

PERSONAL MEDICATION MANAGEMENT IN EVERYDAY LIFE:
PRELIMINARY RESULTS REGARDING ELDER'S
PREFERRED MEDICATION REMINDER MODALITIES

by
Jennie A. Abrahamson, MLIS

A MASTER'S CAPSTONE PROJECT

Presented to the Department of Medical Informatics and Clinical Epidemiology
and the Oregon Health & Science University
School of Medicine
in partial fulfillment of
the requirements for the degree of
Master of Biomedical Informatics
December 2008

School of Medicine
Oregon Health & Science University

Certificate of Approval

This is to certify that the Master's Capstone Project of

Jennie A. Abrahamson

***Personal Medication Management in Everyday Life:
Preliminary Results Regarding Elders'
Preferred Medication Reminder Modalities***

Has been approved

**Advisor: Holly B. Jimison, PhD
Department of Medical Informatics & Clinical Epidemiology**

Table of Contents

Acknowledgments.....	iii
Abstract.....	iv
Introduction and Purpose.....	1
Methods.....	2
Results.....	8
Ongoing Qualitative Data Analysis Report and Discussion.....	17
Conclusions and Next Steps.....	24
References.....	28
Appendix 1.....	30
Appendix 2.....	31
Appendix 3.....	34
Appendix 4.....	41
Appendix 5.....	45

List of Tables

Table 1.....	9
Table 2.....	9
Table 3.....	9
Table 4.....	11
Table 5.....	14
Table 6.....	16

Acknowledgments

I thank the National Library of Medicine and the Department of Medical Informatics & Clinical Epidemiology for funding my biomedical informatics fellowship training, which gave rise to this study. It takes a library and its staff to support any degree of academic work; the OHSU library staff members deserve thanks for their outstanding library service. I also thank Oregon's Roybal Center for Aging and Technology (ORCATECH), particularly staff member Nicole Larimer, and Intel's Behavioral Assessment and Intervention Commons (BAIC) for providing the infrastructure within which to conduct this study.

I thank my advisor, Dr. Holly B. Jimison, for facilitating my education in consumer health informatics, a field that promises many exciting discoveries and solutions for the years to come for all involved. I am grateful to Holly for introducing me to human-computer interaction research and the compelling domain of elder health. I am also thankful to her for cheering me on when our study took some remarkable turns!

This study would not have been possible without our participants, who opened their lives and homes to in-depth investigation with equal parts cheer, commitment, and curiosity. I am deeply thankful to them for the lessons and inspiration I derived from working with them, which now inform my own everyday life. Their contributions to research promise to improve life for their own and future generations.

Abstract

An expanding elderly population worldwide, with associated needs for medication and adherence assistance, requires improved understanding of elders' general medication management practices and preferences regarding medication reminder devices. The purpose of this study was to investigate elders' preferences regarding a variety of commercially available medication reminder device types and reminding modes. The study also explored elders' general medication management behavior. Findings suggest that elders' medication reminder device preferences can be assessed via consideration of four general types of internal and external contextual factors: affective, cognitive, physical, and social factors. Preliminary study findings and design implications are discussed, along with plans for future analysis and research.

Introduction and Purpose

Experts predict that by 2030, “1 billion (or) 1 in every 8 of the earth’s inhabitants” will be age 65 or older [1]. The U.S. National Institute on Aging (NIA) recently identified “nine emerging trends in global aging.” These trends include increasing chronic disease rates, a significant increase in our “oldest old” (age 85 and older) population, and “changing family structures” which amplify the need to support self-care and for elders living in their own homes as they age [1, 2]. Medication adherence is an important component of elders’ self-care because elders are more likely to have multiple health conditions, requiring multiple medications. Moreover, previous studies have reported that elders have only 26-59% medication adherence rates [3].

The central purpose of this study was to understand the preferences of elderly people regarding various features of medication reminder systems intended to support medication adherence. To achieve a more holistic understanding of elders’ medication management behavior, we explored elders’ medication management practices and barriers and facilitators to their ability to take medications according to their treatment plan. We also considered how our study methodology contributes to the emerging literature regarding best approaches to studying health and information behavior and information and communication technology (ICT) use in everyday and in-home environments [4-6].

