leave the workstation at standing height and simply use a high seat under the sink for seated users. This would allow for quick tasks to be performed while standing and make it easier on a spouse who does not need to sit. If the chair is 23-24” high it is the ideal height for the 36” high counter. More details on chair recommendations will be found below.

**Main central workstation**

The circle surrounding the user in Figure 32 illustrates the maximum reach distance for a seated user. This reach distance was based on anthropometric and ergonomic guidelines for the elderly (Kothiyal & Tettey, 2001; Pressman, 2007). The smallest guidelines were used to ensure the design would be comfortable for all. Men are generally larger than women and the reach distances for elderly are smaller than for average adults. The guidelines for elderly women were therefore used to be sure that...
smaller users would still be able to reach everything as intended comfortably. The blue rectangle shown in Figure 3.2 is the recommended primary zone where work is most comfortable and therefore where the most frequent work should take place. The sink is in this optimal space but the whole surface to the right of the sink can slide into this space which brings the cooktop and a cutting/mixing area into this optimal work zone. This way all 3 top priority tasks can be performed where it is most comfortable.

Figure 3.2: Reach distances

Slider
The section of the counter to the right of the sink slides the stove top and cutting surface into the optimal workspace (Figure 3.3). This body slides along a stainless steel raised extension of the sink. Meaning any spills or messes can easily be flushed off the slider section and drain into the sink. The gap between the slider and the front counter piece is 1/4” which should be large enough to allow water to flow through and drain without flowing over and onto the user while also narrow enough to avoid fingers getting caught as it moves. Nylon wheels with ball bearings reduce friction so that it can slide from side to side with minimal effort (see Figure 3.4). Horizontal nylon wheels also push against both side walls of this cavity to keep the whole assembly held tight as it slides and maintain a consistent gap for water to drain off.
Integrated on the slider are two components which require electricity. These components are an induction stove on one side and an appliance carousel with electrical outlets on the other (more details...
on these components below). To run power to these components, flexible cables connect from the side of the drain and into the induction stove. Another cable can run from the stove to the electrical outlets (see Figure 35 for illustration).

Figure 35: Flexible wiring for the slider assembly

Sink

The sink is directly in front the seated user. The cooktop and cutting surface can move in and out of this main workspace but the sink is always beneath it all which helps keep spills contained. The sink depth is 6” which is a comparatively shallow sink. This was chosen for 2 reasons. First, the sink needs to clear the top of the seated user’s legs while also keeping the top of the sink (and side slider) low enough to prevent the user from needing to keep their arms and shoulders raised in a tiring posture. 6” inches is about the maximum comfortable distance between knees and worksurface. And second, some
designers insist that Shallower sinks are more ergonomic for standing users because they don’t have to
bend the back to reach the bottom (Ott, 2013).

Also, there are not significant disadvantages to using a shallow sink. Generally larger/deeper sinks have
the benefit of being able to wash very large dishes without splashing out of the sink. Other than that,
the sink just become a place to store more dirty dishes. The target group for this design is senior living
apartments which generally have only 1 or 2 people in the household and are less likely to host events in
the apartment itself so they do not require big meals and large quantities of dirty dishes aren’t created
so quickly.

The drain is in the corner of the sink to allow for more leg room for seated users. It is far enough to the
side to install a garbage disposal without interfering with the leg room.

The faucet should be an articulating faucet like Kohler’s Karbon kitchen faucet (Figure 36) because it
needs to be installed extending down from the cabinets above the sink. This is so the slider with the
stove top can have more surface area and slide over the sink without the faucet getting in the way. One
reason for this faucet choice was due to the movement of the storage above the sink. These shelves in
the cabinet can be pulled out and come down to counter height (more details below, see Figure 47). If a
rigid faucet was used it would block this movement. Using this multi-armed Karbon faucet the moving
storage will simply push the faucet down and out of the way without a problem. User testing was done
to make sure that reaching the faucet and water control lever at this unconventional position would be
comfortable and accessible.

