The Potential for Tele-Presence to Assist and Aid with the Supervision of Medication Self-Management

Thesis

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Abstract

Medication self-management is a complex and challenging issue. There have been many different methods and mechanisms created to assist individuals who manage their own medications. Pill boxes, new icons for medication labels, automated pill dispensers, and even phone calls reminding patients to take their prescriptions have all fallen short in the quest to help people appropriately self-medicate. This study looks at how the addition of tele-presence to a dynamic automated medication dispensing device can benefit individuals, and help them to better administer their medications. Through the tele-presence, patients can easily be connected to a variety of caregivers, including family members and the patients’ doctors. The main goals for this device are to allow patients to remain independent longer, to enhance understanding of the medications the patient is taking, to keep caregivers informed of the patient’s current status, to allow improved continuity of care, to better respond to the dynamic nature of health, to improve quality of life, and to provide peace of mind for not only the patients but also for their caregivers.
Dedication

This paper is dedicated to everyone who helped me through my erratic but purposeful journey through higher education, especially my family and friends. I would especially like to thank Kyle Van Volkinburg for all of his support and encouragement throughout this process.
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Chapter 1: Why Successful Medication Self-Management is Important

In this paper, medication self-management is defined as one’s ability to take medications prescribed by a health care professional. Successful medication self-management leads to the alleviation of symptoms, the treatment of diseases, and other positive outcomes related to the condition for which the medication was prescribed. When patients are unable to successfully manage self-medicating, many complex and detrimental problems can occur. It must be remembered that any complex system, such as health or health care, is highly interrelated and coupled, with deficits in one area able to cause negative effects in other areas of that system. For example, cognitive issues can cascade and create problems “critical to safe and independent living” (Carlson, Fried et al. 2005).

Both direct and indirect consequences of unsuccessful medication self-management must be considered in order to get a systemic view of the health of an individual. It has been determined in one study that 5.5% of hospital admissions result from poor adherence to one’s medical routine, (Dowse and Ehlers 2005) while another claims that up to 19% of hospital visits are related to non-adherence (Hayes, Larimer et al. 2009). Problems arise for both the community and individuals when people are unable to successfully self-medicate, such as the fact that it becomes very difficult for
doctors to prescribe the proper doses or to determine the efficacy of medications that the patients are taking (Connor, Rafter et al. 2004). The cost of patients unsuccessfully self-medicating can be seen through the increasing prices of insurance, drug resistance from incompletely treated infections, wasted medication (Ryan-Woolley and Rees 2005), and through other means, such as patient health and healthcare costs (Shrank, Avorn et al. 2007). It is estimated that drug errors and adherence issues cost between $50 billion and $100 billion yearly, in the United States alone (Dowse and Ehlers 2005; Shrank, Avorn et al. 2007). Non-adherence leads to hospitalizations, higher health care costs, and mortality (Mackin and Arean 2007). There can also be ineffective treatments and analysis of treatments if medications are not taken properly (Farris and Phillips 2008).

The overarching goal of this study is to allow elderly patients to remain in their own homes longer. In order for this to happen, patients have to remain generally independent, and able to function. Family members often act as overseers for the patient to ensure the patient is able to continue to live on his or her own. This study looks at a way for patients to be connected to family members, who can then check that the patients are still able to successfully function on their own. The family members and caregivers can then provide the patient with any needed assistance. The family members also need to ensure the patient is able to self-medicate successfully. Managing self-medication is one of the key activities which must be dealt with for independent daily living. This study looks at a means for extend the patient’s abilities and helps family and other caregivers to assess the patient’s medication management capabilities. Thus, the family
members or caregivers are able to both assess and assist the patient while the patient remains in his or her own home.

The author has chosen not to say “non-adherence” or “non-compliance” in this paper when she is referring to patients on a medical regimen, unless it is the terminology used in a referenced source. Generally, these are widely used terms and they appear in most of the literature on this topic. Yet using either of those phrases infers that the patient is resistant, or simply unwilling, to follow the prescribed medication schedule. This is not the case. There are many reasons why a patient may not exactly follow a medication regimen. Patients should be appreciated for their efforts, and aided with any shortcomings.
Chapter 2: General Obstacles to Successful Self-Medication

There are several distinct steps to successfully self-medicate. Some of these steps include taking the medication at the designated time(s), taking the proper medication at the given time, and obtaining refills of medication before running out (Beckman, Parker et al. 2005). A more complete set of challenging aspects of medication self-management will be listed in the following section. A systems approach towards the problem of medication self-management takes into account the specific illness, health systems, support system, the patient, and other factors, and realizes that all of these aspects play a role in successful management of self-medication (Connor, Rafter et al. 2004). Further, when adverse events occur, physical, technological, psychosocial and cultural elements all contribute to the event, be it an accident in a nuclear power plant or not taking one’s medications (Buckle, Clarkson et al. 2006). Medication self-administration is a complex, multidimensional issue.

Taking medications is a complex process that requires multiple cognitive processes and physical strength, amongst others demands (Beckman, Parker et al. 2005; Hayes, Larimer et al. 2009). Older adults often have chronic conditions and tend to require more medications (Carlson, Fried et al. 2005; Farris and Phillips 2008). There have also been studies performed that show cognition interacts with medicine regimen
complexity (Maddigan, Farris et al. 2003). This can be an additional problem for older adults. Age is related to changes in capacity, including that needed to successfully manage self-medication (Farris and Phillips 2008). Aging could diminish both vision and cognition by affecting underlying attributes involved in both of these components of taking medication (Windham, Griswold et al. 2005).

The general process of comprehension places demands on general cognition (Levinthal, Morrow et al. 2008). Cognitive impairment affects one’s ability to successfully take medication, and studies have shown that adherence may be more related to cognitive status than previously shown. In one study, a group of participants with lower cognitive functioning exhibited a 27.8% rate of medical adherence, while the higher cognitive functioning group exhibited 75% adherence (Hayes, Larimer et al. 2009).

Taking and managing medications is a skill required for independent living, and is one that can be supported through different aids (Hayes, Larimer et al. 2009). For example, both older and younger individuals have a difficult time with reading small text, so this should be avoided regardless of the age of the individual (Filik, Purdy et al. 2006). Universal design is the concept that products and systems should be able to be easily utilized by a variety of users with different capabilities, in a variety of different situations. The principles of universal design include having a design (1) that is usable by people with a wide range of abilities, (2) that can take into account different user preferences, (3) that is simple and easy to understand without requiring special skills, (4) information provided by the device is effectively communicated to the user, (5) that incorporates
sufficient tolerance for mistakes and errors, (6) that does not require excess physical
effort and that (7) is an appropriate size and takes up an acceptable amount of space
(Connell, Jones et al. 1997). The practices of universal design should be applied to assist
individuals in successful medication self-management. In general, problems arise with self-medication when the demand of the medications (therapeutic self-care) exceeds the
ability of the patient (self-care agency) (Maddigan, Farris et al. 2003).
Chapter 3: Why Taking Medication Successfully is Difficult for Individuals

Everyday life is analogous to managing a complex and dynamic system. Taking medication is just one segment of the system, but one with potentially significant impact. Good health is a pre-requisite for many daily activities. However, without successful self-management of medications, many activities based on health are unable to be performed by the patient. While taking medication is only one part of staying healthy or preventing worsening health, it is quite necessary. Looking at self-medication, to the exclusion of other aspects of the patient’s biological and psychosocial environment, is detrimental to establishing good health and a good life, but realizing the role that medication plays can assist the patient in becoming a successful partner and contributor to their future.

What makes successful management of medication challenging? There are different individual factors and reasons which fall into fourteen general categories. However, many factors are somewhat overlapping and can be put into multiple categories. The author has organized these factors into comprehensive categories. The placement is open to argument. The fourteen categories are (1) the patient’s personal beliefs and issues, (2) interruptions of life, (3) physical difficulties, (4) traits of the medication, (5) the complexity of the medical regimen, (6) the patient’s cognition,
(7) transportation concerns, (8) the patient’s finances, (9) the medical instructions, (10) medication storage, (11) traits of the patient, (12) governmental issues, (13) traits of the disease, and (14) the presence of assistants or caregivers. Each of these principles will be discussed in terms of their relevance to medication self-management.
Patient’s Personal Beliefs and Issues

Personal beliefs about medication are a large contributor to the patient’s motivation and willingness to take medication (Ownby 2006). Personal and cultural views on taking and needing medication influences self-medication (Arlt, Lindner et al. 2008). How much patients “own” their condition and treatment, and take responsibility for it, relates to the likelihood that the patients will follow through with their self-medication regimens (Buckle, Clarkson et al. 2006). Sometimes, patients do not want to take medication because they do not think the medication is helping them. Other times, patients are weary of having medical issues and so do not want to continue taking medication (Simons and Blount 2007). Motivation to take medication is also related to what kind of mental model the patients have formed of their disease, and how the medication plays a part in the disease’s regulation (Klein and Meininger 2004).

Motivation is another aspect of personal beliefs affecting successful self-medication. Even if other obstacles are overcome, if a patient does not want to be a partner in their health management, self-medication will not be successful. Self-medication is a complex, multidimensional phenomenon (Dowse and Ehlers 2005). Any element examined in isolation (such as solely focusing on the patient), if solely focused on, will not lead to sufficiently improved self-medication. Each factor interplays with other factors to create an emergent property of successful self-medication and health maintenance.

If a patient refuses to take medication, or simply does not take the medication, a single point of failure exists (Kairuz, Bye et al. 2008). Patients who are forgetful of
taking their medications, or who do not attend their medical appointments could also be lacking motivation to take adequate care of their health (Carlson, Fried et al. 2005; Mackin and Arean 2007). Further, patients may change their medication dose according to whether they feel better or worse on a given day (Ryan-Woolley and Rees 2005; Kairuz, Bye et al. 2008). Patients may also be under the impression that the medication is not helping them. If the medication is not producing any positive or noticeable health effects, the patient may decide to not take the medication (Carlson, Fried et al. 2005). Problems can arise due to the patient not taking the preventative medicines, and a downward spiral can begin.

**Interruptions of Life**

Medication can cause interruptions in life, and alternatively, medical regimens can be thwarted by daily interruptions. A patient may not be at home when they need to take the medicine, or he may be too busy or preoccupied to take it. The dosage times for the medication may be inconvenient, interrupting a favorite show or a regular bathing time (Sleath, Krishnadas et al. 2009). The medication may hinder an activity or hobby of the patient, and place other restrictions on activities (Ownby 2006). There may even be a phone call or knock at the door which causes the patient to forget to take their medication, or forget if they have already taken it.

**Physical Difficulties**

Physical issues can be impairments or restrictions that the individual possesses which hinders her ability to interact with her medical regimen as intended. Individual
factors which fall into this category are vision, arthritis, hearing, or a delayed swallowing reflex (Kairuz, Bye et al. 2008). Reduced manual dexterity is another issue that could force an individual to be unable to take medication (Sleath, Krishnadas et al. 2009). Sometimes a patient may drop a pill and not realize that they have done so. This is especially problematic for individuals with diabetes who could have sensory impairment in their fingers and not be able to feel the pills. Vision also affects one’s ability to differentiate between pill colors and being able to read the small print size on medication bottles (Beckman, Parker et al. 2005; Buckle, Clarkson et al. 2006). Sometimes the individual is simply too sick to be able to take the medicine (Simons and Blount 2007).

Opening blister packages or bottles poses challenges for many individuals (Buckle, Clarkson et al. 2006). Patients with arthritis or other conditions which reduce strength are particularly vulnerable to their physical abilities complicating self-medication. Negative side effects are another factor that leads to physical issues interfering with self-medication (Mackin and Arean 2007; Arlt, Lindner et al. 2008; Kairuz, Bye et al. 2008). If a patient has a disease with dynamic symptoms, such as high blood pressure level, it is difficult to tell whether or not the medication should or should not be taken without proper biofeedback. Possible side effects or complications can arise if the patient is not correctly self-medicating.

Traits of the Medication

Traits of the medication itself can influence the ease or complexity of successful medication self-management. If the medication is to be inhaled or injected, the route of
entry can pose problems for individuals who may be squeamish or lack the physical strength required for the dosing mechanism. Side effects of the medication are again a problem if they cause sufficient distress to the patient. Also, some medication must be taken with food or water. If the patient is unable to access food or water this presents another problem.

Many medications have side effects. If a patient is not knowledgeable about the possible side effects related to the medication, she may become concerned and not continue with the medication. A lack of understanding of the purpose of the medication can lead to patients not taking their prescriptions. Fear of a particular side effect can also influence patients to not take a medication. Patients tend to forget some of the counseling they received from the doctor, and so may be surprised by a certain side effect or result of the medication (Shrank, Avorn et al. 2007).

**Complexity of the Medical Regimen**

The medication regimen and issues related to it can lead the patient to be more or less likely to self-medicate successfully. One of the most basic problems with a complex medical regimen is what to do if one misses a dose. If the patient has lost the instructions, or is unable to interpret the terminology, the potential for successful self-medication dramatically decreases.

The amount of medication that the patient must manage is a large contributor to the complexity of self-medication (Carlson, Fried et al. 2005; Mackin and Arean 2007; Arlt, Lindner et al. 2008; Hayes, Larimer et al. 2009). The more medications there are to
handle, the more possibilities there are for interactions, side effects and confusion. Complexity is a significant obstacle to successful medication self-management (Carlson, Fried et al. 2005). Sometimes the dosage of medications change intermittently, and patients must remember what amount to take depending on where they are in the medication series. If the patient is taking two medications with similar sounding names or similar packaging, an extra measure of caution must be executed (Buckle, Clarkson et al. 2006; Filik, Purdy et al. 2006). Many medical regimens are not adaptive to the patient’s current needs or state, and so are not able to meet the dynamic changes necessary to control the disease.

The Patient’s Cognition and Other Cognitive Considerations

Cognitive issues can be a considerable roadblock to self-medication. Cognitive abilities and limitations, reasoning, knowledge, and judgment all come into play when following a medical regimen (Maddigan, Farris et al. 2003). Perceived barriers to taking medication and lack of knowledge about medication greatly influence the complex cognitive task of taking medication (Mackin and Arean 2007). Patients often forget if they have already taken their medication. Misplacing medication is another symptom of cognitive issues that can be a detriment to medication self-management. If a patient is stressed, anxious or depressed, they are less able to give full attention to the medication’s regimen (Mackin and Arean 2007). Also some medical issues, such as dementia, affect cognition and one’s ability to navigate complex medical regimens.
A patient’s intellectual aptitude and organizational skills can help to somewhat overcome cognitive issues (Ownby 2006). Confusion about a dosing schedule, along with poorly organized medical information, can degrade one’s ability to successfully self-medicate (Buckle, Clarkson et al. 2006). Highly complex medication schedules that the patient cannot understand are one of the most well documented problems affecting medication self-management.

**Transportation Concerns**

The issue with transportation is related to the means that patients have at their disposal to get around. If the patient has family members in the area they may be able to help the patient, but the family members may be too busy with work or caring for children to provide assistance. If patients do not have cars, are unable to drive, or are far from public transit, they will have a difficult time getting to a pharmacy to refill their medication. Using a cab may be cost prohibitive for some patients. Further, some medications have side effects that place limitations on patients’ abilities. These include warnings for patients not to drive while on certain medications.

**The Patient’s Finances**

Prescription medication can be quite expensive. Some patients do not have enough money for their medications, and so must cut pills in half or take them every other day. If the patient has insurance, this situation may be alleviated, but this is not necessarily the case (Ownby 2006).
Medical Instructions

The patient needs to be able to interpret the instructions and directions that accompany the medications in order to be able to self-medicate (Beckman, Parker et al. 2005). Medication labels are another potential source of confusion related to proper medication management techniques (Shrank, Avorn et al. 2007), and do not help patients recall where they are in their daily regimen (Leysia and Stinne 2006). Many labels and instructions have text sizes that are small and difficult to read (Buckle, Clarkson et al. 2006). The information on the medical instructions may not be organized in a coherent manner and causes people to hunt for the answers to their questions among a large amount of technical information and abbreviations (Buckle, Clarkson et al. 2006). Even if pictures are added to the labels to improve comprehension, studies have shown that images and symbolic information are difficult to interpret (Fisk and Rogers 2002). The language in which the information is written, as well as the amount of medical jargon or number of abbreviations, are related to higher cognitive taxation. Many labels and pamphlets given to patients are not very durable, and with normal use these information sources could deteriorate or be lost (Buckle, Clarkson et al. 2006).

Medication Storage

Storage is another potentially significant barrier to successful medication self-management. If patients throw away the original bottle when putting medication into a pill organizer, or decant their medication, valuable information provided by the original bottle or container is lost (Buckle, Clarkson et al. 2006; Kairuz, Bye et al. 2008). The use
of aids such as a pillbox or automated pill dispensing system can assist with physical challenges, but still do not retain information about the medication such as the reason for its use (Carlson, Fried et al. 2005).

Traits of the Patient

Attributes of the patient are significant factors in self-medication. Age, gender, overall health as in the presence of depression or anxiety (Mackin and Arean 2007), socio-cultural influences, the individual’s health care system, family, patterns of living, the environment, and the resources available have often been related to the level of self-medication success (Maddigan, Farris et al. 2003; Ownby 2006). Other factors include education level, which is related to not being able to read directions or instructions written at a high reading level (Kripalani, Robertson et al. 2007), smoking, drinking alcohol, and ethnicity (Arlt, Lindner et al. 2008).

The amount of exposure and experience that people have previously had with medication can also influence successful self-medication (Carlson, Fried et al. 2005). The patient’s knowledge of the regimen and the purpose of the medications can lead to patients more easily being able to self-medicate than if they were not knowledgeable or had created poor mental models of their medication (Arlt, Lindner et al. 2008). The mental or developmental state of the individual is another personal factor that can have a large influence on the ability to self-manage medications (Maddigan, Farris et al. 2003). Living alone and not having another person around to remind patients when to take their
medication, or if the patient already has taken the medication that day, puts more responsibility and pressure on the patient (Arlt, Lindner et al. 2008).

**Governmental Issues**

The type of assistance that the government provides can aid or hinder individuals who are tasked with medication self-management. Different health care systems may provide more monetary support for patients. The type of government also influences the resources that are available for patients (Maddigan, Farris et al. 2003).

**Traits of the Disease**

The disease itself can require a complex medication schedule (Connor, Rafter et al. 2004). For example, patients with Type 2 diabetes have a dynamic condition that has to be constantly regulated in order to ensure that blood sugar is neither too high nor too low (Klein and Meininger 2004). As mentioned before, certain diseases or complications from diseases can affect the patient’s cognition and ability to self-medicate. Some diseases also make the patient more susceptible to side effects of medications (Hayes, Larimer et al. 2009).

**Presence of Assistants or Caregivers**

If the patient does not have a healthcare assistant or spouse that can help them with their medications, the probability of successful medication self-management decreases (Carlson, Fried et al. 2005). No amount of good design or engineering can ensure a patient will be able to successfully self-medicate if key problematic factors are not understood and addressed first. Having an assistant to help a patient with medication
can be very effective. If there is no one checking in on patients, they may forget to take their medications, or may stop taking their medications all together. However, it is also problematic if there are multiple people checking on a single patient and the caregivers do not clearly communicate with each other. While any one caregiver may know if the patient took her pills while that caregiver was present, they may not know if the patient took other medications before the caregiver arrived. If the patient is unable to open or administer medication, a caregiver or aid of some sort is needed (Sleath, Krishnadas et al. 2009).