Figure 36: Kohler Karbon Faucet Image source: https://thegadgetflow.com/wp-content/uploads/2013/03/
Stovetop

A waterproof induction stove with 2 burners are integrated into the slider. It is common for cooktops to have 4 burners but people cooking small meals for only 1 or 2 people rarely use more than 2 at once so for this target user 2 is sufficient. Induction burners were chosen for this design though it’s possible that this system could be reconfigurable and customizable for the specific residents. Induction was seen as the best choice because it can be interchangeably used as a burner or as an extension of the counterspace. The stovetop area is a continuous flat surface (unlike gas stovetops or stoves with exposed burner coils) and the burners themselves do not get hot. They use a magnetic field to induce electric currents within the iron of the cookware so only the dish itself gets hot. So, when a hot pan, for example, is removed that space can immediately be used for other items. This also reduces the risk of the user burning themselves, even if they forget to turn off the burner. Also, the whole stovetop assembly can be manufactured very thin (1.5” or less) so it takes up less space in the sink as it slides over.

The burners themselves are somewhat outside the optimal workspace highlighted earlier. But that is not a problem because generally the hands don’t need to reach the burners since the user will be using a utensil to interact with a pot or pan. The common lengths of these utensils naturally allow the user’s hands to remain in the optimal space while a pot is being heated so this layout proved to be comfortable. This placement was also chosen for safety reasons. A seated user’s face is closer to the counter height than it would be for a standing user. If the burners were closer toward the front of the counter the risk of hot oil splashing in the users face while frying food would be much higher. This placement distances the burners from the user’s face to avoid this danger.

Appliance carousel

The right half of the slider assembly is a lazy-susan mechanism with electrical outlets in the center (see Figure 37). This can be used for a few purposes. First, people often have 3-5 common countertop appliances that they use frequently. For example, a toaster, electric kettle, slow cooker, and a mixer. This carousel allows access to all of these from the central position. They can remain plugged in to the column in the center and the lazy-susan can be rotated around so the user can access one at a time as seen in Figure 38.
Figure 37: Additional features in main workspace

Figure 38: Reaching appliances
Even with 4 appliances on the carousel, about half of the space on the carousel should still be available. This space could be used for other commonly needed items like ingredients or a knife block. Alternatively, it could simply be left open to have more space to set aside bowls of mixed ingredients, or dirty dishes during the process of cooking.

**Pour assist**

Based on the research, the most common task that was identified as being both difficult for seniors and also poses a danger for serious injury, is pouring hot water from a pot. A full pot can be very heavy and pouring it requires gripping thin handles with both hands and twisting the wrists in an awkward motion. A few of the research participants complained of difficulty performing this task. Losing grip means dropping the pot which can splash or spill large quantities of hot water onto the user which causes serious scalds. So, a key feature in this design addresses this issue. The handle for moving the slider surface is designed to double as a pot pouring aid (see Figure 37 and Figure 39). The pot can be dragged off the cutting surface a bit and onto the handle, which slightly tilts the pot without needing to lift at all. Once it is tilted and centered in the pouring aid it is captured such that the pot is stabilized and can’t easily roll forward or backward and the center of gravity is offset so that it takes very little effort to continue to tilt and pour. This action can be done with one hand making it easy to use this process with a utensil in the other hand to scoop contents out to serve onto another dish or into a strainer.

![Using the slider handle to assist with pot pouring](image39.png)
Left side space

To the left side of the sink there is 12” of space to keep temporary items like ingredients or dishes. Toward the back of the counter there is space for a trash chute through the counter. A trash bin can be stored under the sink and against the wall (on a platform which can pull out). The counter 30” deep which is 6” more than the standard counter depth and is big enough that a typical kitchen trash bin will not constrict the leg space. The trash chute is 10” x 6” which should be large enough for a majority of waste that will be made during the cooking process. Only for larger items will the user need to back up and pull the trash forward. The plastic lining of the chute is removable so that it can be washed.

Fridge

To the left of the main workspace is the refrigerating unit which is mounted into the counter (Figures 40 and 41). From the standard seated position, a user can reach just inside the opening of the refrigerator. The circular shelves can rotate like a lazy-susan so desired items can be rotated around to an easy access position. The height of the bottom shelf level with the rest of the counter so heavier items can be stored in the bottom and simply slide in and out instead of needing to be lifted. The top section is the freezer. Freezer shelves can also rotate. The highest shelf is still at a comfortable reach height.
The volume of the inside of the fridge is about 13 cubic feet and the volume of the freezer is about 6 cubic feet for a total of 19. This is comparable to many top-mounted freezer units that are often found in smaller apartments. Typical volume for this type of unit ranges from 10 – 25 cubic inches (RemPros, 2018). This is somewhat smaller than the most spacious refrigerators but seems sufficient since again, the target user lives in a household of only 1 or 2. Some of the residents that were interviewed at Clark-Lindsey complained that their oversized fridges were not necessary and took up too much space in their small kitchen.

Considerations were given to wall thickness. In general, the thickness of the walls of a refrigerating unit is important to energy efficiency. The thicker the walls are, the more insulated it can be and the more easily it will retain the cold temperature inside. Based on observations, typical refrigerators have a wall thickness of around 2.5” with 2” being the minimum. So, the wall thickness for this concept was set at 2” minimum. The width of the cooling system which runs along the back of refrigerators was observed to be about 3” thick so a pocket 3” wide was allotted to give ample space on the left side of the housing to integrate these cooling components (see figure 42).
Figure 42: Refrigerator section views
The door was designed not to swing open like typical fridge doors because that would interfere with the ability to set items on the counter in front of the fridge. To eliminate the possibility of knocking things off the counter when opening the door, it was designed to slide open following the circular contour of the fridge (Figure 42). The door runs along a sealed track at the top and bottom and should work well for compression seals on both sides of the door.

Oven

Under the fridge is the oven which is accessed by pulling the whole unit forward like a drawer (Figure 43). It is a convection microwave which can function as both a microwave for quick heating and as a traditional oven for baking. This technology has existed for several years but has not yet gained widespread popularity. It was chosen for this concept to give the user access to both functionalities within this workstation’s limited space.

Unlike typical ovens, the viewing window and door however are located on the top instead of the front. Looking down into the oven to check on the food is easier and more comfortable than it would be for traditional ovens which require bending over to peer into the side. To open the oven the top door slides back towards the wall. The platform inside the oven is designed with a scissor lift mechanism which allows the platform to raise up out of the oven and extend up to the level of the counter (Figure 44). The door slides open and, the inner platform can be raised to counter height. This allows dishes to easily slide from the counter onto the platform and into the oven from a comfortable posture.

Similarly to the refrigerator, considerations were given to wall thickness of the oven for feasibility and energy efficiency. Based on observations, typical ovens have a minimum wall/door thickness of around 2” so this was the wall thickness used for this concept. There is plenty of space in the back for the heating system and motor for the scissor lift system (Figure 45). Though much more research and design work would need to be done to resolve the engineering details.
Figure 43: Drawer-style oven

Figure 44: Raising oven platform
Dishwasher

Opposite the oven, below the counter to the right of the user, is the dishwasher. As stated earlier the drawer-style dishwasher is an improvement on typical dishwashers. Since the dishwasher was not one of the priority tasks the project did not focus on designing a new product. Instead an existing product was chosen to incorporate into the workstation. The Fisher and Paykel double DishDrawer was chosen (Figure 46). It has two sections which can be washed independently. This means that there can always be one drawer for clean dishes and one for dirty dishes. This way there is always a place to put the dirty dishes instead of the sink which would clutter up the main workspace.
Storage

The cabinets above the sink can be pulled down in order to reach the highest shelves (Figure 47). These function similarly to the existing product examples shown earlier. They use counterweights so that moving the shelves up and down takes almost no effort and they stay at whatever height they are placed. Without moving from their central location, a user can comfortably access the leftmost cabinet and some of the middle cabinet. These should be used to store the most common dishes and ingredients. Undoubtedly this will not suffice for all needs and the user will have to occasionally move to other storage spaces but these should significantly reduce the amount of times they need to get up and move around.

For smaller common items, like cooking utensils and measuring cups, there are utensil drawers are on either side of the sink (Figure 48). The fridge and slider both take up some of this space but only 2.5” below the counter height. This leaves around 3.5” of depth for these drawers. Based on the observations, this type of smaller storage was required as frequently as the large storage space for dishes and ingredients so both types needed to be included.
Figure 47: Pull-down shelving

Figure 48: Left side utensil drawer
To the right of the dishwasher is a section of drawers for more storage space. These are not accessible from the central position so they are not intended for the highest frequency use. All cabinets and drawers are ‘push-to-open’ so no outer handles are necessary.

Additional Considerations

Chair

Though it was decided that the chair itself was somewhat outside the scope of the project, considerations were given to what kind of chair that would be best for this workstation. It is recommended that a height adjustable chair with wheels be used. The perfect sitting height can vary from person to person and even 1” can make a significant difference so the chair height should adjustable for optimal comfort. If the counter is left at a comfortable standing height, a chair that is 23-24” high is the ideal height for the 36” high counter. This is around bar-stool height and some studies show that seats with this height are much easier for the elderly to use since it takes less effort to stand back up (Weiner, Long, Hughes, Chandler, 1993; Holden, Fernie, Lunau, 1988). A chair with wheels is recommended since it was discovered that scooting a chair forward while seated is actually very difficult for those with diminished strength or with back pain. Wheels should solve that problem.