To summarize, most people that self-manage their medications are able to do so with some success. However, their degree of success hinges upon a multitude of interrelated factors, where the failure of any one factor can prevent a positive outcome. Everyone occasionally experiences confusion, or may forget to do something, and unfortunately, life is not a well organized and structured series of events with built-in reminders. Thus, we have to aid and remind ourselves by putting information into our environment, and by putting knowledge in the world so it does not have to be kept in the head. This helps to ensure that critical tasks, such as medication self-management, are accomplished successfully.
Chapter 4: Existing Ideas to Aid in Medication Self-Administration

Everyday competence relates to how well people can perform actions to remain independent (Beckman, Parker et al. 2005). Self-medication is a patient-managed aspect of health care (Farris and Phillips 2008). Everyone, especially the elderly, needs to be able to self-medicate safely and effectively (Drummond, Drummond et al. 2004). There are multiple types of information that can be, and are, distributed with medications (Shrank, Avorn et al. 2007). However, too much information accompanying the medication can make patients feel overwhelmed (Praska, Kripalani et al. 2005). Communication, patient education, and the use of aids, such as medication cards, are possible ways to alleviate this issue (Kairuz, Bye et al. 2008). Poor communication about medications is particularly problematic for the elderly as they have age-related declines in cognitive resources necessary for comprehension, which complicates making inferences (Morrow, Leirer et al. 1996).

Multiple studies have shown that having patients self-report on their adherence produces either under or over estimates (Owsley, Sloane et al. 2002), reporting biases (Buckle, Clarkson et al. 2006) or unreliable reports (Ownby 2006). Self-reports are subject to memory and social desires (Owsley, Sloane et al. 2002). There is a noted
disconnect between perceived adherence and actual adherence (Mackin and Arean 2007), not unlike the disconnect between the blunt (healthcare system) and sharp (patient) ends of different cognitive systems. Further, there is a distinct mismatch between objective measures of performance, and subjective judgments of performance, in human factors (Filik, Purdy et al. 2006). This is why it is desirable to have some external reminder and tracking system assisting patients with taking their medications.

To address these issues one needs a systematic approach, which starts with looking at interacting factors and realizing that knowledge is held by different stakeholders at different levels. There are inherent dangers in considering an element in isolation, as mentioned previously. User-centered design leads to better and more competitive products, especially in complex situations such as medication self-management (Buckle, Clarkson et al. 2006).

It has been found that 30% of all medications in the United States are taken by people 65 and older (Nikolaus, Kruse et al. 1996). The elderly take three to four drugs on average (Nikolaus, Kruse et al. 1996), and 58% of community-dwelling older adults take three or more medicines (Windham, Griswold et al. 2005). This means that medication self-management is an important issue for the elderly. Older adults have an average non-adherence rate of 20-50% (Mackin and Arean 2007; Shrank, Avorn et al. 2007), with older adults in developed countries normally exhibiting only 50% adherence to long-term therapy (Dowse and Ehlers 2005). The prevalence of cognitive impairment increases with age and can hinder medication self-management. Additionally, older patients tend to have more medical conditions (Arlt, Lindner et al. 2008). However, it must be recalled
that not only the elderly have difficulty with medication self-management. Cueing mechanisms and aids can assist anyone who is on a medical regimen and provide an extra reminder or source of assurance that one’s medications were taken. With the many different factors that make medication self-management challenging, a cueing device needs to be able to address these diverse areas without introducing new sources of possible errors or problems.

There should be some sort of cueing method for patients to help them take their medications (Ryan-Woolley and Rees 2005). Sometimes people put medication to be taken at night near a bed-stand, which provides a type of memory aid (Kairuz, Bye et al. 2008). Humans exhibit a preference for event-based reminders over time-based reminders, so pillboxes or schedules that are based around things such as meals have been shown to be more effective (Arlt, Lindner et al. 2008). Some aids that have been developed include putting multiple medications into a single pill (fixed-dose), or putting multiple pills into a single blister pack (Connor, Rafter et al. 2004). A number of pharmacies even will create personal blister packs for patients (Kairuz, Bye et al. 2008). Even so, preparing individually tailored medication packs or schedules is time consuming. Opening blister packs and security seals may pose problems for the elderly. Further, personally tailored blister packs are not an option that is widely available.

Therefore, many elderly patients rely on pillboxes.

Seventy percent of elders use pillboxes or other reminders to assist them in taking their medications (Windham, Griswold et al. 2005). The use of a pillbox has been shown to increase adherence in one study 4.5 times (Ownby 2006). Yet there have been other
studies that have shown some elderly people have problems with medication organizers, so this may not be the best option for everyone (Connor, Rafter et al. 2004). Further, pill counts from medication organizers or medication bottles as a means to verify compliance are inaccurate ways to measure patient self-administration. There is a possibility of the patient throwing away unused pills, or decanting the medication, destroying the integrity of the count (Osterberg and Blaschke 2005). When patients transfer medications into another container, such as a medication organizer, labels and safety information that are necessary for the medication to be properly taken may be discarded (Kairuz, Bye et al. 2008). For people who have arthritis or poor manual dexterity, a pillbox could also be challenging to use. Pillboxes are not able to hold liquid medications or medications that are inhaled (Kripalani, Robertson et al. 2007). Also, medication organizers are not good for certain types of pills, or large pills that will not properly fit into the compartments (Kairuz, Bye et al. 2008).

On medication labels, using different colors, designs, or capitalizing some letters makes it easier to tell different medications apart (Filik, Purdy et al. 2006; Kripalani, Robertson et al. 2007). Other methods to aid in helping patients differentiate medications and increase understanding of the medication include using larger or bold print, explicitly stating the condition the medication treats in an easily visible manner, and not using abbreviations or shortened warning labels (Kairuz, Bye et al. 2008). However, these methods require that pharmacies change their labeling system, or that drug manufacturers develop different labeling techniques. Some text or color combinations could be proprietary, and thus the company would not willingly change the design of their
product. There must be a fair amount of buy-in from the different producers and sellers of medication before the aforementioned techniques would be feasible.

Humans have a cognitive preference for pictures over text, and images have been demonstrated to help people with forming mental models (Katz, Kripalani et al. 2006). Text and pictures together have been shown to produce better recall in patients, which is called the “pictorial superiority effect” (Houts, Doak et al. 2006; Katz, Kripalani et al. 2006). People who received illustrated instructions were significantly more likely to do what was recommended in the instructions, and the combination of text plus images was related to patients being 1.5 times more likely to give the right answers to questions about their medical regimen (Houts, Doak et al. 2006). Yet providing images or pictures exhibits many of the same challenges as changing the font or the color on a medication label, and may meet much of the same resistance.

The use of culturally sensitive icons has the ability to improve comprehension (Shrank, Avorn et al. 2007), and people prefer icons that reflect their culture (Houts, Doak et al. 2006). Pictures provide a context for organizing information, and simple pictures are the most effective in improving comprehension. It has been demonstrated that the use of captions can reduce ambiguity and misinterpretations of images by patients. The use of images was shown to allow a group of patients to be significantly more likely to remember content, to follow instructions, and to properly answer more comprehension questions than a group who just read text. However, the patient must understand the elements the picture is trying to explain, and be familiar with them, to
create a picture or icon that is beneficial (Morrow, Leirer et al. 1996; Houts, Doak et al. 2006).

One study used medication labels that had blank clock faces to be filled in by the doctor to indicate the times that the patient should take the medication (Dowse and Ehlers 2005). However, timelines have been shown to be more effective than clock face icons. Timelines are also particularly useful for Americans as timelines are read left to right like English text, and are similar to calendars that people already use for memory aids (Morrow, Leirer et al. 1996). Pictograms have been demonstrated to improve the accuracy of timing for taking the medication, for influencing patients not to take the medication on an empty stomach if the medication requires food, for completing the entire regimen of medication, and for dealing with complex medical regimens. The most easily understood pictograms utilize realistic colors, draw images to scale, use appropriate magnification, and maintain an uncluttered background (Katz, Kripalani et al. 2006).

Icons may help to integrate information into organized mental models that represent the task the patient is to perform. Icons are less likely than text to tax working memory, and as this capability declines in the elderly, this is especially helpful for this group. Icons also may be more compatible than text instructions with how people represent spatial information.

The use of pictograms, or to-be-filled-in clock faces, require more time from professionals and create more demand on them and their workplace (Dowse and Ehlers 2005). One study determined that the creation of information cards for patients by a
pharmacy, including materials, would cost around $5 per card, which could be cost prohibitive for a smaller pharmacy (Kripalani, Robertson et al. 2007). Pictograms enhance comprehension and recall, but can be misinterpreted by a patient (Dowse and Ehlers 2005). In one study there was preliminary misunderstanding of images, but in the real world patients are to receive counseling about the image’s meanings to prevent this. One cannot simply introduce images and expect patients to understand their meaning without both counseling and testing of the images. However, even though more time and effort is initially required to counsel and inform patients about icons and their meaning, after training the same icons could be used on all medications to increase comprehension (Hanson 1995). Again, images should be accompanied with captions and explanatory text to support understanding (Katz, Kripalani et al. 2006).

Some electronic devices have been created which are put into the cap of the medication bottle that allow patients to see how many times they have taken their medications and when they last took them. This information can also be viewed and formatted by the patient’s caregivers and doctors. Yet this method does not protect against patients improperly taking the medication, or taking improper amounts of the medication (Balkrishnan 2008). Just because a patient has opened a pill bottle does not mean that the medication was taken. A bottle can be opened and closed with no pills being removed, the incorrect number of pills can be taken, the pill bottle can be decanted, or multiple doses of medication can be removed at one time. Medication bottles that have electronic monitors in the lid can be thwarted by these occurrences.
Using an automated pill dispenser is another way that patients can use a physical organizing aid to assist them in medication self-management. There are many different models available on the market, but some are not much more than pillboxes with attached alarms that produce auditory signals when the patient is to take the medication. Even some devices that help to eliminate the physical challenges of medication self-management can only hold up to a week’s worth of medication, requiring more frequent refilling than some pillboxes. Also, devices that provide the most features for the patient are the most expensive (Wakefield, Orris et al. 2008). These features consist of things such as reminders for other daily tasks, devices with visual displays, and devices that have mechanisms to prevent double dosing of medication. Some machines are able to display both auditory and visual text to aid the patient in remembering to take medication, or reminding patients if the medications have stipulations such as being taken with food or water. Yet fancy features are not always helpful for the patient, and can cause more problems than a simple pillbox. For one automated medication dispensing device on the market, 30% of the need for technical assistance was due to the cups in which the medications were placed being improperly loaded into the machine (Buckwalter, Wakefield et al. 2004).

Phone calls have been used to give patients auditory reminders to take their medications. If a family caregiver is calling the patient, she has to make sure that she calls the patients at the proper times throughout the day. Family members who are busy or have meetings or appointments may not be able to call the patient on time, and so the patient will not take his medications at the prescribed time. If the call is coming from a
pharmacy or doctor, there could be an expense linked to the phone call in the amount of
time the person has to spend making calls throughout the day and is unable to treat other
patients.

The presence of a caregiver can help patients to remember when to take their
medications, or if they have already taken them. A caregiver could be a professional that
goes and visits the patient at predetermined intervals, or a family member who lives with
the patient or checks in on them often. Yet caregivers have been shown to be inaccurate
in assessing patients’ medication-taking abilities. Further, the elderly themselves predict
their medication self-management abilities on their prior functioning and skills, and not
on their current state, leading to problems (Cotrell, Wild et al. 2006). Hiring a
professional caregiver is a costly enterprise. If a family member is acting as the
caregiver, if he or she lives far away there is a cost for the caregiver, both in the time it
takes to travel to the patient and cost of gasoline or a ticket. This method does not
provide “real time” assistance to the patient due to the travel time, which could be
problematic if there is an urgent medical matter. If the family member has a full time job
then he or she might not be able to check in with the patient very frequently due to work
demands.

There are many different means to assist patients with their medication self-
management. The use of medication schedules tests the patient’s comprehension and
ability to integrate information, while the use of a pillbox is related to all cognitive
functions, as well as physical capabilities (Carlson, Fried et al. 2005). This could be
problematic for patients who have decreased cognitive abilities, as pillboxes must first be
filled correctly and then dispensed at the correct times. The integration function of images, pictograms and pictures is what is believed to help patient comprehension and adherence (Houts, Doak et al. 2006). However, each of the aforementioned aids has shortcomings and limitations in their ability to assist patients to manage self-medication.
Chapter 5: The Next Generation of Automated Medication Dispensing Machines

Patients need to be assisted occasionally in order for them to become active participants in their own medication self-management. Patient medication self-management is one of the most important factors for patients to be able to safely and adequately take care of themselves. However, it must be remembered that adherence is a dynamic process, and is subject to multiple interacting factors (Arlt, Lindner et al. 2008). This is why some less adaptable and personalized aids, such as the simple pillbox, are not helpful to everyone. Today’s automated medication dispensing devices are capable of assisting on many levels, but still do not provide the dynamic and real-time interactions needed by some patients.

There is a desire from many sides and from many stakeholders for an assistive medication managing device. Pharmaceutical companies would like for people to take more of their medications, thereby maintaining and growing their business. If patients take their medications as prescribed, it is also easier to determine the efficacy of the medication and its effect on the patient. Caregivers and insurance companies would like patients to take medications correctly so they will not be hospitalized for their medical conditions as often, and would have better medical outcomes. Dr. Anil Sahai, creator of the MD.2 medication dispensing device, said he decided to make this device “after he
observed many of his patients who were able to handle most activities of daily living were prematurely admitted to acute or long-term care facilities because they were unable to properly manage their medications” (Buckwalter, Wakefield et al. 2004). Patients themselves would enjoy and benefit from such a device in that they would have a higher quality of life and more peace of mind concerning successfully managing their medications.

Current automated medication dispensing machines have many shortcomings that limit the amount of aid they can provide a patient. Some devices have a limited number of alarms that can go off in a single day, possibly making the patient change their usual dosing schedule. Some patients have to take two pills of a single medication on some days, and a single pill on other days. Other times, different doses of a single medication need to be combined to produce the correct daily dose, such as combining a 4mg pill with a 2mg pill to create a 6mg total dosage. This makes it very challenging to properly load a pillbox. Along with this, some pill dispensers have pre-set time intervals for when alarms are able to be set, such as making every thirty minutes the minimum time between alarms. Other devices have a limited number of compartments or pill slots available which could cause problems for patients on many different medications or who take large pills.

Automated pill dispensers that require a physical key to lock, unlock, and refill the machine can be extremely problematic for individuals with arthritis or limited manual dexterity. The key can become lost and compromise the safety and security of the patient’s medications. If there is an indicator for missed doses, some machines are only
able to indicate a single missed dose, even if there were multiple missed doses. Machines that sound an alarm until all pills are taken do not take into account the fact that if some medications are taken late, that day’s dose is to be skipped. One type of medication machine must be physically inverted for the medication to be dispensed. The patient is required to pick up and control the machine while catching the medication which is dispensed, requiring coordination and manual dexterity. Pill containers with lids that must be manually opened also pose challenges for individuals with decreased manual dexterity or physical strength.

To address the many aforementioned shortcomings, a medication dispensing device is needed that is adaptable and flexible for the diverse challenges of everyday life. Such a device would necessarily have many functional requirements. These are aspects of the device that are essential for the machine to sufficiently function and provide assistance. The following paragraphs describe the key categories of functional requirements for an adaptable medication dispensing device. These requirements have been determined through the literature review and the author’s ideas. The mechanics and more technical details of the design are beyond the scope of this paper and are left to future research. A unique feature of this particular medication dispensing device is an interface which will provide tele-presence for a caregiver to “check in” on the patient remotely. The tele-presence provides a “back-up” when the machine’s built-in, on-the-scene knowledge is too limited to adequately aid the patient. The tele-presence can make up for reasoning or interpretation shortcomings in the device. Such a dynamic machine
will be able to radically assist with medication self-management, the “world’s other drug problem” (Morton 2008). This will be described more fully in the next section.

The size and portability of a medication dispensing device is a large determining factor that will establish if patients find the machine useful. If the machine is too large, a patient may not use it because he or she will not be able to place it out of sight if company comes over. Some patients do not want others to know they are on medication, and if the device is too large or heavy to easily move out of the way, it may not be accepted into the home or will get covered up in the presence of company. The more days’ worth of medication the machine can hold, the larger and heavier it will become. There will have to be a tradeoff between the size of the machine and its capacity. Also, if the patient is unable to fill the device on his own, it may be helpful for the filling element of the device to be detachable. This way patients could bring it to their pharmacy or the doctor to have them assist with refilling or to check the patient’s prior dosing.

Filling the machine is another precursor to its proper use. When the machine is opened by the patient or authorized individual with the security mechanism, the machine is ready to accept new medication into any empty medication column. There could be a swing out panel on the front of the machine, or a large handle on the top of the machine to gain access to the inside. If the patient forgets the code, the interface could provide a prompt to a user-selected question to allow them admission to the medications. If the patient can still not remember the code, the machine can call the help center and a person could help the patient reset their alarm.
Each medication bottle will have an RFID (radio frequency identification) tag attached to the label so the machine can tell if two medications will have an adverse interaction, and will prevent this from happening by alerting a pharmacist or other caregiver and not dispensing the two medications. Medications that are improperly dispensed from the machine will be automatically put into a holding tank in the rear of the machine while a new dose is dispensed. This information would be recorded on the device’s log of medical activity and can be reviewed by the patient or caregivers. The device would also have the ability to tell the patient the potential side effects to be expected from different medications, which the device will glean from the RFID tags on the medication bottles.

Columns inside the machine that still have pills in them will not automatically open their individual lids, thus not allowing medications to be improperly placed into them. However, if the person filling the machine wishes to add in pills into a column that is not yet empty, there would be a way to easily do this with the machine verifying that the pills going into the column were the same kind that was already in the column. If the pills were a different type of medication, or a different dose of the same medication, the machine would let the person know that there was a discrepancy. Empty columns also clear out their RFID history in anticipation of the new medications. This means that the patient or caregiver does not have to place the medications into the same columns each time the machine is refilled. All information, such as the side effects and the dosing schedule, are encoded on the medication label and transferred to the machine through RFID.
Cost is a prohibitive factor for many patients. If the device costs too much, even if it works wonders, patients will not be able to utilize it. If an insurance or a pharmaceutical company could subsidize the cost, it would open up the capabilities of the device to a much larger percentage of patients who would derive benefits from the machine. Renting, rather than purchasing the machine, might make it more affordable.

In order to be a medication dispensing device, the machine will need to have some mechanical ability to dole out medication. The device could contain a basin, or some sort of drawer that opens for the patient. Either method will have a pressure sensitive material lining it, which will be able to check the weight of the dispensed medication to ensure that the proper number of pills was dispensed. There could also be some sort of laser that checks the medication for problems, much like the laser “eyes” that check food products on production lines. If the pills were incorrectly dispensed, they would be pushed back into the holding tank inside the machine, and that dosage of pills would be re-dispensed. When the pills are removed from the pressure sensitive pad, the machine will know when they were taken out by the patient, and can add this information to the medication-taking report generated by the machine.

The machine’s purpose is to make medication self-management easier and safer. After the machine is loaded, the loading mechanism will lock. Also, pills would only dispense when the patient is within a predetermined range and her wristband sends out an RFID signal to the device to dispense that time’s medications. If the medications are dispensed and not taken, the machine will, after a predetermined time interval, place the medications into the holding tank in the machine. The holding tank will be accessed by
the patient or caregiver through the same means by which the machine is loaded. The medication can then be placed back into the dispenser or discarded.

The patient will have the option of wearing a wristband, pendant or necklace that will have an RFID tag on it. Medication information will be stored on this device, which will allow the patient to know when to take their medications even if they are too far from the base unit to hear its alarms. The device will have the same alarm options as the main machine to indicate when to take medications. When the base unit alarms, the patient will be able to dispense the medications by bringing the wearable device within a predetermined distance of the base. This will allow hands-free operation of the machine. If the patient does not wish to use the wristband, necklace or pendant, they could perhaps press a button on the machine which would dispense the medications. The controlled dispensing will also prevent medication from being dispensed without the patient present, and having a pet or child eat the pills. Further, if the pills need to be kept in the dark or are sensitive to humidity, this feature would prevent the medication from being tainted. The wristband, pendant or necklace would also have a panic button on it if the patient is in need of help or has an emergency.

Just because medication is dispensed, it does not mean that it was taken (Balkrishnan 2008). This can be a very serious problem. The machine needs to have a way to tell that the medication was actually taken. This could perhaps be done by having facial recognition software “watch” the patient take his pills, or have a caregiver watch the patient through the interface. A more simplistic method would be to have the patient push a button once she had swallowed her medications. Yet this is unreliable and
patients could merely push the button without taking the pills. This area of assisting medication self-management is quite tricky as it depends upon the patient.

If the patient does not take all of her pills, there needs to be a way to tell which pills were left behind. There could be pill recognition software built into the machine which could identify from the videotaped data which pills were taken by the patient. This software would also be used to determine which, if any, pills were left in the medication holding basin or drawer. From this software, the machine would know if a missed pill should be added to the next scheduled dose, or if it should be skipped all together, depending on the information related to that pill’s RFID label. Another feature of this software would be to provide the caregiver viewing the recorded footage with an option to put some sort of circle or other indicator around the pills so that if any pills were left over at the end of the dose they can be easily identified.

There are many different kinds of alarms that the machine could use to notify the patient it is time to take their medicine. These alarms could consist of beeps, the voice of a friendly but firm family member telling the patient it is time to take her pills, lights, vibration, or music, amongst others. The proper duration of the alarm is also quite variable. These features could be set by the user to their preferences. However, the alarm should be able to be silenced or paused if the patient needs to finish a prior activity. The device will also have a “5 minute pause” button which the patient can push if she is on a phone call or someone came to the door when she was to take her medications in order to silence the alarm. There will be a maximum number of times that this button
will be able to be pushed, as determined by the dosing schedule on the medication bottles.

The alarm should be variable for different times of the day and for different medications so that the patient does not stop paying attention to the alarms, much like people who stop hearing the ticking of a clock after living with it for awhile. There could also be different alarms for medication that have to be taken with food or water. This information would also be displayed on the interface of the machine. Alarms could be set for reminding the patient to take other, non-pill, medications such as inhalers. For non-prescription pills, such as OTCs or vitamins, the machine will be able to read the RFID labels from those bottles and incorporate their recommended dosing schedules into that of the prescription pills. If the patient chooses not to have their vitamins dispensed by the device, the machine can issue an alert that it is time to take the other medications. The machine would also issue alerts when the medication is running low and the patient is in need of a refill. This information would also be put into the report that the machine would generate daily.

Another challenge for patients is the physical dexterity required to manage self-medication. Bottles are often difficult to open for patients with reduced strength, or a disease such as arthritis. As the machine will dispense the medications for the patient, there will be no need to struggle with the daily opening of bottles for dosing.

The interface of the device is going to be a very important part of this medication dispensing machine. Patients will be able to tell with a glance at the machine where they are in their dosing regimen for the day, and if they have missed a dose. One idea for
indicating a missed dose is to have a timeline on the interface of the device. Times correlated to either no medication needing to be taken, or medication successfully taken, will be green on the timeline. Times that medications were missed will be shown in red on the timeline. The user can touch the screen on the red areas and see what medications were missed, and the machine will automatically change the rest of the dosing schedule to account for the missed doses. The schedule will be changed based on the information contained on the RFID tag from the original medication bottles. Patients will be informed that their normal schedule will be changed as needed to account for the missed dose. A special light or alarm could also be used to indicate a missed dose. The interface is also a way for the patient to inquire about possible side effects of the medication or to connect with a chosen caregiver. Answers to queries will then be displayed on the same interface where they were asked. The answers will be in straightforward phrases and will not include complex wording or challenging phrasing. The interface will use large text in an easy-to-read font for individuals who may have poor vision.

Many patients may not be very comfortable with technology, or lack skills associated with higher technological devices. The patient can have the machine dial the call center if the patient needs assistance with anything. Further, when the machine is set up for the first time, it will guide the user on how to use it and its features.

The medication dispensing device must be flexible, adaptable and adjustable. It will automatically adjust dosing for a missed dose, eliminating the need for the patient to find the medical instructions and properly interpret them. Some medications are taken as needed, for symptoms such as pain or congestion. The device will have some mechanism
for the patient to indicate if these types of medications are needed, and if they are, the
machine will dispense the recommended dose.

If the patient knows that she is going to be out of the house at the scheduled
dosing time for her medications, she can push an “early dispense” button which will
dispense all of the pills for the selected time that the patient will be missing. This way,
the machine becomes more “portable.” The patient will not be stuck at home during the
dosing times, and will be able to live a less interrupted life. The fact that the medications
were dispensed early will be included on the daily generated report. This feature does
introduce the possibility that the patient will forget or lose her medications, but if this is
the case then she can input this into the machine and the device will update her future
medication-taking schedule as needed.

Maintaining the machine in good working order is essential to ensuring it is able
to properly dispense medications. The machine will run scheduled diagnostics on itself
to make sure that it is calibrated to be able to properly dispense medications. If it detects
a problem, it could call the help center and give a technician its diagnostics report so the
issue could be identified and dealt with. Like resetting a cable box, some problems
would be able to be taken care of remotely so the patient will not be burdened with
maintenance issues. The machine could indicate on the interface when it is in need of
maintenance or repair that is unable to be performed remotely.

The machine would generally run on AC power. However, in the case of a power
outage, the patient still needs to be able to take his or her medications. The machine
would have a battery backup system to avoid the patient being prevented from self-
medicating. It would have a long life, lasting up to one month. When the machine is on battery power, it would still be able to fully function. Once the AC power returned, the machine would update its generated reports, indicating that there was a power outage. The patient would not have to manually reset or fix the machine once the power came back on.

Communicating with caregivers is going to be an invaluable feature of this machine. Through the machine, the patient can call a doctor or other caregivers if they are in need of help. There will be a report that is generated daily which will capture the medical history of the patients through their interactions with the machine. If there is a problem, such as no medication being taken that day, the machine will include this in the generated report. The machine is able to connect to caregivers through a phone line or wireless internet connection, depending on what the patient has. Caregivers can actively seek out this report from the machine, or it can be programmed to send out the report daily, weekly, or at some other interval.

The patient does not necessarily need access to all of the information that a family member, caregiver, or a doctor would need. If the patient has cognitive issues or is not comfortable with technology, access to a large amount of information may be confusing and overwhelming. A family member or caregiver would be able to control the amount of data the patient can see if there is a concern of the patient being overwhelmed. Patients would be able to access such information as what a medication is used for, what medications they have already taken that day, the color of a pill, and other pieces of information that would help the patient to self-medicate. There could also be voice
recognition software so the patient could ask the machine about common side effects of the medication if the patient is experiencing some unusual symptoms. The patient’s queries would be recorded for the caregivers and doctors to access. This way, the doctor would know if the patient was asking about a rare or serious side effect, and would be able to take appropriate measures.

Due to the fact that this machine is a medical device to be used at home, it is subject to the FDA and its policies. The “FDA regulates medical devices that consumers use themselves without professional medical assistance in the same way as other medical devices” (Medical Devices, 2009). The CDRH Home Health Care Committee defines a “home medical device” as:

A device intended for use in a non-clinical or transitory environment, is managed partly or wholly by the user, requires adequate labeling for the user, and may require training for the user by a health care professional in order to be used safely and effectively (2009).

Therefore, once this device is at a level where it is ready to be prototyped, it must guarantee that it meets all of the standards of the FDA to ensure the safety of the patients who will be using it.

There have been many different methods and types of devices created to assist patients in performing successful self-medication. However, there is a problem in that any single method or device thus far designed is unable to sufficiently address all of the challenges of self-medication. The biggest challenge in assisting medication self-management is the ability to comprehend the patients’ perspectives. This is related to
understanding where the patient is in his or her daily routine, what side effects or other complications the patient is experiencing, any confusion about the medication’s schedule (especially in the event of a missed dose), and other factors linked to successfully taking medication. Without having a caregiver physically on-site in the patient’s home, understanding the patient’s perspective is quite difficult.

This is where the concept of tele-presence enters. Tele-presence is the idea that an individual can be “present” in a setting without physically being in said setting. Being “present,” however, is not as simple as having a view into the space. It means being able to interact with patients and sharing their mental models and mindsets. It means understanding the current situation in-depth, not merely on a superficial level. Tele-presence can be mentally associated with being transported into a space via some device and related interface.

In the medical arena, tele-presence is related to a caregiver being able to “enter” the home or environment of the patient to provide answers to questions, monitor the patient, and to generally ensure that medication is being successfully taken by the patient. Successful medication self-management is not simply “taking the medications as prescribed.” If a patient is on medication to lower blood pressure, and the patient’s blood pressure is already low that day, should the medication still be taken? If a medicine is prescribed to treat nausea, but has severe side effects, should the patient continue to take it? These are not simple and straightforward questions that can be answered by the sometimes confusing instructions given out with prescriptions at the pharmacy. Further,
without having full understanding of the context or the patient’s perspectives, responses to these questions could logically vary.
Chapter 6: Benefits of Tele-Presence

Tele-presence is an exciting approach to assisting medication self-management. Especially for long term medication treatments, the patient needs support and help to successfully self-medicate. With tele-presence, a caregiver is able to aid the patient in a very direct and contextually aware manner. Caregivers can have a more intimate understanding of what is going on with the patient, and in the patient’s home. Further, the caregiver does not have to drive or otherwise get to the patient’s home, so there is a savings in both transit cost and time.

If a caregiver does not have a solid understanding of the patient’s situation, it is possible to misinterpret or misunderstand what the patient is going through and give an inappropriate response to the patient’s questions. Having the ability to “be” in the patient’s home with them is invaluable for patient safety, wellbeing, and convenience. Tele-presence allows the caregiver to get the big picture view from “being” with the patient, but also a more detailed view of what the patient is doing at the current time, as well as how the patient has been performing her medication self-management recently. Tele-presence also provides context for the caregiver to be able to resolve ambiguities and provide tailored help. Through tele-presence, caregivers can answer questions about various facets that make taking medication challenging.
Tele-presence could also be an extremely valuable tool for family members who are charged with care giving. For example, if one has an elderly parent who is on a number of prescriptions, that individual would likely find it useful to be able to remotely check the parent’s health status and whether he or she is successfully self-medicating. A child or other family member could “check in” on their family without physically traveling to the patient’s residence. Tele-presence can provide peace of mind for both the patient and the patient’s family without the hassle and expense of traveling to the patient’s home. Tele-presence is able to supply a link from the patient’s home to multiple caregivers, as well as to assistance in the case of an emergency, or with everyday questions that arise in the course of medication therapy.

Providing tele-presence for caregivers in patients’ homes accelerates and facilitates information flow. Medication instructions are challenging to follow for anyone, and if a patient is very ill or stressed, it becomes even more difficult to successfully self-manage medications. Connecting caregivers with patients in their homes allows the caregiver to get a better idea of the patient’s viewpoint for managing medications. The challenges of medication self-management fluctuate daily. Interruptions, the patient’s physical and mental state, daily plans, meetings, and many other factors that can influence medication self-management are dynamic. Tele-presence can allow a caregiver to ensure that the patient is able to navigate life’s changing challenges and still be able to take his or her medications.

Tele-presence provides more in-depth, contextually sensitive and detailed information in a shorter amount of time than a phone call or email. It allows a dynamic
exchange between the caregiver and patient to address the issues that arise during medication self-management. The caregiver is able to develop situational awareness of the patient and his environment. Tele-presence goes beyond incremental improvements with medication management such as images on labels or using blister packaging. It takes medical assistance directly to the patient, and meshes the worlds of the patient and the caregiver through an interface.

With medical tele-presence provided by this device, patients can stay in their homes longer and maintain their independence while remaining safe. Their quality of life will be maintained and even improved. Patients can live alone without feelings of worry or fear related to managing medications. The cost of health care will decrease due to fewer patients requiring care in hospitals or nursing homes. These establishments will be less overwhelmed and burdened as there will be proportionally fewer patients to inhabit them. There is more peace of mind for everyone involved in the patient’s wellbeing, including the patient herself.

Tele-presence allows one to focus more on the future and what could be, instead of on the present and what is. It opens up a whole new realm of possibilities for remote medical care. There is much current interest and time being spent in developing tele-presence, especially in the medical world. However, the way to incorporate tele-presence into such a device, and to have it provide benefits for both the patient and the family members and other caregivers, is not clear or straightforward. This makes integrating the concept of tele-presence both more exciting and challenging.
There are many examples of medical tele-presence available for study. The next section of this paper will briefly look at a few examples.
Chapter 7: Current Medical Uses of Tele-presence

There are many current uses of tele-presence in the medical field. Some of these uses involve doctors working directly with a patient, while others allow a doctor to interact with nurses or other trained individuals to provide guidance and acquire insight into the patient’s condition. When a doctor is able to alter and influence her interactions with a patient, the doctor is able to get a better sense of what is going on with the patient, also known as gaining better situational awareness. Through tele-presence the doctor can, for example, know the skill levels of the individuals in an ambulance, and so can make more educated decisions about what procedures can be done in transit and which should wait until the patient has arrived at the hospital. In emergencies, the doctor can override the typical protocol for the medical crew and thus is able to better tend to the urgent situation.

There are some ambulances that have fully implemented test software to allow tele-presence with the hospital while a patient is being transported. The data from the ambulance is transmitted to the hospital through satellites, radio, or cellular links. The system allows the doctor to see the patient’s vital signs, which have been automatically captured by the tele-presence software. This is important for being able to determine the severity of an injury, and 89% of responders exposed to a medical tele-presence system
believed it did a better job than what the information from a simple audio feed would provide (Kerry, Michael et al. 2008). The medical crew in the ambulance can indicate which parts of the patient are injured by clicking on a virtual image of a body instead of recording the number of the body parts that are injured, which then must be decoded later on. A speaker allows the doctor to talk to those in the ambulance and provide guidance on what actions the medical crew should take.

Medical tele-presence is very helpful when a patient needs to see an expert, but there is not one available at the current hospital or nearby. Patients can also be diagnosed remotely. Patients who have been in accidents and must be tended to quickly greatly benefit from tele-presence applications which allow doctors who are spread out around the same hospital, or potentially around the world, to meet and discuss the best course of action. The specialized tele-medical application, KAMEDIN, allows doctors to choose from typical image manipulations for radiological data, such as defining areas of interest and zooming in on particular regions. When doctors want to remotely meet, the medical data of the patient is uploaded to all participating members so everyone is up to date and has the most current information. Only one doctor at a time may manipulate images, but all participants’ mouse arrows are permanently on all screens. Images may also be drawn on, so specific areas may be brought to the forefront of attention (Handels, Busch et al. 1997).

Another application of medical tele-presence involves a remotely controlled robot that is placed within a patient’s hospital room. The robot allows the navigator to control either the movements of the entire robot, or to change the orientation of the head in
isolation. There is a wide angle lens, as well as a zoom lens, that allows the user of the robot to see the patient’s entire room or to focus in on areas of interest. If the robot operator clicks on an aspect of the room on her screen, the lens will automatically zoom in on that item, reducing the need for precise mouse work. Further, the robot comes with an option to automatically look directly ahead or directly behind the robot to check for obstacles. Infrared sensors allow the robot’s user to be aware of obstacles that are off to the sides of the robot, so that user can have a better sense of what is in the room and where the robot is in the room. When the robot stops moving and is at rest for awhile it automatically goes into manipulating the “head” mode, instead of “whole” robot mode, so that a sudden movement does not cause an accident.

To compensate for the fact that this particular robot was not designed with arms, the robot allows the user to take a picture of items in the room, or to take pictures from the user’s computer screen, and share them with the people in the patient’s room. The user can highlight specific areas by drawing circles or arrows on the captured image. The robot operator can also share files from her own computer with those in the patient’s room. So the individuals in the patient’s room know who is operating the robot, the user’s image is projected onto the robot’s interface along with his or her name.

In trauma situations, actions must be taken quickly to ensure a successful outcome for the patient. However, trauma centers tend to be in urban areas, leaving out the rural majority of the United States, and the world in general (Latifi, Ong et al. 2005). Some trauma centers use phones to consult with experts and specialists, but this does not always provide sufficient information to properly diagnose the situation. If the trauma
expert is able to “view the vital signs, medical records, and diagnostic images, the trauma surgeon in collaboration with the referring physician and/or other health care provider can make more appropriate treatment and disposition decisions” (Latifi, Ong et al. 2005). Through medical tele-presence, the trauma expert is able to view more, and more accurate, information through the audio and video from the patient’s location. Having medical tele-presence can prevent patients being unnecessarily moved between hospitals, makes sure the patient is receiving the proper medical attention, and is able to keep patients close to their families (Latifi, Ong et al. 2005).

The Ohio State University is also looking into how medical tele-presence could improve patient care. With electronic health records, patients and physicians have up-to-date information about current health conditions. Results of tests cannot be lost, so there will not be a need for repeating expensive examinations. Further, patients can share biofeedback data with physicians, who are then able to alter medical doses or recommend further treatments. Especially for patients who live in rural or remote areas, medical tele-presence can assist those who are home-bound, and can also provide more expertise than may be locally available. The electronic medical records are available to certain associated ambulances, allowing them detailed medical information about the patient (Gabbe 2008). Ohio State doctors have remotely performed surgeries utilizing real-time audio and video feedback from the operating room (Crawford 2000). Ohio State has even advanced medical tele-presence so far as to propose a “digital hospital” for patients, using a variety of wireless devices to connect patients with their doctors (McCann 2008). There is also the Da Vinci Surgical System at Ohio State, which allows a doctor to be
seated at a desk while remotely performing heart surgery on a patient. The system is able to transform the doctor’s movements on controllers into small cuts inside the patient in real-time. Because of the smaller cuts, the patient is able to heal faster and experiences less pain (Creating the Future of Medicine, 2009).
Chapter 8: Design Ideas Gathered from Group Discussions

The novel medication dispensing device proposed in this thesis deals with the grey area of medication self-management. This grey area exists when it is uncertain if a patient, living on her own, is able to successfully self-medicate and manage her medications. This machine is designed for a range of patient abilities and scenarios.

“Typical” users of this machine would consist of individuals who are living alone in their own homes, and who may be elderly. They take multiple medications, and multiple doses of these medications. The patient lives reasonably far away, and so is not within close range for frequent check-ins from family members or caregivers. They are generally able to perform adequately with taking medication, but there is no one there to determine day to day if they are self-medicating accurately. There is no method to ensure that these patients are able to successfully take their medications, and this causes concern for family members and caregivers. The machine would provide a way for family members and caregivers to ensure, on a daily basis, that the patient was successfully self-medicating.

When the daily routine is varied, or the medication schedule is changed, there is an increased potential for medication misadministration to occur. The purpose of this device is to keep people in their homes longer, to improve their quality of life, to allow
better continuity of care, to better deal with the dynamic nature of health, to bring peace of mind to the patients and their caregivers, and to improve understanding of the patients’ medical regimen. The device helps the patient deal with the challenges of self-medicating in an interactive and innovative way.

In order to generate a list of functional requirements for the medication dispensing device, the author performed a pilot test and six discussion groups. A discussion group set-up was used as it allows participants to openly explore new ideas and feed off of one another to come up with the functional requirements for the machine. In a discussion, participants can also bring up concerns, and ask questions if they are unsure of a term or aspect of a scenario. It also allows more relaxed and casual discussions than a highly structured set-up.

Each discussion group was set up in the same manner. There were three overall sections which required participant responses, and a final summary section, presented in a PowerPoint format. The PowerPoint is found in Appendix B for further reference. Participants started with a warm-up and envisioning activity where they were presented with scenarios to get them thinking about what an automated medication dispensing device would have to do in order to be useful. The second section of the discussion dealt with the concept of tele-presence, and how the medication dispensing device would be able to remotely connect people while creating situational awareness and context sensitivity. The third section pushed the concept of tele-presence further and allowed participants to imagine a scenario where a caregiver, a family member, and the patient were discussing a potential change to the patient’s medication through the device. A
fourth section included a summary of the functional requirements determined by the author for the device. This fourth section was mainly for the participants to make any comments or present concerns related to the current list of functional requirements.