Lighting

Many of the seniors who were interviewed mentioned how important it was to them that there be adequate lighting. This is especially helpful to those any kind of vision loss. So undercabinet lighting is integrated into the design to ensure abundant source of light close to the workspace.

Window

Earlier concepts had storage directly behind the sink. Feedback on these designs revealed that people felt like the space was too tight and constricted and also that they would be disappointed to lose the window view that most kitchens have behind the sink. For the final concept this space was used to maximize the depth of the slider which also allows for the window.
Chapter 7: Conclusion

This project studied the difficulties that seniors face in a traditional kitchen and which obstacles can be most dangerous. The design presented here explores an experimental kitchen layout and appliances with innovative features which could dramatically reduce these difficulties and enable seniors to continue to prepare a wider variety of meals for themselves and maintain their independence and dignity longer than they otherwise could.

General feedback on the design was positive. Most felt that there were several features which were appealing not only for seniors or those with limited mobility, but also the average healthy adult. Of particular interest were the rotating refrigerator shelves since many people find that refrigerators are too deep and reaching the back is somewhat a nuisance. Another feature which stood out to people was the pouring assist. It is a common task which people don’t think about much but when they see the pouring aid they realize how much easier the task could be. Again, many able-bodied adults were interested in this feature for themselves. This proves that the design was somewhat successful in being marketable to a wide market and not only seen as an assistive design for people with disabilities. This would hopefully make it more likely adopted by seniors who could really benefit from it.

There are many concerns about some of the design details. It may be an improvement in some aspects but present new problems or concerns with the new features. For example, some are concerned that the platform that extends up out of the oven presents a greater safety risk because the hot platform would be more easily leaned against or rubbed against with the legs. There are likely design features which could be added to minimize this risk but haven’t been explored yet. Some are concerned that sliding the stove top back and forth would make it more likely that the dish slide off. The model testing made the designer confident that the pot would not easily slide around and that the risk is not great. But more considerations should be given to features which hold the pot in place. There are many add-on products that exist which perform this function, or the design could take inspiration from boat kitchens which have features which help keep the dish stable. These could be options to add to this design.

The refrigerator and oven each could be their own design project and require much more exploration and engineering to determine their feasibility. These details were not explored in detail because the emphasis was the ergonomics of the overall workstation. But the next steps were this project to continue would be to explore the details of the scissor lift mechanism working inside the hot oven, and the sealing surfaces of the sliding fridge door track.
Other next steps would be to create a modular system so that the workstation was somewhat customizable depending on the preferences of the residents. Some people don’t use the oven much and some might want a specific counterspace. So for example, if space under the fridge could have several modular unit options where one could change the oven out for pull-out counterspace or the dishwasher could be replaced with a set of drawers to have more accessible storage space.
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Redlick, F., Cooke, A., Gomez, M., Banfield, J., Cartotto, R. C., Fish, J.S. (Sep, 2002). *Journal of Burn Care & Rehabilitation*, Vol. 23, No. 5, 351-356,


Appendix A: IRB documents
September 21, 2017

Jennifer Amos, Ph.D.
Bioengineering
1304 West Springfield Avenue
Urbana, IL 61801

RE: Human Factors and Safety for Seniors who Cook
IRB Protocol Number: 18159

Dear Dr. Amos:

This letter authorizes the use of human subjects in your project entitled Human Factors and Safety for Seniors who Cook. The University of Illinois at Urbana-Champaign Institutional Review Board (IRB) approved, by expedited review, the protocol as described in your IRB application. The expiration date for this protocol, IRB number 18159, is September 20, 2020. The risk designation applied to your project is no more than minimal risk.

Copies of the attached date-stamped consent form(s) must be used in obtaining informed consent. If there is a need to revise or alter the consent form(s), please submit the revised form(s) for IRB review, approval, and date-stamping prior to use.

Under applicable regulations, no changes to procedures involving human subjects may be made without prior IRB review and approval. The regulations also require that you promptly notify the IRB of any problems involving human subjects, including unanticipated side effects, adverse reactions, and any injuries or complications that arise during the project.

You were granted a three-year approval. If there are any changes to the protocol that result in your study becoming ineligible for the extended approval period, the RPI is responsible for immediately notifying the IRB via an amendment. The protocol will be issued a modified expiration date accordingly.

If you have any questions about the IRB process, or if you need assistance at any time, please feel free to contact me at the OPRS office, or visit our website at https://www.oprs.research.illinois.edu.

Sincerely,

Jennifer Ford
Human Subjects Research Specialist, Office for the Protection of Research Subjects

Attachment(s): Research team attachment, written consent form

c: Matthew Bowman
RESEARCH TEAM APPLICATION
Form to Report All Investigators That Will Participate in Any Way on The Research

IRB Number 18159
Responsible Project Investigator: Jennifer Amos

Project Title: Human Factors and Safety for Seniors Who Cook

☒ Submitting with Initial New Protocol Application
☐ Changing research team, date of submission __________

List all investigators engaged in the research study, including those from other institutions. Include all persons who will be 1) directly responsible for the project’s design or implementation, 2) recruitment, 3) obtain informed consent, 4) involved in data collection, data analysis, or follow-up.

Collaborators, outside consultants, and all graduate and undergraduate students should be listed if they will be responsible for these activities. Include all investigators named on grant proposals who will be engaged in human subjects’ research.

Note: Changes made to the Responsible Project Investigator require a revised New Protocol application and amendment form.

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Affiliation: ☐ University of Illinois Faculty ☐ Academic Professional/Staff ☒ Grad Student ☐ Undergrad Student ☐ Visiting Scholar, or ☐ Non-Urbana-Champaign campus Affiliate of (Institution):

Training: ☒ CITI Training, Date of Completion, 8-28-2017 see attached additional training, Date of Completion, ☐ Please check box if this individual should be copied on IRB correspondence
INVESTIGATOR ASSURANCES

I certify that the information supplied on this form is complete and correct and that new members of the research team will not engage in research until IRB approval has been obtained.

Responsible Project Investigator ___________________________ Date 09/15/17

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University of Illinois at Urbana-Champaign
Institutional Review Board

Approved: September 21, 2017
IRB #: 17154

1 Additional CITI modules may be required depending on subject populations or types of research. These include: (i) research enrolling children; (ii) research enrolling prisoners; (iii) FDA regulated research; (iv) data collected via the internet; (v) research conducted in public elementary/secondary schools; and, (vi) researchers conducted in international sites.
Industrial Design Department
University of Illinois at Urbana-Champaign

Human Factors and Safety for Seniors Who Cook

Investigators directing research: Matthew Bowman, Industrial Design Department, University of Illinois at Urbana-Champaign

Research project:

Homes and appliances are generally not designed with the elderly in mind despite predictions that by 2030 20% of the US population will be over 65. This older age group has different capabilities and needs which are therefore often neglected by product designers. This can lead to safety concerns, frustration, and loss of independence. Maintaining independence as people age is an important factor which contributes to prolonging physical and emotional health. Preparing meals is one of these daily activities that becomes increasingly more difficult. Additionally, burns are the second-leading cause of death from home accidents among older adults and most burn and scald injuries happen in the kitchen.

The end goal of this research is to design an appliance to aid the seniors, who may have limited strength, mobility, or vision, to cook or prepare food with greater ease and safety. In order to design for their needs, research needs to be done to better understand their cooking habits, difficulties, and attitudes.

What will be required of you:

By participating in this project, the data you provide will be used in the publication of the research. The research will be performed through semi-structured interviews and observation. The context of a participant's habits can give meaning to their behaviors and make it possible to understand their behavior better. The objective of the interview is to gather contextual information on each participant to thoroughly understand their experience with cooking, their cooking habits, safety concerns, and difficulties with cooking.
Potential Risks:
There are minimal risks associated with participation in this study beyond those risks participants experience when they engage in cooking activities at home.

Benefits:
Using this research, I will design an appliance to aid the elderly, who may have limited strength, mobility, or vision, to cook or prepare food with greater ease and safety. This will aid them in maintaining independence with food preparation. Maintaining independence as people age is an important factor which contributes to prolonging physical and emotional health.

People over age 65 are much more vulnerable to burn injuries than other age groups. The majority of burn and scald injuries occur in the kitchen. Kitchen equipment that have features which help prevent burns or scalds will be an important part of the design. Thus, this has the potential to create a more comfortable and safer kitchen for the seniors, provide more independence, and save lives.

Your participation will give us insight into cooking habits and needs so that this appliance can solve these ergonomic and safety issues.