The discussion groups included a variety of individuals, including a medical doctor (n=1), a psychologist (n=1), nurses (n=2), a pharmacist (n=1), an owner of a company that helps older adults manage their finances (n=1), a psychoanalyst (n=1), individuals who manage their family members’ medication (n=6), and older adults who themselves would be potential users of the machine (n=10). Some participants fall into more than one category, and so have been listed twice as they gave input from multiple perspectives. In all, there were 19 participants total in the pilot test and discussion groups. The participants were told that the main goals of the discussion group were not to come up with the final look or functionality of the machine. They were to explore what aspects and characteristics of such a machine would prove useful to assist individuals to successfully self-medicate, to come up with a more complete list of functional requirements for the machine, and to uncover situations which make medication self-management challenging. The overall categories of ideas that were addressed in the discussions include ideas which are related to the functional requirements previously discussed, problems or concerns with the design of the machine, and new ideas that could be added to the machine to improve its usability and functionality. The following paragraphs summarize the feedback and ideas gathered from the different group discussions.
Some important ideas and functional requirements were brought up by multiple groups. These ideas included:

- Having a video recording of the patient that would provide an added means to ensure patients took their medication
- Notifying the caregiver or a family member if the patient was not taking his or her medications
- Have biofeedback recorded for the patient, which would be accessible to caregivers and family members
- Having a video component on the machine which could be manipulated by a family member or caregiver to look around the patient’s environment
- The fact that a doctor would likely not be available to immediately respond to a patient who “called” in on this device
- Having a wristband that would alert the patient that it was time to take her medication even if she was far away from the main machine
- Having a family member control the amount of information a patient could access if it would cause confusion or be overwhelming for the patient
- Having a long battery life in the case of a power outage, or patients taking the device on vacation with them
- Allowing patients to say how they are feeling and if they are experiencing any symptoms while they are being recorded taking their medications
- Having an interface able to display and give a description of the patient’s medication
Some unique ideas were brought up by these discussion groups. These ideas consisted of:

- Having a family member or caregiver act as a gatekeeper when the patient wanted to contact the doctor if the patient suffered from dementia or was a hypochondriac
- Allowing two or more individuals in a single home to both use their devices, while only be able to access their personal machine (and having these machines not look identical)
- Having the machine verbally guide the patient on how to operate and interact with the machine
- Having tele-presence to allow a doctor to tell if a patient is confused about what the doctor is saying, and then provide another explanation or example
- Realizing that different manufacturers of the same medication may have different looking pills
- Having a wristband that can take vital signs of the patient
- Having the machine dispense pills into a pillbox if the patient is going to be gone during her normal medication-taking time
- Having a website where the patient’s condition could be updated, and the patient’s friends, family and caregivers would be able to post replies to the updates
• Having tele-presence that would be able to reduce feelings of isolation for elderly patients who may be homebound

• Having the tele-presence connect patients with similar diseases or conditions, and allow them to form a support group

• Having patients classified as being high, medium, or low risk and having alerts sent to a nursing help center indicate this designation

• Having cameras throughout the home to ensure the patient was performing household tasks, beyond medication self-management, successfully

• Having the machine record trends of the patient missing doses and then highlighting this in its reports

All discussion groups had an idea of what types of patient would be helped by this medication dispensing device. Many groups also mentioned that not everyone would be helped by this device, and not everyone would be comfortable enough with the technology or have the cognitive ability to use such a machine. Common situations that were mentioned where individuals would benefit from this machine include:

• Individuals who live far away from family members or their caregivers

• Patients with physical limitations which reduce their vision or strength

• Patients with decreased cognitive functioning

• Elderly patients who live on their own and do not have someone around to remind them to take their medications

• Patients with dynamic conditions or variable symptoms
Pilot Test of Discussion Group

The pilot test of the PowerPoint and discussion group included an adult with a physical handicap who managed his own medications, and a pharmacist who not only filled medications for patients who brought in prescriptions, but also talked to patients over the phone in order to prepare medication for them to pick up at a later time. They felt that having a video and audio connection with the patient, much like a webcam, would be very helpful for a family member or a caregiver to connect with the patient. Instead of just having a telephone, with both audio and visual components a caregiver could get a better sense of the individual’s environment, and the patient would be able to show a doctor or pharmacist a medication bottle instead of having to describe it. They also felt that a video component would be able to provide redundancy, or a back-up assurance method, that the patients took their medication. Of course, a caregiver could ask the patient if he took his medication, but the video recording would provide more “proof.” If a patient did not take his pills, the pharmacist thought the machine should email a caregiver to let them know the patient was not taking the medication. For medications that are taken as needed, such as those for pain, the machine would only dispense up to the maximum number of pills as dictated by the prescription the patient received.

They mentioned that the machine should have its own phone number so that a caregiver or family member could “call up” grandma to check in on her using the tele-presence features of the device. If the camera could be controlled by the caregiver, then he or she could look around the patient’s home to make sure they were okay. In the case
that a patient would be remotely connecting with a doctor, the doctor should have access to all of the audio and video recordings, as well as the reports generated by the machine, so the doctor could make a more educated decision about the patient’s medical routine and medication schedule. This group felt that the patient, family members, and the doctor should have access to all recorded information on the patient in order to make the best decision possible about the patient’s care.

The doctor should also be able to remotely increase or decrease the dose of the patient’s medication if necessary. Having this ability would allow the doctor to better tailor the patient’s medications to her current set of symptoms. If medications were changed, the machine would be able to alert the caregivers and family members so they would be aware of the new schedule.

As there would not likely be a doctor always waiting to take a call from the machine, the device would be able to display the estimated wait time for a doctor to respond to a query from a patient. The tele-presence would be especially helpful for people who live far away from their doctor’s office. It was mentioned that patients who had mental deficits may exploit this aspect of the machine. In this case, a caregiver or family member would have to approve the patient’s request to speak to a doctor.

The participants felt that the idea of a wristband that would be able to alert the patient if he was outside, or far from the machine and could not hear its alarm, would be useful. They also felt this wristband should have a button for emergency situations, such as if the patient had fallen or was having a heart attack. The wristband could also collect biofeedback information from the patient. If the wristband realized the patient’s blood
pressure was very high, or their pulse was unusually low, it would be able to call an ambulance without needing a direct phone line.

Discussion Group One

The first discussion group included a nurse who had performed pill counts in the past to check for successful self-medication, and the owner of a company that assists elderly individuals with managing finances. These individuals cared for a mother-in-law and a mother, respectively, including helping them to manage their medications and answering questions about what different pills were for and what they do. Some concerns they expressed included patients who would simply not take their medications, no matter how much prompting they received. In Human Factors, the human is not the problem. There is always a reason why the patient “will not” take her medication. Perhaps she does not understand the directions as they are written with medical terminology. Perhaps the dosing times are inconvenient and so the patient is not able to take the medication as the instructions say. Perhaps she has experienced negative side effects from the medication. The answer is never that the patient is wrong. There is a problem with the system, in this case the medication self-management system, and this machine aims to assist the patient to navigate this system with a successful outcome.

Some individuals also have significant physical limitations, including macular degeneration, leading to very poor eye sight and the inability to tell if a pill was left in a dispenser. With the weight sensors on the dispensing mechanism, and the dispensing mechanism itself, this challenge would be overcome. There could also be a fingerprint
reader on the machine to open the device for refills so that the patient would not have to pull on a handle or open a lid.

An interesting area of concern that this group mentioned was having two individuals in the same home that both used this device. Different devices would have distinct RFID frequencies for reading medication bottle labels. Also, the patient’s wristbands would synch up with the machine that the particular patient used, so each machine did not record both individuals’ activities.

The participants mentioned that this device would be very useful for individuals who did not have any living family members, or have caregivers close by. They also thought it would help to soothe the anxiety some patients experience if they are late taking a pill, or miss one altogether. As the machine would know the medication schedule, patients would not have to remember everything on their own. Also, the machine provides confirmation that the patients took their pill with the facts that the dispensing dish would be empty and there would be a video of the patient swallowing the pills.

This group felt that the machine should notify a caregiver if patients were not taking their medication, and that the machine should be able to record biofeedback information from the patient, as did those in the pilot test. The report that the machine generates would include the patient’s missing any pills, and the wristband could record biological data from the patient. This group specifically mentioned that if the patient was not taking his or her medication, this information should not be texted to the caregiver’s cell phone if the caregiver was not familiar with texting. They felt that there should be a
database where all of the information about the patient is stored, including the full list of medications the patient is taking. All caregivers and family members would have access to this secure database. Also, if the patient’s condition worsened, the database could send an email to all the individuals who had access to that patient’s information. If a caregiver or family member did not have a computer, they would be able to call in and access the patient’s information.

The wristband that the patient would wear should be able to activate the dispensing mechanism when the person gets close to the machine. The wristband would turn on the camera and the audio recording capabilities of the device. Further, the wristband would have a variety of alarms, just like the main device. In particular, the wristband should be able to vibrate to alert the patients it is time to take their medications, especially if a patient has poor hearing or vision. The wristband would also be able to read the patient’s body temperature and the levels of different medications in the patient’s blood without requiring a blood draw. This would allow caregivers to know the patient was actually taking his or her medication successfully. This ability would also have uses for patients with diabetes. All of this information would be recorded in the report which was generated by the machine, and stored for future reference. This group thought it was important that this device be a wristband, and not a pendant or necklace. A wristband could permanently stay on a patient, preventing patients with dementia from taking it off, losing it, or having it become inaccessible in the case of a fall.

A nursing staff that would be available around the clock would be able to talk with patients through the tele-presence capabilities of the machine. This would provide
another way for patients to contact someone if there was an emergency, or their regular caregivers or health care professionals were unavailable. The machine would be able to answer questions about side effects and drug interactions itself, and would only need to call the nursing staff if the question was beyond its capabilities. The machine would be able to provide a list of side effects if the patient was asking about them, and then have a button where patients could call their doctor or the nursing staff if they still needed more help.

When talking about the machine allowing a caregiver, a patient and a family member to all communicate, this group also brought up the fact that a doctor would not likely be immediately available to answer a patient’s questions. Yet once the doctor was available, the device would allow the doctor to have access to the patient’s medical records and reports of how the patient was doing with his self-medicating. This group believed that if patients had access to all of their medical information, they might be overwhelmed and become confused. Thus, the amount of information that the patient receives should be tailored to the individual. This is interesting as the pilot test group thought that all people who were involved with the medical regimen of the patient, including the patient, should have access to all of the recorded medical information.

This group again mentioned the fact that the doctor should be able to remotely change the dose of a medication which the patient was already taking. However, if the doctor prescribed a new medication, the patient or a caregiver would still have to get the medication from a pharmacy. There also will be a setting on the machine that ejects all
of the pills from a column inside the device if the patient is no longer taking that medication.

An added benefit of the video recording is that a caregiver or family member could “look around” the patient’s surroundings and check to make sure that the living space was clean. If the patient was recorded taking medication in the same clothes for days on end, or if the patient did not look as if he or she was keeping up proper hygiene, a family member or caregiver would know that the patient needed extra help. It could also indicate a new, or worsening, problem with the patient’s mental status or wellbeing.

Some concerns this group had with the idea of the machine recording video footage of the patient taking her medication was that the patient may not want to go to the same place every day to take her medications. She could potentially get them from the machine, and then go into another room to take the medication, rendering the video-taping confirmation of the patient taking her pills useless. This situation could also occur if the medications were to be taken with food and the patient took the pills out of the bathroom where he had placed the machine, and into the dining room. If the patient wanted to have the machine in the bathroom, but still eat in the dining room, the patient could possibly have two machines that were synced, or could have an interface in both rooms with the accompanying video recording component. This way, patients could be in any room that had the interface component and still be recorded taking their medications. The goal, however, is to make the use of the machine attractive enough that the patient will want to take his medications from the machine every day.
If the machine is expensive, some patients will not be able to afford it. This group thought that Medicare would be able to cover, or partially cover, the cost of this machine. Insurance might also be able to cover some, or all, of the machine’s price. Another concern that was mentioned was the pressure sensitive material that would weigh the medication which was dispensed from the machine could get dirty, and then would not be able to properly determine the weight of the medication. This could be checked for in the machine’s self diagnostic checks. There could also be a brush that would come down and clean off any debris in the dispensing dish after each dispensing.

There are always trade-offs that must be made in order to produce a useful machine. Not all of the constraints can be met, and especially not in a single device. Concerns point to constraints on the design of the machine, and these constraints must be dealt with before a successful design can be created.

*Discussion Group Two*

This group consisted of a medical doctor, and a nurse who had experience filling pill boxes and taking care of her mother. They thought that this machine would be ideal for elderly people who lived alone and did not have anyone around to remind them to take their medication. Also, individuals with cognitive problems would benefit from having reminders of when to take their medication, as well as the machine keeping track of what medications they were taking.

These participants were able to drawing on their personal experiences with taking care of family members, as well as problems and issues they have seen in the workplace.
Before the PowerPoint presentation had even started, this group was able to come up with many good ideas and possible problems with an automated medication dispensing device. Some of the concerns that this group brought up were related to how some patients, and especially elderly patients, might have memory or cognitive problems. This means that the machine cannot require too much technical skill. However, the patient will only have to interact minimally with the machine, getting dispensed pills and possibly using a touch screen to connect to the desired caregiver.

If the device could have a voice that would say it was time for the patient to take his or her medication, and what the medication was for, the patient would not have to remember any information about the pills, and would be able to tell it was time to take the medications without having to be in the same room as the machine. A wristband that produced a redundant alarm for patients would also help to remind them if they were outside or out of hearing range of the base unit.

This group felt that filling the machine would pose a challenge to many individuals. If the part of the machine which housed the medications was removable, the patients could take that portion of the machine with them to a pharmacy where the pharmacist could fill the machine for them. The pharmacist would also be able to answer questions about the patient’s medication. However, patients may have questions at times when they are not at the pharmacy. The machine would only be able to answer certain questions about the medication with pre-recorded messages, and other queries would have to be answered by a human. This issue is covered by the machine’s tele-presence capabilities.
There could be an optional service with this device where a nurse would come to the patients’ home and refill the machine for them. If a patient needed help, he or she could simply press a button on the machine, or an icon on the touch screen, and be connected to a caregiver. The nurse would also be connected through the machine’s tele-presence to multiple patients and be able to check in on them remotely. If a patient did not take her pills, the nurse could “call” the patient through the machine’s interface and remind her again. Further, if there was a problem, the patient could call up the nursing service, somewhat like an “OnStar” feature. Problems could then be referred to the patient’s doctor by the nurse on call. This group felt strongly that there needed to be a human “somewhere in the chain” to connect with the patient and overcome the machine’s limitations.

This group mentioned that patients could constantly be calling a doctor or nurse, even if they were not experiencing symptoms. The idea from a previous group of having a family member “okay” the patient to call the doctor may be one way to get around patients who otherwise would call unnecessarily. If patients were experiencing mild or moderate symptoms, they would be able to state this on the video recording while they were taking their medications. This would then be available for the doctor to see when he reviewed that patient’s records.

The participants mentioned that the machine should be big enough to be able to hold at least a week’s worth of medication. If the patient took a large number of medications, or did not want to have to refill the machine often, there could be different “models” of the machine. These models would take different approaches to the number
of pills the machine can hold and the size of the machine tradeoff. The amount of tele-presence the machine provided could also be specified by the needs of the patient. The amount of assistance the patient required would be related to the price of the machine, with optional features being available at an additional cost.

Physical challenges affect many patients, so this machine should not require a lot of physical strength or dexterity to use. This group though that the lid of the machine could pop up automatically when patients scanned their fingerprints, reducing the need for physical interaction with the device. Further, the machine could ask a patient if she was “Mrs. Brown,” or whatever the patient’s name may be, and could have voice recognition software to understand the patient’s reply. Then the machine could dispense the medication for the patient. The machine could even guide patients to place their finger on the fingerprint scanner in order to open the machine or to dispense a dose of medication.

Patients who were not experienced with computers or more advanced technology would have to be taught how to use the machine. Patients could be trained in the hospital after they received surgery or were diagnosed with a new disease, so once they got home they would already have practice with the machine and be able to use it successfully. The training could even be incorporated into occupational therapy. The machine would guide the user on how to navigate it, and there would be a phone number to call with technical questions. However, because the patient is to interact with the machine, it has to be simple and straightforward.
This group felt that the fact the machine would know the medication schedule and would issue alerts to take the medication was its strongest benefit. The nurse’s mother often slept past the time when she was to take her morning medications. If she had this device, she would be woken up by the alarm and would be able to take her medication on time. Her mother also forgets what her different medications are for, and then does not take them. The machine would be able to remind patients what different pills were for, and as all the needed medications are dispensed at once, the patient would not have to remember to open multiple pill bottles.

Patients may not trust the machine, and so the machine’s ability to connect to humans provides reassurance for the patient. The machine should indicate whenever it is recording video or audio so that patients do not fear they are constantly being watched. Further, the machine can answer some of the patient’s questions, such as displaying a picture of their medication on its interface and explaining what the medication is for, and any common side effects. Lastly, the machine should have an atomic clock so that the time will automatically be updated.

Discussion Group Three

This discussion group was held at a retirement center. The participants are potential users of this machine. This group, as well as group four which was also held at the retirement center, were very valuable. The participants were able to think about what aspects of the machine would personally be beneficial, and which features were not useful. They also came up with questions and concerns about the machine and its use.
At first, this group felt that a telephone would be able to provide the same communication aspects as this machine. If a patient had severe cognitive problems, they thought that the patient may need to be in a center where caregivers were close at hand to personally interact with the patient. This device would not be for individuals who needed constant monitoring. However, the participants felt that the machine would provide a way for caregivers to see if a patient was taking her medication, and that this is where the machine would be advantageous. Some thought that if the machine could take a photograph of the patients’ pillbox it would allow the caregiver a way to ensure the patient was not leaving pills behind. A wristband that could vibrate and alert the patients to take medication if they were not near the base unit was another idea that was strongly supported. Presbycusis, or age related hearing loss, is a common challenge that this machine would help individuals overcome through its loud alarms, flashing lights, and vibration. Also, a long battery life in the case of a power outage or a patient taking the device on a trip would be useful.

This machine would allow people that were far away from each other to be able to “meet.” Further, it can collect objective information about how a patient was doing with managing his or her medications. This way, caregivers do not have to rely on asking patients if they took their medication. If the patients are elderly or suffer from dementia, subjective means of measuring medication self-management may be insufficient or incorrect.

This group was concerned that if patients were sick and were trying to remotely connect with a doctor, the doctor may be too busy to see them. The wait time to speak
with a doctor might be very long, and if it was after hours the doctor’s office may be
closed. Instead, they thought it would be better to go to a hospital if a patient was
experiencing problematic symptoms, and felt that this is what the doctor would have said
anyway.

With respect to the machine’s alarms and dispensing mechanism, having a loud
siren to alert patients, and a rotating component that dispensed the pills, would be useful.
Many participants of the group already owned pill boxes that rotated and so were
comfortable with this technology and felt it was easy to use and understand. If there
could be a button on the device that allowed patients to verify they had taken their
medications, the participants felt this would be an easy and clear-cut way to ensure that
medication was taken. However, just because a patient pushes the button does not
necessarily mean that the patient took the medication.

For the tele-presence provided by the machine, the participants felt that the date
and time should be stamped on the video and audio footage for cataloging. Not all
caregivers have web cameras or equipment which would allow them to interact with this
machine. Therefore, family members and caregivers may have to purchase an interface
that allows them to receive the full benefits of this machine, and take full advantage of its
tele-presence capabilities.

This group mentioned that this device would not be for everyone. Some people
would be too sick, or too intimidated, by the device to benefit from its use. For some,
this could be overcome by having a family member regulate the amount of information
that the patient had access to, as mentioned in a previous discussion group. Patients that needed close monitoring may benefit from moving to an assisted living facility.

Discussion Group Four

This discussion group was held at the same retirement home as the previous group. The participants in this group liked the idea that the machine would be able to transmit information to a doctor, caregiver or family member. They also felt the machine should remind patients to take their medications, and to remind the patients where they were in their daily medication-taking routine. This would be accomplished by the machine’s interface and alerting system. Then the information recorded by the machine could be transmitted through emails that indicated the time when the patient took each of his pills. This would provide a simple way to see if the patients were staying up with their medications, and if they had missed any doses.

A concern the group had was that even if the machine dispensed a pill and the patient had removed it from the device, it did not mean that the patient had taken the pill. At first they thought that having the patient verbally confirm that she took the pill would be a way to deal with this issue. However, they quickly decided this was insufficient as a patient could say she had taken her pills when in fact she had not. This is where the video recording capabilities of the machine would be useful.

Since many patients take eye drops, ear drops, inhalers or injected medication, this machine would need a way to remind the patient to take these types of medication as well. While the device would not dispense these medications, it could still issue alarms
for these medications and record the patient taking them. An important feature of this
machine is that it allows patients to be in control of taking their medication, and does not
force it upon them.

The medications that had already been taken by the patient that day could be
displayed on the interface if the patient had a question about what she had already taken.
The entire medication schedule could also be displayed on the interface. The image of
the patient’s pills and a description of what the pill does could also be displayed on this
screen. This would especially be helpful for patients that get their medication through
mail order systems, as different manufactures that make the same medication can produce
very different looking pills.

If the patient was not taking his medication, a family member could “call” the
machine and remind the patient that it was time for his pills. There should be icons or
pictures for different family members and caregivers, and patients would be able to touch
the icon on the interface to be connected with the person of their choice. This ability to
connect with others would be helpful if the patient was feeling sick, or if the patient’s
medication regimen had changed and a caregiver wanted to make sure he was still able to
take his medication successfully. Side effects of new medications, or changes in
medication, could also be seen with the tele-presence. While this group said that elderly
patients now might not be very comfortable with advanced technology, baby boomers
often have to use computers for their jobs, and having tele-presence or a touch screen
would not be foreign to them.
The audio and video recordings provide a “double check” for ensuring the patient had taken the medication. They also provide a way for family members to make sure the patient is well enough to get up out of bed to take the medication, and that the patient looks well. If the patient was feeling sick, she could say this while taking her medication so it would be captured in the machine’s recordings.

There exists a problem with a patient saying that she has taken her medication, but a doctor or other caregiver not believe her. This problem was also brought up in another group. With this device, one would be able to objectively verify if the patient took the medication. Also, the patient could take nasal sprays or other non-pill forms of medication in front of the machine, so this too would be recorded and added to the patient’s records.

One participant wanted to be able to pour all of her medications into the machine and then have the machine sort them out and dispense the proper medications at the correct time. Such a sorting mechanism would be quite complex, but would be easier for a patient to use than having to put medications into separated columns. If the patient was unable to open pill bottles, a caregiver or family member could come and fill the machine for the patient, or the patient could bring the detachable top of the machine to his pharmacy. Especially if medication comes with child proof caps, a person other than the patient may have to do the filling of the medication dispensing device.

Some people keep old medication bottles around that have easy to open lids, and put new medicine into the old bottles. If the patient then discards the new medication bottle, information about that new medication is lost. As this machine would scan the
medication labels with RFID to determine the schedule and other relevant information, the issue of lost information would not be a problem. Even though the machine would not be able to dispense liquid and other non-pill medications, it would still be able to remind the patient when the medication was to be taken, and can record the patient taking it.

If a patient was suffering from a problematic symptom or side effect, the device would allow the patient to access a doctor or a nurse. This person would know the patient's entire medical history, and would be able to give more complete advice than the machine would. Also, symptoms could be related to other diseases which the patient may have, and the doctor or nurse would be able to check on this.

If a doctor was communicating with the patient, the doctor would be able to see the patient’s expression and tell if he or she was confused. The doctor could then change the explanation so the patient could understand. If the doctor was proposing a complex medication schedule, the doctor might be able to simplify it based on the patient’s experience. The doctor would also be able to change patients’ medication remotely, and then would be able to explain the change to them and their caregivers though the tele-presence interface.

A wristband that reminded the patient to take his medication would be very useful, this group thought. The wristband could also take the patient’s vital signs and call a doctor or 911 if it noticed a problem. This group also thought that it would be useful if the caregiver could turn on the patient’s camera remotely and move it around with a
joystick to get a more complete view of the patient’s environment. However, this ability should not make the device too expensive, or add in additional complexity.

Patients are not always home at the time when they are supposed to take their medications. To overcome this, there will be a way for the machine to dispense medications early into some sort of pill box that patients could take with them. This would especially be useful if the patient was having a meal in a public setting and could not bring an entire machine with him. This pill box could issue the same types of alerts as the main unit, or could communicate with the wristband and have the wristband alert the patient. When the patient returned home, the wristband would be able to sync up with the main device and send it all of the information on how the patient performed taking his medications while away from home. This information would then be incorporated into the reports generated by the machine. The base unit would also be able to tell when the wristband’s battery was running low and needed to be recharged. Or, to eliminate this concern entirely, the wristband’s battery could be “recharged” by the patient’s moving around, like an automatic or self-winding watch.

Patients may become overwhelmed if they are presented with the full report of how they are doing with taking their medications. Therefore, the machine could have a setting that would highlight only problem areas. This is similar to only getting information from a doctor about a blood draw in the areas where abnormalities were discovered.
Discussion Group Five

In this discussion group there was a psychoanalyst and a psychologist. The psychoanalyst had taken care of both her mother and her aunt who had Parkinson’s disease. These participants were able to not only see this machine as helping patients with physical maladies, but also patients with psychological issues. This is an important prospective use of this machine, and would expand the potential field of users.

One of the greatest benefits of this machine for these participants was that a doctor could make a change to a patient’s medication, and then remind the patient that a change had occurred when the medication was dispensed. The machine would be able to show the doctor’s name and tell the patient that the doctor had changed the medication schedule. It would also say that the machine had incorporated this change and that the patient would not have to do anything other than take the medication dispensed by the machine. The fact that the medication was changed would also be recorded on the report generated by the machine.

When the pills were dispensed for the first few days of a change, the machine could again remind the patients that their normal medication-taking routine had been changed by the doctor and that they were now getting two of the red pills when they used to get one. Some elderly patients become very “rigid” in their routines and become worried if their medication schedule changes. This machine would provide an explanation of the change, which doctor made the change, and what would be different due to the change.
The patients would be able to ask the machine questions about changes in their routine, or simply about the medication they were taking, and any concerns they had. The machine would be able to provide some responses based on the information it received through the RFID from the pharmacy’s medication labels. However, if the patient needed more information, the machine could connect the patient to a family member or a caregiver. The ability to understand the changes that are happening to their medication, and the ability to ask questions, would also help patients with mental problems to “stay on track” and successfully self-medicate. The machine would also allow patients to take medication for specific symptoms as needed, but would prevent the patient from overdosing on medication due to the RFID information on the pill bottle’s label. Further, it would allow patients to successfully take their medications without necessarily having to know what the medications were for.

The main question that a caregiver would have is whether the patient took the pills the machine dispensed. This group thought that the patients could push a button to verify that they took the medication, or that there could be a way for the machine to tell that the pills were removed from the dispensing dish. For this device, the machine will be able to tell when the pills were removed due to the pressure sensitive material lining the dispensing dish and the pill recognition software. This would allow the caregiver to know that the pills were removed from the machine, and the video footage would provide a way for the caregiver to watch the patient swallowing the pills.

Urgent care centers would have the tele-presence aspect of this machine so that patients who were unable to contact their regular doctors would still be able to connect to
a nurse or doctor. This group also mentioned having an 800 number where nurses would always be available to assist patients. The American population is aging, and this machine would be able to help individuals who did not have someone nearby to take care of them with its ability to connect the patient to nurses or other caregivers. The fact that the machine is able to connect the patient to other humans is key, as this machine will necessarily not be able to provide all of the services a patient may need.

These participants thought it might be helpful if the patient, or a patient’s family members, could post updates online that would be shared with pre-approved individuals such as friends and doctors. The website could email all of the patient’s friends, family, and caregivers when new updates were posted, and then these individuals would be able to write responses or replies to the updates. This website could be linked to the report generated by the machine to provide a more informal way to see how the patient was doing. Also, patients could say when they were going to bed so that no one would call them and wake them up. All of this information would be accessible by a nurse or doctor, and could provide another way for the doctor to check on how the patient was feeling and the severity of his or her symptoms.

Many diseases are related to a decrease in strength or coordination. This machine would help these patients, especially those with movement problems, by dispensing the pills for the patients without requiring them to open a pill bottle. This group thought that a touch screen interface would be helpful for those who could not, or did not know, how to use a keyboard to input information into the device. Voice recognition software is another way for the patient to input information without having to use a keyboard.
However, these technologies may be unfamiliar to some patients and would have to be taught to those patients.

A problem that these participants noted was the issue of a patient dropping a pill after it had been dispensed. The dispensing dish would be attached to the machine so that it would not be easily knocked over, but this does not guarantee that once a pill was removed it was ingested. The patient would be able to input to the machine that he dropped his pill, and the machine would then dispense another one, or wait until the proper time to dispense a new pill, depending on the specifications of the medication.

The machine would be able to tell which pill was dropped by its pill recognition software coupled with the video recording of the patient removing the pills from the dispensing dish. However, if the patient dropped a pill, took another one from the machine, and later found the pill and took it, this could pose a problem. Patients should be instructed that if they drop a pill and cannot find it within a few minutes to input this to the machine, and not take the dropped pill if they found it later. Otherwise patients could potentially overdose themselves. The fact that the patient dropped the pill would be recorded in the machine-generated report. If a caregiver noticed a trend of a patient dropping pills, this could indicate a worsening condition or symptom.

The machine should indicate on its report how many doses of medication the patient has left, and when a refill is needed. The machine should give the refill warning a few days before the pills actually run out. The machine also needs to record if the patient is taking the medication with food or water, as required by the medication. If the machine is not placed in the kitchen, or where food is usually eaten, it would not be able
to record the fact that the patient took the medication with food. This was brought up by
multiple groups, and the idea of having multiple interfaces in the rooms where the patient
most often took her medication would be a way to ensure the patient was recorded taking
her medications. However, if the placement of the machine was close to both of these
sources, and attractive enough, the patient would not have a problem with taking his
medications in front of the machine daily.

The patient’s wristband could sense the increase in blood sugar and thus know
that the patient had taken the medication with food, or that the patient did not eat food if
the medication was to be taken on an empty stomach. It would issue a reminder if the
patient needed to take medication that was supposed to be taken with food or required
other special instructions. The wristband would also be able to measure blood pressure,
and save this information with a time stamp to the machine’s report. If the patient had an
alcohol problem, the wristband could measure the amount of alcohol in the patient’s
blood.

The interface and video aspects of the machine should be able to be initiated by
both the patient and caregivers. If a caregiver was concerned that the patient was eating
expired food, she could “call up” the patient through the machine and have the patient
hold up meat or produce so the caregiver could see it. The interface would also allow a
caregiver to inquire about a patient’s symptoms, and to ask if she was noticing any side
effects of her medications.

Another benefit of this machine is that it can help elderly individuals to feel less
isolated. A doctor could connect to multiple patients with the same condition at once,
and they could all discuss their symptoms and remedies they have found. The patients could even talk without the doctor, providing a sort of support group and information database about their particular disease or condition.

This machine provides more frequent updates of a patient’s symptoms, and supplies a doctor with more detailed information than annual check-ups. With very dynamic conditions, the doctor or a nurse could check in with the patient every day. If the wristband recorded biofeedback data from the patient, it would help to determine if a patient was improving, or if his symptoms were getting worse and action was needed. The wristband would also be able to sense if there was a sharp drop in the patient’s blood pressure or other physical indicators of problems, and could alert emergency personnel. This information would also be sent to the patient’s doctor.

Through the interface, the doctor can ask a patient questions about his symptoms. The doctor could also look at the recorded information and see if there is a pattern with the onset of symptoms and the use of the medication. If the patient has a mental condition, the doctor could perform quick mental assessments through the interface to see if the patient is experiencing more problems than normal. The doctor can check the overall appearance of the patient, and see if she is able to move around without pain, or if her speech is becoming slurred. The doctor can also ask the patient if she has been taking her medication lately. If the patient says yes, and the doctor watches the video recordings and notices the patient often not taking her medication, it could indicate a problem.
Discussion Group Six

This discussion group consisted of an adult who took care of her mother, and helped her mother to manage her medications. Her main concern was that the machine be very simple, and not require the patient to push many buttons or perform complex actions. This will be accomplished by the wristband dispensing the medications and activating the video recording. The machine would have a camera which a family member could turn on and watch the patient through. There should be cameras in the rooms the patient most often uses. With multiple cameras, a family member could check and see how much laundry was piling up, if the patient was exercising as told, and would be able to monitor household tasks. Multiple cameras would also be able to show what the patient ate that day, why she did not answer a phone call, and if the home was clean. However, this is going beyond the scope of the initial lightweight medication dispensing device. The family member needs to be able to talk to the patient through the machine and get verbal confirmation that the patient is doing well.

With respect to taking medications, the machine should be able to record what, if any, pills were missed by the patient. This would be accomplished by the pressure sensitive material lining the dispensing dish and the pill recognition software. This participant mentioned her mother not being able to always open medication bottles as a source of concern, which this machine would address through its dispensing mechanism.

The participant thought that the machine might be able to determine information about the patient’s medications through the pharmacy’s prescription number on the medication bottle, which is unique to each medication for each patient. The machine
could connect to the pharmacy’s database and be able to access information about side effects or drug interactions in this way. If the machine was hooked up to the pharmacy, it would also be able to order any refills the patient needed. Perhaps a pharmacy technician could even deliver the pills to the patient’s home and load the machine for him. The machine would have access to all previous medications the patient was on and could use this information if the patient was experiencing a new or worsening symptom. Having access to previous medications would provide a more detailed context for discovering the source of current problems for the patient.

If the patient had a visiting nurse, the nurse could wear a badge or other device which would remotely connect to the medication dispensing device. This badge could record what tasks the nurse had performed, and any medications the nurse had given to the patient, so that family members or other caregivers would all be on the same page, and know what still needed to be done. The nurse would also be able to indicate if the patient had any problems that day, which would be added to the machine-generated report.

The patient’s wristband would have a system similar to “Life Alert” that would call for help if the patient fell, and then let caregivers know of the incident. The wristband would also be able to tell if the patient took her medication, and then email or text caregivers if the patient did not take her pills. The caregivers would be able to talk to the patient through the wristband. If the wristband was removed by the patient, temperature sensors would sense this and would let caregivers know that the patient had removed it.
If any problems were noted by the wristband, such as if the patient fell, the wristband would connect the patient to a help center where nurses would be on call at all times. This help center could have computers that received all alarms from patients in trouble. If a patient had been determined to be high risk, the type of alarm on the computer would indicate this and more immediate action should be taken. The type of wristband could even be different based on the patient’s classification as a high, medium or low risk individual.

If the patient was remotely meeting with a family member and a doctor, the machine should allow the doctor to pull up the patient’s files to show the family member and the patient. The family member could also bring up specific video clips that illustrated specific examples of the patient experiencing different symptoms. The patient could say how she was feeling in the daily video recordings, and this information would be captured and saved by the machine. Dynamic conditions, such as diabetes, might require the doctor to check on the machine’s reports more often, and “meet” with the patient more frequently. All people connected through the interface at the same time should be able to see each other, and what the others are doing. This visual component would also allow the patient to indicate areas where he had pain or was experiencing other problems. Seeing the patient would let the doctor know if the patient looked pale or was exhibiting a new symptom. This information could then be related to any recent changes in the patient’s medication, or could also indicate the patient was sick.

The videotapes would be able to provide a comparison of how the patient’s symptoms were progressing. The machine also could produce a trend chart which would
show things such as a patient tending to miss more and more pills as time progressed. If the machine noticed a detrimental trend, it would highlight this information in the report it generates.

The family member or caregiver helping the patient may not be comfortable with technology, and so the machine cannot be too challenging or complex. As other groups have mentioned, if patients have reduced cognitive functioning, having access to all of their medical information may be overwhelming. However, if caregivers or family members are not well versed in technology, they also may need limited, or filtered, information.
Chapter 9: Analysis of Discussion Groups

The above comments were generated while viewing the PowerPoint presentation attached in Appendix B. These comments were stream-of-consciousness, reflecting the participants’ hopes, dreams, fears and concerns in relation to a medication dispensing device. There is a difference between the participant’s stated needs, what these needs indicate, and how they influenced the design of the machine. The participant’s comments should not be taken at face value. They should be analyzed to see what the comments point to, and what underlying aspects or traits they reveal. For example, if a participant mentions a concern, the concern is related to a constraint on the machine’s capabilities or functions.

The discussion groups were very valuable sources of information for determining the functional requirements of the medication dispensing device. The meetings produced a wealth of feedback about the automated machine, and pointed to aspects of the design and functional requirements that were necessary for the machine to work successfully. They were, in essence, directed brainstorming sessions, or knowledge elicitations, with the end result being focused ideas about the design of an automated medication dispensing device, instead of gathering opinions for existing or prototyped items.
Most of the discussion groups were able to immediately start coming up with ways a machine would be able to help individuals manage their medications. However, one or two groups needed more prompting. They asked to see images of what the machine would look like, or at least to know what certain features of the machine were going to be. However, as this is preliminary work, there were no images to show to the participants. A certain level of free and unconstrained thinking was necessary in order for participants to be able to actively come up with functional requirements. Some participants were expecting to be shown different sketches of the machine on which to provide feedback, and these were the participants who had the most initial trouble thinking about the potential uses of the machine.

Some very interesting and new ideas were brought up by the participants of the discussion groups, which can be incorporated into this medication dispensing machine. While the discussions sometimes veered away from the initial idea of a medication dispensing device, overall the ideas and input gathered from the groups were useful. In future discussion groups, the scenarios should be more detailed in order to help the participants better relate to them. The use of mock-ups may also help the participants who required more prompting to have a more solid initial idea of the device on which to build. However, for this initial round of information gathering, the author did not want to have any images or prompts which could sway or influence the participants’ design generation.

All participants used the scenarios presented in the PowerPoint to help ground their ideas in relation to this new device. Some stayed more closely to the specifics of the
scenarios, while others took the scenarios as examples of a category of potential issues. Both types of participant feedback were helpful, yet the participants who did not stay as close to the particular scenarios for their feedback basis seemed to develop a more complex grasp of the machine’s potential features and functionality. Participants who were willing to “play” with the idea of the machine were able to push the idea further, and generate more new ideas, than participants who took the scenarios at face value.

A pitfall of the discussion groups were participants who simply stated a pillbox and a telephone would fulfill all of the scenarios brought up in the PowerPoint. Other participants thought the idea was too complicated, and stopped considering it further. After these declarations, the participants were unable to get these thoughts out of their heads and stayed with these mindsets throughout the discussion. They were unable to provide much feedback on the presented scenarios or the possible functional requirements of such a machine.

It was interesting to see the different perspectives brought to bear by potential users of the machine and medical professionals or family members. Medical professionals felt that patients would always be able to access their doctor or nurse, so the idea of a 24/7 nursing staff would only be useful for medical emergencies. Patients and family members believed that they would never be able to talk to a doctor right away, or at all. It was mentioned by one elderly participant that patients should simply not get sick on the weekends as there was no one to assist them besides doctors in hospitals. A middle ground between these two mindsets is necessary to determine adequate functional requirements for the device.
Patients also tended to want the device as more of a reminder system to see if they had already taken their medication, and what pills were still pending for the day. Family members wanted the machine to monitor the patient. Some wanted cameras in all the rooms of the patient’s home. The aim of this device is to empower and assist the patient with medication self-management. A whole house surveillance system does not fulfill this goal.

All of the comments from the participants can be linked to the desire for certain functional requirements in the device. The PowerPoint slides which contained the stimuli were organized around scenarios which exposed the challenges of managing self-medication, and the concept of tele-presence assisting a patient to successfully self-medicate. For the analysis, the comments from the discussion groups were organized as to what underlying functional requirement they were indicating. These functional requirements are then listed in the tables at the end of this section.

For the analysis, the author has chosen not to give specific examples of ways to address the functional requirements or concerns mentioned by the participants. While general needs are identified, citing a certain way to overcome a challenge may elicit the idea that there is only one correct way to address the comments. This is not the case, and is not the goal of this study.