Confidentiality:
All data generated by the study will managed though the online secured data management system provided by the research site institution. All data files (e.g. survey responses and recordings) will be filed with a pseudonym to protect the identity of the participants. The data management plan will be consistent with the IRB standards. Access to the data for study will be limited to the research team and only summary information will provided to the advisory board members and published in the dissemination outlets (e.g. journals and conference papers).

In general, we will not tell anyone any information about you. When this research is discussed or published, no one will know that you were in the study. However, laws and university rules might require us to disclose information about you. For example, if required by laws or University Policy, study information which identifies you and the consent form signed by you may be seen or copied by the following people or groups:

- The university committee and office that reviews and approves research studies, the Institutional Review Board (IRB) and Office for Protection of Research Subjects;
- University and state auditors, and Departments of the university responsible for oversight of research

**Voluntary participation and withdrawal:**
Participation in the research is voluntary. You are free to stop participating at any time with no penalty.

**Dissemination of findings:**
The results of the research may be published in journals and presented at lectures and professional meetings, but you will not be identified in any such publication or presentation.

**Contact Information:**
You will be given a copy of this consent form for your records. If at any time, either now or later, you have a question, please feel free to ask it. If you have any questions about your rights as a participant in this study or any concerns or complaints, please contact the University of Illinois Institutional Review Board at 217-333-2670 or via email at irb@illinois.edu If you have any questions about this particular study, you may contact Matthew Bowman at 801 368-6115 or by email at mibowma2@illinois.edu.
Agreement:
By signing this document, I am stating that the nature of the research has been explained to me. I am also stating that I have had the opportunity to ask questions concerning any and all aspects of the procedures involved. I understand that I must be over 18 or older to participate in this study. I am also aware that participation is voluntary, that I may withdraw my consent at any time, and that if I decide not to participate or decide to withdraw my participation, I will not be penalized in any way.

I am over 18 years old: _____ YES _____ NO

Please indicate below whether you are voluntarily choosing to participate in this study.

PARTICIPATE: I, the undersigned, hereby consent to be a participant in the research project described above conducted at the University of Illinois.

Signature of participant: ______________________________________________

Printed name: _______________________________________________________

Date: __________________________________________________________________

Signature of investigator: ______________________________________________

If you are agreeing to participate, please also fill out this section:
Photos and video recording are often used to ensure the accuracy of the information. Please check the box that indicates your willingness to be photographed and filmed. This images and videos may be used in a publication or presentation of the research.

_____ YES: I consent to be photographed and video recording taken of me during the interview process

_____ NO: I do not consent to be photographed and video recording taken of me during the interview process

University of Illinois at Urbana-Champaign
Institutional Review Board
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Appendix B: Recruitment Materials
Do you cook?
We want to know why or why not. Participate in our research study!

Kitchens and appliances are generally designed for people ages 18 - 65. Seniors may have different needs and preferences which are therefore neglected by product designers.

I am a design student and I would like to interview anyone interested to understand your cooking habits and thoughts.

I hope to use this research to design new and better appliances.

If interested in being interviewed please contact Matthew at (801) 368-6115 or mlbowma2@illinois.edu
Like to cook?
Get a demo of this experimental kitchen design and give your feedback.

The end goal of this project is to design a more ergonomic kitchen which minimizes how much the user needs to move or lift.

If interested, contact Matthew at (801) 368-6115 or mlbowma2@illinois.edu
Appendix C: Interview questions

Demographics

Name
Age
Sex

Ethnography

About how often do you cook?
Which meals do you prepare?
How important to you is it to you to be able to do your own cooking?
Why do you like cooking? What about cooking don’t you like?
Who else uses your kitchen?
Which appliances do you use most? Like most?
Which appliances do you not like using?
What difficulties do you face when using your kitchen?
Is there anything you find frustrating when preparing your food?
Are there dishes that you used to make often, that you don’t like doing anymore?
Are there tools/appliances that you used to use often that you don’t like using anymore?
Have you or anyone you know ever had a serious burn in the kitchen and how did it happen?
Have you or anyone you know had any serious accidents in the kitchen? What happened?
Are you very concerned about safety hazards or risks of injury while cooking? What in particular
Are there any improvements you would like to see in kitchen design / appliance design, to make
things better to use?

Disability

Do you have any condition which makes it more difficult to cook such as arthritis? Please Explain.

Following up

Would you be interested in a follow up interview?
Would you be interested in a follow up to show me your kitchen and how you cook a typical meal?