There are three tables found at the end of this section. Table 1, the Functional Requirements of a Medication Dispensing Device, combines the functional requirements mentioned from the different discussion groups with those determined by the author. The “support” column takes comments from the different discussions or ideas as a basis for
the functional requirement. The criticality rating for the different functional requirements relates to the necessity of the function to the machine’s ability to assist patients with medication self-management. There are three different levels of criticality, including critical, important, and useful. Critical requirements allow the machine to fulfill its basic functions, important requirements allow the machine to be more adaptable and functional for the patient, and useful requirements are those which are not necessary for the machine to work, but provide a practical service. The goals of this machine are related to the most critical of functions of the machine, or those that help it to allow caregivers and family members to assist and assess the capabilities of the patient. These are the features which would be necessary for a first step, primary prototype of the machine.

In order to actually create a medication dispensing device that would serve the goals laid out in this paper, it would have to include all of the critical functional requirements. These are the essential, basic functions that would allow the machine to be a useful and beneficial aid for successful self-medication. This machine may not be able to do everything that the participants mentioned, or even all of the things the author thinks are important. However, the boundary of the machine has to be drawn somewhere. If not, the scope of the device will continue to grow, and nothing will come to fruition as the device will never be complete.

Table 2, the Scope of Functional Requirements, takes the functional requirements and concepts from the discussion groups and the author’s work and divides them into different scopes. The “core” scope includes concepts which relate to the direct function of the machine aiding the patient. The “broad” scope relates to the interaction of the
patient or the machine with family members, caregivers and healthcare specialists. The “broadest” scope concepts go beyond the stakeholders immediately linked to the patient, such as third party service providers.

Table 3, the Lightweight and Heavyweight Functional Requirement Classifications, takes the functional requirements and concepts, and divides them into “lightweight” and “heavyweight” classifications. Lightweight concepts are those that can easily and quickly be incorporated into the device. They allow the patient to interact with caregivers or family members. The lightweight concepts for this machine are those which relate to the user of this machine as a single patient living at home, managing her own medications, and living far enough away that it is inconvenient to visit every day. Lightweight features might not encompass all of the desired capabilities of the machine. However, they do provide some value to potential users. Heavyweight concepts are ideas which are more complex and challenging. They are not necessarily available yet, and may have to wait for technological advances or additional infrastructure. Heavyweight ideas are those more bent towards the future than the present.

There is a trade-off between lightweight and heavyweight functions. Lightweight features can be quickly incorporated into a machine which would be able to be used now, but would not provide the machine will the full list of features mentioned here. Heavyweight features make the machine more complex and require more time to develop, but would allow the machine to provide more valuable features for the users. If the lightweight features are useful for patients, they will become more interested in the
device and would want it to have more of the heavyweight features. This would allow an evolving machine which would change as new technologies are incorporated.

This machine does more than simply remind patients of their medication schedules. It allows interactions across different roles. Patients, family members, caregivers, and professional healthcare specialists are able to “meet” and discuss the patient’s needs and concerns. Through this interaction, the machine can provide better continuity of care and more dynamic reactions to changes in the patient’s health status.

All stakeholders in the patient’s health are able to communicate with one another, and have access to the same information to make informed and appropriate decisions. This ability to connect stakeholders is what makes this machine the “next generation” of medication dispensing devices. It is more than just a glorified pillbox, it is a portal into the patient’s world. It provides a means for family and caregivers to calibrate themselves to the patient’s abilities, and to aid them with any shortcomings.

Pilot Test

Many of the comments made by the participants of the pilot test of the discussion group were related to the idea of having a quick general view of the patient and his wellbeing, but also having the ability to get a more detailed and focused view of the patient or particular areas of interest. Having both video and audio components allows a caregiver to take a quick look into the patient’s home to see if everything looks well. Through the interface of the machine, a caregiver or family member can easily see any missed medications from a glance at the machine’s generated report. The participants in
this group wanted to have an email or text notification if the patient was not taking his pills. This too points to the idea of having a simple and fast way to check in on the patient. With the interaction through the machine’s tele-presence, the caregiver can ask the patient questions if there is a specific area of concern or confusion. The recorded view clips allow caregivers and family members to look for trends or unusual occurrences, which can then be shared with the patient’s doctor. Also, if a family member or caregiver is able to move the camera around remotely, she can look for signs that the patient is not doing well, such as a messy bedroom or dirty dishes piling up.

This group also discussed the idea of building a communication network. They did not only want to be able to use the tele-presence for connecting to caregivers and family members. This group felt the machine should also be able to connect to other support systems. The interface should facilitate easy connections to individuals both near and far from the patient. If the machine notes a problem, such as the patient not taking her medication, a family member or caregiver can be notified by the machine. If the patient’s medication changes, the doctor can let family members and caregivers know of the change. This way everyone is on the same page and understands the patient’s current condition. Allowing information to be shared remotely is an extremely important aspect of this machine for these participants. This group’s idea of a wristband that is able to take and share biological measurements is linked to the idea of communicating the patient’s state to caregivers. With more frequent updates from patient monitors, problems can be realized and action can be taken before medical issues cause the patient’s health to deteriorate.
Discussion Group One

This group discussed the ability of the machine to monitor the patient in-depth. They again mentioned the biofeedback mechanism of the wristband to keep tabs on the patient and any changes the patient may experience. A nursing staff that would be available 24/7 reflects the desire to have a monitoring system in place for the patient.

Having access to recorded footage of the patient would allow caregivers to view the patient’s actions after they had occurred, and interact with the patient in an asynchronous manner. No matter what time of day, or if other caregivers were busy, this group wanted the patient to be watched, and to be able to call for assistance if needed. This group also mentioned the idea that a patient may not want to go to the same place every day to take his medication. If there were multiple machines in a patient’s home, each with tele-presence capabilities, it would become more like a “Big Brother” situation where the patient could be watched at all times. This is not the goal of this machine. The automated dispensing machine is to empower patients and to allow them to successfully manage their own medication, not to have them constantly watched over by others. Some monitoring is necessary, but there should not be a whole house full of cameras and sensors to keep track of the patient.

Staying up-to-date with the patient was another desire for this group. These participants wanted to receive updates or alerts when a patient misses medication. If a doctor alters the typical medication schedule for the patient, the patient and caregivers should be reminded of this for the first few days of the change. The video recordings also provide updates of how the patient is looking and feeling. If a patient wears the same
clothing for a few days, it could indicate a new or worsening problem such as advancing Alzheimer’s. The fact that this group wanted to receive messages when medications were running low is also linked to the idea of staying updated and knowing when action will be required.

Allowing patients to gain knowledge of their own medications was the third overarching category this group mentioned. A patient should be able to ask the device about the common side effects associated with her medication without requiring outside help. The machine should also be able to determine drug interactions, especially for OTC medications such as allergy pills. This would allow patients to better manage their medications on their own, without having to call a pharmacy or ask a nurse basic questions about their medication.

Discussion Group Two

This group discussed varied ideas related to the patient’s interactions with the machine. The overall conclusion was that the machine cannot be too technically complex or else patients will not be able to use it. The design must be patient-centered, straightforward, and take into account the way a patient would interact with the device. This machine is for assisting the patient, and as such should be designed from the patient’s perspective.

Along with the ease with which the patient should be able to interact with the machine is how the machine helps the patient cope with personal deficits. If a patient has a memory or cognitive impairment, the machine can help the patient somewhat overcome
this and allow her to continue managing her own medications. Further, if the dosing
times for the medication are inconvenient, such as during the patient’s usual sleeping
times, the machine can dispense medications later, in essence pushing back the entire
medication schedule for the patient.

This group also mentioned having an on-call nursing staff that would watch over
the patient to make sure he was taking his medications. If there was a problem, this staff
would be able to assist the patient through the machine, or go to the patient’s home. This
idea combines communication and monitoring into a single entity.

The patients must trust the machine in order for it to assist them in taking their
medications. The idea that the machine is “attached” to humans is one way for patients
to feel more secure about using the medication dispensing device. Another is that the
machine itself could provide human-like reassurance for the patient. There is currently
work being done on the social faces of robots and machines, and if a patient felt more at
ease and could better use the machine due to its social face, this may be a promising
future direction of study for this device. Many signals are communicated non-verbally,
such as through body stance or facial features. In order to keep the patients in control of
their medications, signals as well as alerts could be used to inform patients when to take
medication. Patients would not want to be passive subjects to the machine. They want to
be empowered by the machine which allows them more control over their medications
and their lives.
Discussion Group Three

The entire discussion by this group was based on the idea of monitoring patients. The participants wanted to take a picture of the patient’s pillbox after dispensing times to see if any pills were left behind, to have a wristband which records if the patient took his medications, to have the patients push a button to indicate they took their medications, and to have the machine collect other objective information that allows a caregiver to tell if the patient has taken all of her pills. The means to tell that not all of the pills were taken would also be useful for the patient to know. This group also mentioned that if a doctor was not able to speak with a patient, a caregiver should be available to answer questions.

The above type of monitoring does not allow the patients to have control over their medication. It does not help the patient deal with daily interruptions and complications of managing medication so patients can stay on their own longer. Instead of empowering the patient, a machine that only included this monitoring feature would become somewhat of a “tattletale” machine.

Discussion Group Four

This group also discussed the advantages of having a quick overview of the patient’s activities and then a more detailed and in-depth view if problems arose. The machine could send a report when medications were taken, as an easy way to see if the patient got her medications or not. In the more detailed view, a family member could use the tele-presence to talk with the patient about problematic aspects of medication.
management. The whole record of the patient’s medication-taking for a selected time period could be displayed, and highlighted areas could indicate trouble. The doctor would have access to the patient’s entire medical history through the machine, and would be able to use this information to make well-informed decisions about adding to or changing the patient’s current medications. If the doctor was explaining a health concern or a new medication to the patient through the tele-presence on the machine, the doctor would potentially be able to tell if the patient was confused or looked worried, and would be able to address this. The participants also mentioned the ability to turn on the camera on the patient’s medication dispensing device and look around their home.

Monitoring the patient through the machine was also brought up by this discussion group. The participants wanted to have the patients verbally state if they had taken their medications. They also wanted the machine to only allow the person to take medication out of the machine at the “proper” time. Again, the goal of this machine is not to force the patients to listen to the machine. It is to help them manage their own medications successfully.

Increasing the patient’s knowledge about her medications was another goal of this group. Sometimes the same medication can look very different if it is made by different manufacturers. This machine would verify if two pills were different or the same. It would be able to display an image of the pills for further justification for the patient.

This group also discussed the occurrence of being away from the machine when it is time to take one’s medications. The patient is not always going to be able to access the
machine when it is time for his or her pills. There should be a way for the patient to still medicate when they are not able to get to the main machine.

Discussion Group Five

When medication schedules are changed there is a higher likelihood of problems with taking the medication. As other groups have mentioned, changes are interruptions in the patient’s normal routine and often require extra reminders and assistance. The machine could provide an explanation of the change, and tell the patient that all she has to do is take the medication from the machine, as the change has already been incorporated. This will also help to assure patients that the machine is up-to-date and accurate. The machine should also be able to update the caregivers with remaining medication amounts. Finally, if the patient was able to blog about her symptoms it would provide another way to get updates on the patient’s health and wellbeing.

This group also wanted a monitoring system. They discussed having a way to tell if the patient was taking the medication with food or water, having a 24/7 nursing staff, and getting biofeedback from a wristband. This is, as mentioned above, not a device that will tattle on the patient for medication management shortcomings. Monitoring is useful, but it must be done in a way that puts the patient in control.

Communication through the tele-presence feature of this machine is able to not only connect the patient to family members and caregivers, but also to other patients who have similar symptoms or medical issues. This reduction of isolation and increase in support would allow patients to better manage their medications. They also mentioned
the fact that with the tele-presence the patients could more dynamically discuss their symptoms and the medications they are taking with their doctor. If the patient experiences a negative side effect, this communication would allow them to let the doctor know.

This discussion group also discussed the issue of a patient dropping a pill which had been dispensed. Therefore, this machine needs to be able to overcome interruptions and unexpected occurrences in the patient’s routine. The machine must be adaptable and “understanding” in the event that a patient loses a pill, and dynamically alter the planned schedule to cope with the change.

Discussion Group Six

This participant was interested in creating a complex monitoring system for the patient. There would be cameras in every room so the family members can check on the condition of the house, make sure the patient is eating well, and that there is not dirty clothing piling up. For the wristband, there could be a sensor that would indicate if the patient had removed it from her wrist, and the caregiver would then tell the patient to put it back on. The wristband would also have a link to medical services if there was an accident or emergency. Again, this sort of monitoring is not the goal of the machine, and the patients would not feel empowered if they were being constantly monitored. This participant also thought that the machine could create trend charts to see how a patient was performing her medication self-management. Trend charts would allow caregivers or family members to tell at a glance if a patient’s symptoms or abilities were changing,
either for the better or the worse. Each point on the chart could be linked to the machine-generated report from that day for an easy way to get more detailed information on the patient. Further, this allow trends to be seen without having to dig through all of the machine’s reports and drawing one’s own conclusions. It may be difficult to properly determine how the patient was doing based on automatic sensors. Further, the patient may have to input data into the trend charts, creating a higher level of complexity. However, the ability to automatically create trend charts is useful and allows caregivers to more easily assist and assess the patient. The idea of the machine being very easy and simple to operate was again brought up, reiterating the patient-centered perspective this machine will possess.

The following tables provide summaries of the functional requirements for the medication dispensing machine from the discussion groups (Table 1), and the author’s thoughts combined with the literature review preformed. They also detail the scope of different functional requirements (Table 2), as well as if the requirement can be easily incorporated as a “lightweight” feature, or would require more work as a “heavyweight” functional requirement (Table 3).
<table>
<thead>
<tr>
<th>Discussion Group</th>
<th>Functional Requirement</th>
<th>Support for Requirement</th>
<th>Criticality to Fulfilling Device Goals (Author’s Perspective)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Five Author</td>
<td>Dynamic scheduling</td>
<td>If a pill is dropped, lost, not taken, skipped, etc.</td>
<td>Critical</td>
</tr>
<tr>
<td>Pilot Group Two, Five Author</td>
<td>Communication through tele-presence capabilities including audio and video</td>
<td>Tele-presence “speed dials,” updates, calling caregivers, forming support groups</td>
<td>Critical</td>
</tr>
<tr>
<td>Group One, Five Author</td>
<td>Updating family and caregivers</td>
<td>Knowing when refills are required, change in schedule if patient missed pills, notes changes in symptoms</td>
<td>Critical</td>
</tr>
<tr>
<td>Group One, Four Author</td>
<td>Increasing patient knowledge</td>
<td>Machine knows side effects, interactions, image of pill</td>
<td>Critical</td>
</tr>
<tr>
<td>Group Two, Six Author</td>
<td>Ease of patient interaction</td>
<td>Straightforward, simple, patient-centered</td>
<td>Critical</td>
</tr>
<tr>
<td>Author</td>
<td>Easily indicate missed doses</td>
<td>For both patients and caregivers to easily determine</td>
<td>Critical</td>
</tr>
<tr>
<td>Author</td>
<td>Tele-presence</td>
<td>Remotely check-in on patient in-depth, accelerate information flow, context sensitivity</td>
<td>Critical</td>
</tr>
<tr>
<td>Author</td>
<td>Separated pill filling area inside machine</td>
<td>For dispensing pills, and issuing refill reminders</td>
<td>Critical</td>
</tr>
</tbody>
</table>

continued
Table 1 continued

<table>
<thead>
<tr>
<th>Discussion Group</th>
<th>Functional Requirement</th>
<th>Support for Requirement</th>
<th>Criticality to Fulfilling Device Goals (Author’s Perspective)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Dispensing mechanism</td>
<td>Where medications are delivered to patient</td>
<td>Critical</td>
</tr>
<tr>
<td>Author</td>
<td>Holding tank for improperly dispensed pills</td>
<td>Keeps pills that were improperly dispensed from being given to patient, if pills were dispensed and not taken</td>
<td>Critical</td>
</tr>
<tr>
<td>Author</td>
<td>Interface of machine</td>
<td>Displays patient requested and other data, tele-presence portal</td>
<td>Critical</td>
</tr>
<tr>
<td>Author</td>
<td>Battery back-up to AC power</td>
<td>For power outages, road trips, etc.</td>
<td>Critical</td>
</tr>
<tr>
<td>Author</td>
<td>Daily machine generated report</td>
<td>Updating stakeholders and cataloging data</td>
<td>Critical</td>
</tr>
<tr>
<td>Group One, Two, Three, Four, Five, Six Author</td>
<td>Monitoring</td>
<td>Biofeedback wristband, nursing staff, taking pills in different places, recording missed pills, verifying pills were taken</td>
<td>Important</td>
</tr>
<tr>
<td>Pilot Group Four Author</td>
<td>Ability to have general and detailed views of patient</td>
<td>Video gives more details, notifications give quick summaries, tele-presence allows detailed interactions</td>
<td>Important</td>
</tr>
<tr>
<td>Group Four Author</td>
<td>Taking pills away from main machine</td>
<td>Not always at home, need to take pills</td>
<td>Important</td>
</tr>
</tbody>
</table>

continued
Table 1 continued

<table>
<thead>
<tr>
<th>Discussion Group</th>
<th>Functional Requirement</th>
<th>Support for Requirement</th>
<th>Criticality to Fulfilling Device Goals (Author’s Perspective)</th>
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<tbody>
<tr>
<td>Author</td>
<td>Appropriate number of alarms</td>
<td>Flexible schedule</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Little physical dexterity needed</td>
<td>For patients with reduced manual dexterity and strength</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Size and portability of machine</td>
<td>Small and light enough to move</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Machine can read medication labels for information</td>
<td>For schedule, side effects and interaction data</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Cost</td>
<td>Not too expensive so all patients can afford</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Ensuring medication was taken, check if any pills were left behind</td>
<td>Software to determine pills were taken</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Variety of alerts and alarms</td>
<td>Machine can be personalized for hearing loss, etc.</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Alerts and alarms for non-pill or OTC medication</td>
<td>To remind patient of other medications</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Machine maintenance</td>
<td>Accurate medication dispensing</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Voice recognition software</td>
<td>For patient to be able to speak queries and requests to machine</td>
<td>Important</td>
</tr>
<tr>
<td>Author</td>
<td>Ability to control amount of data patients see</td>
<td>For patients who may be overwhelmed or confused</td>
<td>Useful</td>
</tr>
<tr>
<td>Discussion Group</td>
<td>Functional Requirement</td>
<td>Support for Requirement</td>
<td>Criticality to Fulfilling Device Goals (Author’s Perspective)</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------</td>
<td>-------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Author</td>
<td>Pause button for alarms</td>
<td>If patient is temporarily busy</td>
<td>Useful</td>
</tr>
<tr>
<td>Group Two</td>
<td>Trusting machine</td>
<td>Social face</td>
<td>Useful</td>
</tr>
<tr>
<td>Author</td>
<td>Easy and safe way to refill machine</td>
<td>No lock and key required</td>
<td>Useful</td>
</tr>
<tr>
<td>Author</td>
<td>Wristband to activate camera and dispensing</td>
<td>When patient is close to machine, it activates; issues redundant alerts to take medication</td>
<td>Useful</td>
</tr>
</tbody>
</table>
Table 2. Scope of Functional Requirements

<table>
<thead>
<tr>
<th>Discussion Group</th>
<th>Functional Requirement</th>
<th>Scope (Author’s Perspective)</th>
<th>Reasoning for Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Group Four Author</td>
<td>Ability to have general and detailed views of patient</td>
<td>Core</td>
<td>Easy check-ups with patient</td>
</tr>
<tr>
<td>Group Two, Six Author</td>
<td>Ease of patient interaction</td>
<td>Core</td>
<td>Patient accesses information</td>
</tr>
<tr>
<td>Group Two</td>
<td>Trusting machine</td>
<td>Core</td>
<td>Patient’s personal interactions with machine</td>
</tr>
<tr>
<td>Group Four Author</td>
<td>Taking pills away from main machine</td>
<td>Core</td>
<td>Machine solely interacting with patient</td>
</tr>
<tr>
<td>Author</td>
<td>Appropriate number of alarms</td>
<td>Core</td>
<td>Machine interacting with patient’s daily interruptions</td>
</tr>
<tr>
<td>Author</td>
<td>Easy and safe way to refill machine</td>
<td>Core</td>
<td>Patient interaction</td>
</tr>
<tr>
<td>Author</td>
<td>Little physical dexterity needed</td>
<td>Core</td>
<td>Interacting with machine directly</td>
</tr>
<tr>
<td>Author</td>
<td>Size and portability of machine</td>
<td>Core</td>
<td>Relates to machine itself</td>
</tr>
<tr>
<td>Author</td>
<td>Machine can read medication labels for information</td>
<td>Core</td>
<td>Machine’s ability</td>
</tr>
<tr>
<td>Author</td>
<td>Separated pill filling area inside machine</td>
<td>Core</td>
<td>Machine feature</td>
</tr>
<tr>
<td>Author</td>
<td>Cost</td>
<td>Core</td>
<td>Machine itself</td>
</tr>
<tr>
<td>Author</td>
<td>Dispensing mechanism</td>
<td>Core</td>
<td>Machine feature</td>
</tr>
<tr>
<td>Author</td>
<td>Wristband to activate camera and dispensing</td>
<td>Core</td>
<td>Patient and machine interaction</td>
</tr>
<tr>
<td>Author</td>
<td>Holding tank for improperly dispensed pills</td>
<td>Core</td>
<td>Machine feature</td>
</tr>
<tr>
<td>Author</td>
<td>Variety of alerts and alarms</td>
<td>Core</td>
<td>For patient</td>
</tr>
</tbody>
</table>

continued
Table 2 continued

<table>
<thead>
<tr>
<th>Discussion Group</th>
<th>Functional Requirement</th>
<th>Scope (Author’s Perspective)</th>
<th>Reasoning for Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Pause button for alarms</td>
<td>Core</td>
<td>For patient</td>
</tr>
<tr>
<td>Author</td>
<td>Alerts and alarms for non-pill medication</td>
<td>Core</td>
<td>For patient</td>
</tr>
<tr>
<td>Author</td>
<td>Machine maintenance</td>
<td>Core</td>
<td>Related to machine</td>
</tr>
<tr>
<td>Author</td>
<td>Battery back-up to AC power</td>
<td>Core</td>
<td>Machine feature</td>
</tr>
<tr>
<td>Author</td>
<td>Voice recognition software</td>
<td>Core</td>
<td>For patient to interact with machine</td>
</tr>
<tr>
<td>Author</td>
<td>Easily indicate missed doses</td>
<td>Broad</td>
<td>Indicate for both patient and caregivers</td>
</tr>
<tr>
<td>Group Five</td>
<td>Dynamic scheduling</td>
<td>Broad</td>
<td>Machine remotely interacts with patient</td>
</tr>
<tr>
<td>Author</td>
<td>Ensuring medication was taken, what if any pills were left behind</td>
<td>Broad</td>
<td>For patient and caregivers</td>
</tr>
<tr>
<td>Author</td>
<td>Daily machine generated report</td>
<td>Broad</td>
<td>For caregivers and patient</td>
</tr>
<tr>
<td>Author</td>
<td>Ability to control amount of data patients see</td>
<td>Broad</td>
<td>Caregivers control</td>
</tr>
<tr>
<td>Group One, Five</td>
<td>Updating family and caregivers</td>
<td>Broad</td>
<td>Connect all stakeholders and third parties</td>
</tr>
<tr>
<td>Author</td>
<td>Increasing patient knowledge</td>
<td>Broad</td>
<td>Connection with family and caregivers only</td>
</tr>
<tr>
<td>Pilot Group Two, Five Author</td>
<td>Communication through tele-presence capabilities including audio and video</td>
<td>Broad</td>
<td>Machine connects the patient with family members and caregivers</td>
</tr>
<tr>
<td></td>
<td></td>
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</table>

continued
Table 2 continued

<table>
<thead>
<tr>
<th>Discussion Group</th>
<th>Functional Requirement</th>
<th>Scope (Author’s Perspective)</th>
<th>Reasoning for Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Tele-presence</td>
<td>Broadest</td>
<td>Connecting all stakeholders and third parties</td>
</tr>
<tr>
<td>Author</td>
<td>Interface of machine</td>
<td>Broadest</td>
<td>All individuals will communicate through interface</td>
</tr>
<tr>
<td>Group One, Two, Three, Four, Five, Six Author</td>
<td>Monitoring</td>
<td>Broadest</td>
<td>Connect all stakeholders and third parties</td>
</tr>
</tbody>
</table>
Table 3. Lightweight and Heavyweight Functional Requirement Classifications

<table>
<thead>
<tr>
<th>Discussion Group</th>
<th>Functional Requirement</th>
<th>Lightweight or Heavyweight</th>
<th>Reasoning for Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Group Four Author</td>
<td>Ability to have general and detailed views of patient</td>
<td>Lightweight</td>
<td>Tele-operation is well utilized, machine generates reports automatically</td>
</tr>
<tr>
<td>Group One, Five Author</td>
<td>Updating family and caregivers</td>
<td>Lightweight</td>
<td>Send generated reports to selected stakeholders</td>
</tr>
<tr>
<td>Group One, Four Author</td>
<td>Increasing patient knowledge</td>
<td>Lightweight</td>
<td>Machine can access database or read from labels and display on interface</td>
</tr>
<tr>
<td>Group Two, Six Author</td>
<td>Ease of patient interaction</td>
<td>Lightweight</td>
<td>Usability testing, prototyping</td>
</tr>
<tr>
<td>Author</td>
<td>Appropriate number of alarms</td>
<td>Lightweight</td>
<td>Technology already exists</td>
</tr>
<tr>
<td>Author</td>
<td>Easy and safe way to refill machine</td>
<td>Lightweight</td>
<td>Technology already exists</td>
</tr>
<tr>
<td>Author</td>
<td>Easily indicate missed doses</td>
<td>Lightweight</td>
<td>Display on interface, from weight sensors</td>
</tr>
<tr>
<td>Author</td>
<td>Little physical dexterity needed</td>
<td>Lightweight</td>
<td>Automatic dispensing</td>
</tr>
<tr>
<td>Author</td>
<td>Size and portability of machine</td>
<td>Lightweight</td>
<td>Related to amount of pills machine can hold</td>
</tr>
<tr>
<td>Author</td>
<td>Separated pill filling area inside machine</td>
<td>Lightweight</td>
<td>Physical aspect of machine</td>
</tr>
<tr>
<td>Author</td>
<td>Dispensing mechanism</td>
<td>Lightweight</td>
<td>Sensing technology exists</td>
</tr>
<tr>
<td>Author</td>
<td>Wristband to activate camera and dispensing</td>
<td>Lightweight</td>
<td>Sensing technology exists</td>
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continued
Table 3 continued

<table>
<thead>
<tr>
<th>Discussion Group</th>
<th>Functional Requirement</th>
<th>Lightweight or Heavyweight</th>
<th>Reasoning for Classification</th>
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<tbody>
<tr>
<td>Author</td>
<td>Holding tank for improperly dispensed pills</td>
<td>Lightweight</td>
<td>Mechanical feature</td>
</tr>
<tr>
<td>Author</td>
<td>Variety of alerts and alarms</td>
<td>Lightweight</td>
<td>Technology exists</td>
</tr>
<tr>
<td>Author</td>
<td>Pause button for alarms</td>
<td>Lightweight</td>
<td>Technology exists</td>
</tr>
<tr>
<td>Author</td>
<td>Alerts and alarms for non-pill medication</td>
<td>Lightweight</td>
<td>Technology exists</td>
</tr>
<tr>
<td>Author</td>
<td>Battery back-up to AC power</td>
<td>Lightweight</td>
<td>Technology exists</td>
</tr>
<tr>
<td>Author</td>
<td>Daily machine generated report</td>
<td>Lightweight</td>
<td>Technology exists</td>
</tr>
<tr>
<td>Author</td>
<td>Ability to control amount of data patients see</td>
<td>Lightweight</td>
<td>Select which fields patient can access</td>
</tr>
<tr>
<td>Author</td>
<td>Voice recognition software</td>
<td>Lightweight</td>
<td>Technology exists</td>
</tr>
<tr>
<td>Group Four</td>
<td>Taking pills away from main machine</td>
<td>Lightweight</td>
<td>Easy to dispense pills early, may be hard to sync up information</td>
</tr>
<tr>
<td>Author</td>
<td>Ensuring medication was taken, what if any pills were left behind</td>
<td>Lightweight</td>
<td>Video recording</td>
</tr>
<tr>
<td>Author</td>
<td>Machine maintenance</td>
<td>Heavyweight if work needs to be done</td>
<td>Third party services machine</td>
</tr>
<tr>
<td>Author</td>
<td>Communication through tele-presence capabilities including audio and video</td>
<td>Heavyweight</td>
<td>Must build and coordinate interfaces, develop biofeedback monitoring</td>
</tr>
</tbody>
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continued
Table 3 continued

<table>
<thead>
<tr>
<th>Discussion Group</th>
<th>Functional Requirement</th>
<th>Lightweight or Heavyweight</th>
<th>Reasoning for Classification</th>
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<tbody>
<tr>
<td>Group One, Two, Three, Four, Five, Six Author</td>
<td>Monitoring</td>
<td>Heavyweight</td>
<td>Building and coordinating machine and technology</td>
</tr>
<tr>
<td>Group Two</td>
<td>Trusting machine</td>
<td>Heavyweight</td>
<td>Much research still needed in social faces</td>
</tr>
<tr>
<td>Author</td>
<td>Tele-presence</td>
<td>Heavyweight</td>
<td>Needs infrastructure</td>
</tr>
<tr>
<td>Author</td>
<td>Machine can read medication labels for information</td>
<td>Heavyweight</td>
<td>Pharmacy labels need to be compliant with machine</td>
</tr>
<tr>
<td>Group Five Author</td>
<td>Dynamic scheduling</td>
<td>Heavyweight</td>
<td>Likely computationally intense programming</td>
</tr>
<tr>
<td>Author</td>
<td>Cost</td>
<td>Heavyweight</td>
<td>Depends on cost of technology and required services</td>
</tr>
<tr>
<td>Author</td>
<td>Interface of machine</td>
<td>Heavyweight</td>
<td>Much testing required</td>
</tr>
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The machine is flexible in that it allows both synchronous and asynchronous interactions. It also is flexible in who initiations interactions, and when. For example, take the functional requirement of being able to get a quick generalized view of the patient, as well as an in-depth view. For the quick overview, a family member can be presented with a spreadsheet or special alert that will tell her if the patient missed a pill. If the family member then wants to follow up on this and ask the patient if they were feeling ill, or if they have been forgetting things lately, the family member can call up the patient through the device and talk with him. The functional requirements of having communication abilities, monitoring the patient, and updating the family members and caregivers have the same flexibility of being synchronous or asynchronous interactions. The functional requirement of communication refers to the machine’s providing live audio and video for the patient to interact with others, which differentiates it from monitoring which refers to the ability of the family member or caregiver to determine how the patient is doing with managing his medications.

The functional requirement of increasing the patient’s knowledge about her medication is also both synchronous and asynchronous, but in a different way from the above functional requirements. The machine can immediately show the patient that he or she has missed a pill by having the pill visible in the dispensing dish and through the interface. However, the patient can also look to see if she has been missing pills more often lately by looking back through the machine-generated reports. This ability of the machine encompasses the functional requirements of easily indicating missed doses, ensuring that medication was taken, and dynamic scheduling of the medication. The
wristband of the patient provides more synchronous information for the patient, as in when to take her medication and activating the dispensing mechanism, and asynchronous interactions for caregivers as it can record information on the patient taking medication away from home and other updates to the machine’s report. Yet the wristband provides synchronous interactions for the caregivers and family members as the wristband cues them and lets them know when the patient is in front of the machine and interacting with it.

All of these capabilities are related to the tele-presence of the machine. The tele-presence is what provides the machine with its flexibility in providing synchronous and asynchronous interactions. It can record information to be viewed at a later time, or can allow a family member or caregiver to actively engage and assist the patient. The tele-presence also allows the patient to initiate interactions with family and caregivers.
This research is to be considered preliminary work for the design of medication dispensing devices with tele-presence. As mentioned, there are already many different types of devices and other means available to assist individuals with managing self-medication. This study’s aim is to determine what functional requirements are necessary for a dynamic and useful medication dispensing device. The addition of tele-presence to this device is what allows it to possess an added measure of flexibility and adaptability. Especially for individuals who live on their own and do not have someone constantly checking in on them, this machine needs to be able to deal with a variety of problems and circumstances which cannot all be predicted. The built-in functional requirements of the machine provide it with a boundary that should be able to deal with the majority of encountered difficulties. However, the tele-presence provides a sort of second boundary, drawn much wider, which encompasses more than the machine could handle on its own.

Once a medical device enters a patient’s home, any closed world assumptions will be insufficient. This means that there is variety in the world, and the machine has to be able to deal with, and overcome, the variety in order to be a beneficial and useful device for assisting medication self-management. Even though a home might not seem like a
sporadic and uncontrolled environment, no two days contain the exact same set of actions or require the exact same reactions. The tele-presence added to this machine is what helps it to succeed in the face of variety, variety which the world will and always will contain. All knowledge needed to successfully dispense and aid a patient in self-medicating cannot be contained by the machine itself. The dispensing device is not an autonomous agent. It can take into account a large amount of information and present this information upon request, but it cannot always decipher nuances in the patient, or determine the intent of the patient’s inquiries. The ability of the machine to connect the patient to another human is where the real beauty and power of this device lie.

The machine and the patient only have common ground insofar as the device is able to understand the patient’s requests and questions, and deliver appropriate information. There are some aspects of human-human interaction that cannot be recognized by a machine. Tele-presence bridges the gap between the machine’s information and flexibility to deal with situations within its range, and the knowledge and particular capabilities possessed by a caregiver, doctor, or family member. Through the tele-presence, another human is provided with the context of the patient and so is able to gain situational awareness into the patient’s environment. Having this medication dispensing device eventually become more interactive, like a robot, is one intriguing way to help the device become more adaptable to the patient’s needs.

It is difficult to know if, and when, patients living alone need assistance with managing medications. The tele-presence feature of the machine allows caregivers and family members to easily recognize how patients are doing with managing medications,
and if the patients need help. Through the tele-presence, patients can connect with family members and caregivers remotely, and the level of assistance the patient requires in order to successfully self-medicate can be determined. Prospective users of this machine are somewhere between being completely independent and partially dependent. The machine allows individuals on this continuum, these pre-assisted living and generally capable patients, to be assisted with self-management at a level appropriate to their skills and shortcomings.

The different discussion groups brought together individuals with a wide range of personal experiences and perspectives. The author was able to compare and contrast the various perspectives, and to utilize them to determine the basis of different functional requirements for the medication dispensing device. In order to elicit the information from the participants of the discussion groups, various stimuli were presented in the form of scenarios related to the difficulties of medication self-management and how to assist patients in managing their medications. The scenarios allowed participants to bring their previous knowledge to the conversations through their personal experiences, as well as allowed them to envision the future of assisting patients with medication self-management. The various scenarios acted as cues for the participants to bring forth relevant personal and professional experience and knowledge about their experiences with medication management and with assisting others to successfully self-medicate.

For the scenarios used in the discussion groups, only a small number of difficulties and noted issues with medication self-management could be incorporated. Out of the fourteen areas of difficulties with medication self-management listed earlier,
this device is able to assist on some level with eleven of them. The areas where the
machine is able to essentially completely overcome the challenges are with physical
difficulties associated with opening medication, the complexity of the regime, medical
instructions, and the medication storage. Challenges of medication self-management
where this machine is able to still make an impact include dealing with interruptions of
life, the traits of the medication, the patient’s cognition, not requiring transportation to
talk to a doctor, traits of the patient such as being unorganized, having an assistant or
caregiver “present,” and with personal beliefs such as the usefulness of a medication.
Even with the incorporation of tele-presence, this machine is not going to be able to help
the patient with his financial situation, alter the governmental healthcare system, or
change the traits of the disease. Despite not being able to address these particular issues,
this machine is still able to address many of the challenges of self-medication and allows
patients to successfully manage their medications while maintaining their independence.

Even with rather open-ended examples which were related to the fourteen general
facets of medication self-management, the participants were able to bring their own
experience and knowledge to bear. This allowed the participants to give very detailed
and in-depth responses to the scenarios. With the addition of tele-presence to the
machine and scenarios, participants could step out of the real world constraints from
modern day technology and think about what features would be useful for the machine to
possess. They were not limited to the breakthroughs of today, but could imagine where
the machine will go in the future.
The end result of the discussion groups were many comments which were related to the machine’s functionality. However, the explicitly stated desires of the participants did not necessarily lead to coherent solutions for the creation of an automated medication dispensing device. Some participants felt that technology would solve all the challenges of self-medication while others felt that technology could never catch up and so this machine was impossible to build. It must be realized that technology is not the final solution to all of the design problems for this machine, nor is it the machine’s insurmountable stumbling block. One of the common issues with using envisioning exercises is that the participants often feel that technology will solve all of the design challenges. To compensate for this, the comments were grouped as support for more abstracted, higher level, functional requirements. The list of functional requirements is not complete, but is a solid start for determining the design seeds of an automated machine of this sort.

The list of functional requirements that the patients and author generated are closely linked with overcoming the fourteen factors which make medication self-management difficult. The following table relates each of the functional requirements to the medication self-management challenges it addresses. It is interesting that the generated functional requirements of the machine are so directly linked to the fourteen challenges of medication management, even without the participants of the focus groups explicitly knowing the challenges beforehand.
Table 4. Facets of Medication Self-Management versus Functional Requirements

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One of technology’s main roles in this machine is to support interactions between the patient, the family members, and the caregivers. This is what makes the tele-presence capabilities of this machine so valuable. The second main role of technology in this machine is to assist the patient with medication self-management. Aspects of the machine that deal with dispensing, issuing reminders, and dynamically adjusting the medication schedule are just some of the areas where technology will play an important part in assisting the patient with medication self-management. The technology will aid in remotely monitoring the patient, with actively dispensing the medication, with reminding the patient of when to take her pills and when she has missed one, with dynamically altering the medication schedule, and with the other functional requirements of the device.

Design’s goal is to reconcile constraints which seem irreconcilable. In the design of this machine, multiple constraints must be dealt with and balanced. The inherent trade-offs of dealing with constraints must also be confronted. The lightweight functions of the machine indicate those features which can be fairly simply incorporated into the machine without building infrastructures or requiring other large supplementary tasks. On the progression of the design of the device from lightweight to heavyweight functional requirements, the machine’s trajectory and value-added aspects can be seen. This machine has a wide range of design possibilities, but will regardless provide invaluable assistance for medication self-management.
The medication dispensing device consists of many functional requirements which combine design’s balancing of constraints with technological innovation. The idea of a pillbox that is connected to the wristband and main unit, which could be used for taking patients’ medications with them, is an appealing solution to the problem of being out of the house when it is time to take one’s medication. The wristband could still remind the patient to take her pills, and the pillbox would have a mechanism that allows it to know when its compartments were opened. This information would then be synched with the main machine and would be included in the machine’s daily reports.

The concept of having a machine able to pick up patterns and trends is exciting. If a patient’s cognitive functioning or dexterity was decreasing, the machine would catch this through the number of forgotten or missed pills, and the frequency with which the patient dropped pills. These charts would be available for a caregiver or doctor, and would indicate problem areas for the patient. The doctor could then talk with the patient about the problems she has been having through the machine’s tele-presence, and take appropriate actions to assist her with her medication self-management. However, it is challenging to get automation to sense trends, especially for all of the interacting factors which make up medication management.

As this machine will have tele-presence capabilities, it is able to connect people who may be separated by a great distance. If a patient has recently been diagnosed with a disease, she could use the tele-presence features of the machine to connect with other patients who had similar conditions. The machine would allow a virtual support group to
be formed with patients able to share tips and tricks for overcoming symptoms, or simply what to expect with a certain illness. This goes beyond simply using the tele-presence for connecting to family members, or even caregivers. As the scope of this idea is quite large it is classified as heavyweight, or a feature which goes further than the machine’s original goals, but one which none the less would be very useful and practical for patients.

The exact way to incorporate tele-presence into this device is currently unknown. Further, the appropriate amount of information the machine needs to collect and transmit is yet to be determined. Apart from its many exciting and novel assistance and assessment capabilities, there are many challenges with tele-presence. Some patients may not feel comfortable knowing that a family member could turn on the camera on the device and watch them. Others may be confused when a caregiver interacts with the patient through the device. They may feel that the device possesses more of a television-like interface and not realize the synchronous aspects. Further, it is difficult to tell what will really prove useful to determine if a patient is successfully self-medicating. Would a camera and microphone be sufficient, or do other features need to be incorporated? These issues, as well as others related to the concept of tele-presence, must be studied in future research.

Even though the precise way in which to utilize tele-presence is not known, it is without doubt one of the most important aspects of the device. The flexibility for interaction that the tele-presence provides is what makes this machine unique and valuable. What if a patient forgets her medication because she overslept? Without this
device, she would have to look up if she was to skip the missed dose, or if she should go ahead and take it. But what if it was close to the time of the second dose of the same medication? Should she still take it? What should she do?

If a caregiver notices that the patient has not taken her medication through alerts or the machine’s report, the caregiver can call up the patient and ask her if she is okay. This way the caregiver knows the patient was not hurt in a fall or had become ill, providing peace of mind. The caregiver could provide reassurance to the patient, and remind the patient that the machine has the ability to properly determine if the medication should be dispensed, or if it should be skipped.

Conversely, the patient could call up a caregiver or family member and let them know that she had missed her medication. She could tell the caregiver that she has been very sleepy lately, and use the machine to determine if this was a common side effect of any of her medications. The fact that she missed her medication would be recorded in the machine’s generated report, and both the patient and caregiver or family member could see if the patient was missing more medications than usual lately. This could be brought up with the patient’s doctor, and the doctor could use the recorded data and speak with the patient through the interface to help her better manage her medications.

Due to the machine, the patient would be able to properly deal with the missed medication without worry or having to find the instructions which initially accompanied the medication. The caregivers and family members would know that the patient missed her medication, but also that she was not hurt, realized she missed her pills, and was
going to take them. They could then be on the watch for the patient missing more pills as time progressed, and see if it possibly pointed to a cognitive issue or worsening symptoms of a disease. Finally, the doctor would know that the patient was having some issues with sleepiness as well as medication management, and could monitor the effects of her medication and change it if necessary.

In order for the machine to be able to perform all of these actions, many capabilities must incorporated. These represent different design challenges and constraints of the machine. How should the machine’s generated report look, and how should it be communicated with caregivers and family members? How will the family members be alerted if the patient does not take her medication? What if the family member is at work? What information does the machine need to record in order for the caregivers to tell how the patient is doing with managing her medications? How will the interface display information for the patient without being too complex or overwhelming? These questions need to be answered with further research.

There are areas of relevant expertise and knowledge which were not included in the discussion groups of this initial study. There are many different kinds of caregivers, both professional and non-professional. Each caregiver, and each person, has a unique and different perspective on dealing with medication self-management. While a variety of types of caregivers were sampled here, there is still room for more individuals to share their insight and ideas. Further, some groups of caregivers and stakeholders were missed
in the discussions, including caregivers that travel to patients’ homes and pharmaceutical companies.

There are still questions that need to be addressed in order to create this medication dispensing device. What if the patient walks away from the machine when she takes her pills so there is no video confirmation? What if the pills are to be taken with food, and so the patient takes them out of the dispenser, cooks a meal, and then takes the medication late? What if the individual pretends as if he swallowed the pill, but in actuality has hidden it under his tongue and then spits it out? There are many more questions and possible actions by the patient that would render the video and audio recording capabilities of the machine insufficient and defeat its purpose.

In order for this machine to work, there must be significant coordination between caregivers, health care professionals, family members, and the patient. If the patient is unable to get to a pharmacy for refills, a caregiver or family member must do so before the patient runs out of medication. Even with a reminder from the machine that a refill is needed, getting the refill is not guaranteed. If the patient is able to acquire the medication, the caregiver may have to coach the patient on how to fill the machine, or may have to go to the patient’s residence to fill it for them. This is not different from current pillboxes, but could potentially be a hassle or inconvenience for both the patient and the caregiver.

One of the possible challenges for the design of the medication dispensing device has nothing to do with the device’s functionality or features. Some individuals are
simply not comfortable with advanced technology, and would not tolerate such a “high
tech” device in their homes. The fact that the machine would be recording video and
audio data may make some patients uncomfortable and worried that they were being
watched without their knowledge. This would not be the case, and the machine would
indicate when it was recording information, but this is a real concern and must be
addressed accordingly.

The next steps for continuing the design of this medication dispensing device
include taking the gathered functional requirements and coming up with ways to
accomplish them. This will include more brainstorming and input from discussion
groups. Underlying themes of the data could be established and related to functional
requirements. Experts in robotics and technology should also be involved to find ways to
realize the functional requirements of the machine, or to deem them currently
improbable.

Currently, the design of this device is in the beginning stages. The functional
requirements of the machine have been gathered through discussion groups, research, and
the author’s ideas. The first generation of this device will include some of the noted
lightweight features in order to produce a device that will quickly be able to assist
patients with medication self-management without having to wait for a large and complex
infrastructure to be built or for new technologies to be created. This first device will not
be able to perform all of the desired functions of the machine, but it will provide value for
patients and will assist them in staying independent.
The key problems that must be solved through this device include allowing the patient to interact with others both synchronously and asynchronously, building a communication network, determining how to appropriately assist patients, developing the technology, discovering how to use tele-presence to assess the capabilities of the patient while being able to assist the patient, and building a dynamic and flexible interface. The key features must be prioritized to ensure that a preliminary device can be made which will include sufficient functionality. Otherwise the device’s desired features will grow and grow, but no machine will be produced as the desired features continuously require new technologies and infrastructures.

After this first device has been used by patients for a time, more possible features will be noted while existing traits are analyzed and enhanced. The device will grow and develop as it is used and incorporated into patient’s homes and lives. Improvements will be made to the current features while new challenges of medication self-management are discovered, and means to overcome the challenges are implemented into the device. Once individuals find the device useful and realize its potential, more complex features can be added which will provide even more worth for the patients and their caregivers and family members. With use, the machine will continue to grow and change as new challenges are incorporated into the device’s capabilities.

More detailed studies need to be undertaken in order to determine an appropriate lightweight prototype of the machine. Which functional requirements are truly lightweight, and which are needed in order to create a valuable and useful device, will be
outcomes of these studies. Discovering the most useful and important features of the
machine will help in deciding which functional requirements are lightweight and which
are heavyweight. The information that the machine needs to collect to produce useful
reports and allow meaningful interactions between the patient, family members and
caregivers will also be studied in more detail. Further, it must be determined if it is even
possible to create a useful lightweight version of the device, or if its valuable attributes
are heavyweight and require more complex technology or infrastructure.

There could even be discussion groups where participants are given objects with
which to “build” their ideal medication dispensing device. By looking at these devices
and listening to the participant’s explanations, valuable design information can be
elicited. Creating more detailed scenarios will also help participants of discussion groups
to have a better basis for their ideas and comments. After this stage, mock-ups and
prototypes may be built for participants to interact with and give feedback on. Usability
testing will happen after the prototypes become more finalized and complete.

This machine is an important advancement in medication self-management and
would provide patients with invaluable assistance. This machine would provide both
assistance and assessment from family members for patients living alone in their homes.
It would ensure that they were able to successfully manage their medications, and would
support the interactions which allow the patients to overcome the complexities of
medication self-management. This work is preliminary and intended to discover the
design features required for a machine of this complexity and novelty. More testing and research must be performed before this device becomes a reality.
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Appendix A: Functional Requirements

The following functional requirements should be considered ideas. They illustrate different ways to perform the desired actions of the medication dispensing device. All of the bolded categories need to be addressed in the device in order for it to function at the expected level.

Size and Portability

- Portable, so the device can be placed out of sight when company comes

- The medication dispensing machine should not be very loud or large, as some patients are quite sensitive about their conditions and do not want others to know they are on medication

- The columns can separate from the base of the machine so patients can take the columns with them to a doctor’s office or a pharmacy

- The machine will be light weight enough so that the person can move it around, or “hide” it if people are visiting

- This machine should be able to store a large amount of medication

- Small enough to fit into a small and cluttered apartment
Cost

- Not too expensive, as some people are unable to pay even a few dollars for a medication organizing pillbox

- Internet access

- Telephone access and data transfer

Safety Features

- The device locks, but is easily opened in order to fill machine

- Prevent medication dispensing if the pills have problematic interactions if taken together

- Improperly dispensed pills will go into the reservoir tank in the back of the machine

- Lock away pills that were not taken

- Pills only dispense when patient comes within a predetermined distance of the machine with their RFID wristband on

- There could be fingerprint identification to access or refill the medication inside the device

Eliminate Need for Physical Strength

- The medication is automatically dispensed in order to eliminate the need for physical dexterity
• No small parts to open, or small lids or bottles to handle daily

**Technical Skill Requirements/ Technical Assistance**

• Usable by people who are not extremely comfortable with technology

• The machine somehow guides the user or caregiver along in the initial set-up

• There is a call center for help with the machine

• Little to no prior skills are needed as machine contains information on how to use itself

**Communication**

• The device calls pharmacy if there is a drug interactions and for other problematic occurrences

• The machine can call the doctor, pharmacist or a caregiver if the person needs help

• The machine is connected to a phone line, or the internet, to deliver the report of the user’s self-medication history to the caregivers, pharmacy and doctors

• If the machine remains empty for a day, the machine will notify the doctor or caregiver (as predetermined) that the patient has not taken their pills and that the machine is empty

• Report of what the patient took and when, etc., is saved and sent to caregivers automatically at pre-set intervals, or if they request it
Interface

- The device can tell the patient, at a glance, where they are in their dosing schedule for the day
- Have an easy to see way of indicating a dose was missed
- Possibly utilizing a timeline to show where the user is in his or her daily routine of taking medications – have properly taken medications in green and missed medications in red, have pending medications in yellow
- The timeline will help with the issue of different patients who need to take medication a different number of times a day, as the timeline will only need to indicate times with missed pills, regardless of the number of dispensing times – there could also be written text saying that the user did not take their medications at X o’clock
- The interface could be a touch screen
- Easy way for the machine to alert the user of possible drug interactions as well as food interactions
- Easy way for information be asked for, and communicated, to the user
- Simplicity and ease of understanding
- Large enough font to easily see
Flexibility, Adaptability and Adjustability

- When a dose is missed: all detailed information will be in the RFID on the label of the pill bottle
- For the next dose the machine will dispense the other pills as usual, but will double up on pills that should be doubled and will skip those that should not be doubled
- Medication schedule is known through the RFID tags that are on the pill bottles and other medications received from the pharmacy – non-pill medications can also be read by the machine
- The machine will not dispense non-pill medication, but will issue an alert when to take them if the user desires
- There will be an option for the user to dispense their pills early if they know when they are going to be out of the house, or during the time when they usually take their pills
- If the pills are dispensed early, it will be recorded on the email and generated report that is sent out to the caregivers
- There should be a delay button (approximately five minutes) if the person is busy, such as if they are on the phone, etc.
- For medications that are taken “as needed,” such as medications for pain, the machine can only dispense up to the maximum allowed dose as determined by the RFID from the pill bottle
Missed Doses/Holding Tank

- Improperly dispensed or missed doses will be put into the “holding tank” in the back of the machine.

- Pills will be easily removed, but cannot be accidentally removed, from the holding tank.

- Pills in the holding tank can be identified by the pill recognition software if the individual wishes to put them back into the machine to be dispensed again, or they could be discarded if the individual so wished.

Filling the Machine

- When the lid is opened the machine gets ready to accept new RFID into empty medication columns.

- The machine has lids over each column so that if there are pills left in a column the person cannot put new or different medications into the already occupied slot.

- However, if the person wished to put more of the same pills into a column that is partially filled, there will be an easy way to do this with the machine’s pill recognition software and RFID reader.

- When doses change the RFID on the label will alert the machine to the changes, or the machine will be linked to the pharmacy or medical clinic, and these will be implemented in the dosages.
• People do not have to put the pills in the same columns every time as the RFID resets the information in the column each time it is emptied and more medication is put into that column

Wearable Supplemental Device

• Store medication-taking information on the wristband
• Panic button on the wristband for the emergencies
• The bracelet/pendant/necklace on the patient will also light up and alert the patient that they have to take their medications
• The user will wear a bracelet/necklace/pendant that will have an RFID reader and writer which will activate the machine to dispense when the user gets close to the machine
• The RFID will ensure the pills will not be sitting out for long periods of time: pills could be sensitive to light or humidity in the air, a child could take the pills, a pet could eat the pills, etc.
• The wristband could record information such as the patient’s blood pressure, temperature, heartbeat, level of medication in the patient’s blood, and other biological measures

Taking Medication and Ensuring it was Taken

• Facial recognition software to tell if the person took their pill
• Perhaps have the person push a button when they have taken their medications

• Have pill recognition software that would tell from the video feedback which pills were taken

**Alert System**

• Method(s) of how the machine tells the person to take their medications – verbally, with flashing lights, with beeps, etc.

• Alerts, lights, sound, voice, vibration are different alarm types to be considered

• Music could play when the patient is to take their pills

• Have a caregiver or family member’s voice recorded and tell patient to take pills – need to have a dominant family personality to be the recorded voice

• The alarms should give the person a chance to take the medications on their own, but if the person does not, then the machine should alert them to take their medications

• There should be a “snooze alarm” on the machine so that if the person is busy for a few minutes the alarm should wait before starting

• Have an alarm that varies so that people do not stop paying attention to it

• The machine can say or can display text that says if the pill needs to be taken with food or water
• Machine alerts people when to take other medications, such as those that are liquids, or an inhaler

• Alert patient when they are going to need a refill a few days ahead of when they will run out of medication

• The alarms should not be too soft or too high pitched to be hard to hear for elderly users – there could be alarms with multiple pitches to remind patients with hearing loss over specific frequency bands

Machine Maintenance

• Machine indicates when it needs service

• How the machine is maintained – the machine can run self diagnostics nightly and check for problems

• If the machine keeps having problems with properly dispensing pills it can indicate it needs service

Dispensing Mechanism

• How the machine is loaded – the person does not have to put the same pills in the same slots every time, each time the machine is opened it will re-read all pharmacy prescription RFIDs

• Pills can be scooped out of a basin

• A drawer could eject with the pills in it
• Prevent over-dosing by having a pressure sensitive pad in the bottom of the dispensing device

• If there is an improper dispensing of pills, the pills are scooped back into the “holding tank” in the back of the machine and the pills for that same time period will be reissued

• The pressure sensitive material is also how the machine knows that the person came up to the machine and took their pills out of it, and also is how the machine can generate its reports that are sent to the caregivers

• The user could also push a button to dispense pills if they do not want to wear the wristband/necklace/pendant

• The machine cannot be opened without a code being put in, or a fingerprint being read from the user or caregiver
  • If the user forgets their code, the machine can call a caregiver or help desk to remind them of the code or have it reset

**Powering Device**

• Long battery life

• Machine runs on AC power but has very long lasting back up batteries to deal with power outages, and machine automatically resets itself to the proper time
Knowing medication schedule

- The pills schedules are recorded on the pharmacy’s RFID on the pill bottle’s label

Tele-presence

- The machine will allow the doctor or caregivers to experience tele-presence, and be “transported” into the patient’s home and life
- Used to assist the patient, as well as check in on them remotely
- Video cameras will aid in communications, and will also be recorded for the doctor or another caregiver to be able to look at later
- Audio recording will also help to improve communication
- The machine gathers information that allows others to check in on the patient and sufficiently tell how they are doing without physically going to check on the patient
- Allows patient or caregivers to initiate connections with others such as the doctor or another family member
- Allows the collected information to be presented in a variety of formats
- Gathers, transmits, and stores information in a secure way
- Allows the family, the patient, and caregivers to collaborate and corroborate medical information
Appendix B: PowerPoint for the Discussion Groups

The Next Generation of Medication Dispensing Devices

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Section 1: Warm-up and Envisioning

• This first section involves scenarios that would make a family member concerned about their loved one who is managing his or her own medications.
  – Think about any personal experiences with caring for others, past or present, which are relevant to the following situations

Section 1: Example 1

• Your mother has recently been to the doctor, and was diagnosed with Disease X. Disease X is related to a decline in cognitive functioning, such as forgetting things.
• She is already on two medications for other diseases, which must each be taken twice a day.
• You are not sure if she always remembers to take her pills, even though she says she does.
Section 1: Example 1

- You would like to be able to check in on your mom to make sure she is taking her medications, you are very busy and she lives far away.
- You decide to create some sort of machine that can help you check on her from a distance.
- What would the machine do to allow you to check in with your mother to make sure she is okay?

Section 1: Example 2

- Your sister is on prescription drops for her eyes. However, lately she has been getting headaches that are interrupting her normal activities.
- She wonders if the headaches are from the eye drops. She reads the label on the bottle, but all it says is to take the drops as directed. She cannot find the pamphlet that came with the bottle originally.
Section 1: Example 2

• It is Friday night and her headache is very bad. She decides to call urgent care to ask about the headaches.

• If you could create a device to have a nurse check in on your sister, what would the device have to do? How would it connect your sister with the urgent care center?

Section 2: Tele-presence

• This section deals with how tele-presence is able to connect people from a distance.
  – Through tele-presence, a caregiver can be “transported” into a patient’s home, without actually going to the patient’s home. This section focuses not only on current technology, but also how technology could grow and change in the future.
Section 2: Tele-presence

• Your aunt lives alone and is on multiple medications. You want to check in on her every night, but you work late.

• She takes her medication twice a day, once in the morning and once in the evening. One medication is for high blood pressure, one is for Alzheimer’s and the last is for arthritis.

Section 2: Tele-presence

• Say you were able to view the following information, collected by the machine. The information represents one day’s worth of recordings and reports.

• Aunt morning
• Aunt night
• Machine generated report
Section 2: Tele-presence

• Did your aunt have any problems today? What information would you need to be able to tell how she is doing?
• What was helpful, and what was not, for you checking in on your aunt?

Section 2: Tele-presence

• What actions would you perform if you physically went to visit your aunt to check up on her? Which of these actions can you perform remotely through the tele-presence provided?
• Is it sufficient to have recorded information? When does the interaction between patient and caregiver have to take place in real-time?
Section 3: Interactions of Stakeholders

• This section focuses on interactions between the patient herself, a doctor or nurse, and a family member.
  – It also deals with how a distant caregiver can gain situational awareness, or understand context, through tele-presence to determine the results of changing a patient’s medication schedule.

Section 3: Interactions of Stakeholders

• A patient has been on pain medication for years for arthritis. Recently, the patient has been having more pain than usual.
• The doctor, the patient, and a family member discuss the pain medication through medication dispensing device.
• How does the machine’s tele-presence ability, and the information it collects, help these three people communicate?
Section 3: Interactions of Stakeholders

• How does the machine’s abilities improve dealing with the changing nature of medical conditions?
• How can the machine help the doctor determine if a patient is simply sick, or if there is a real medical issue with a change in medication?
• Do the doctor, family members, and the patient need access to different information?

Section 4: Aspects of Current Design

• Small and Portable
• Cost
• Safety Features
• Strength Required
• Tele-presence
• Communication
• Interface
• Flexibility
• Missed Doses
• Filling Machine
• Wearable Devices
• Alerts
• Maintenance
• Dispensing Mechanism
• Medication Schedule
• Powering Device
• Ensuring Medications Were Taken
• Technical Skills