This report summarizes preliminary findings regarding participants’ categorically reported preferences and perceived usefulness feedback on device and alert types studied.

Preliminary themes from qualitative interviews focusing on elders' medication management practices, and implications for device design are also shared.

Methods¹

Participants

This study included five participants: four females and one male ranging in age from 74 to 84 years old (mean age 77.8 years). Participants were recruited from the Behavioral Assessment and Intervention Commons (BAIC) Living Lab via purposive sampling to achieve some gender and living status variety (e.g., living alone vs. with others). Other participant selection criteria included generally stable health status, no or insubstantial cognitive impairment, and existing multiple medication or supplement regimen.

Participant recruitment was limited, in part, by project time constraints. Additionally, the richness of data collected and theme saturation observed in early research stages prompted restriction to five participants in favor of achieving data collection depth for the multiple devices tested. Nielsen supports this approach in his article, "Why you only need to test with 5 users" [7]. Participants were given twenty dollars at the end of the study in appreciation for their time and effort.

Research Questions

Five research questions guided the study:

1. What are the demographic and general characteristics of this population related to taking medication and using medication reminder devices (e.g.,

¹ The first study protocol was authored by Dr. Holly Jimison as principal investigator; Ms. Abrahamson subsequently edited and augmented study protocol and instruments, with input from Dr. Jimison.

medical conditions, how many medications do they take, are any of these new medications, education, age, gender, experience and comfort level with technologies studied, cognitive health, medication-related health literacy, etc.)?

2. What barriers to medication adherence do patients experience and what situations give rise to these barriers?
3. What are the important features of a medication reminder device and how can we best tailor these features to adapt to individual users?
4. What are the characteristics and effects of interpersonal help-seeking related to patient medication management?
5. How does this research methodology facilitate research on everyday health information and medication management practices?

Study Details

This was a qualitative observational study where participants used various reminding devices for taking their normal medications or supplements, as if they had just purchased the device for their own use. The devices covered a reasonable scope of currently available commercial medication reminder device types. Participants were instructed to not necessarily rely on these devices, but to test them out in their everyday environment to determine if they found them to be useful. Participants tested devices, one at a time, in semi-randomized order. Participants kept a journal during the study period where they entered structured and unstructured feedback regarding devices tested and comments for the duration of the study.

Four broad device types and seven separate devices were tested by participants (see Appendix for device company details)²:

1. Watch types

1.1 (Three days)

- CADEX Watch with beeping alarm
- Scrolling text message reminder
- Freetext input, popular choices: “time to take your medications” or “take (medication names)”

1.2 (One day)

- MeDose pediatric watch with Velcro adjustable watch band
- Set to beeping alert (can also vibrate)

1.3 (Two days)

- MeDose teen/adult watch with leather band
- Set to vibrating alert (can also beep)

2. Pillboxes with detachable reminding device (three days)

[Device: MEDGlider]

- Day 1: flashing light reminder
- Day 2: voice reminder
- Day 3: beeping reminder

3. Telephone reminder types

- Landline phone reminder message (used participant’s existing home phone) (two-three days)³
- Cell phone reminders set to three modes (used T-Mobile Nokia model 2610 cell phone) (four days to allow for learning more complex device); optional carrying pouch offered (for clipping to belt or purse, or wearing around neck)

Day 1: Vibrate/silent mode w/ phone calendar text reminder note

² Some devices had additional features that were not used in device study, but were mentioned briefly described and explored during each device introduction and follow-up visit.

³ First-round device tests revealed only two days necessary for participants to evaluate.

Day 2: Ringing mode w/ phone calendar text reminder note
Day 3: Ringing mode w/ text messages
Day 4: Ringing mode w/ automated phone calls

4. Light reminder (two-three days)⁴
 - Pink night light plugged into lamp timer (colored light chosen to distinguish device from existing light fixtures) in participant's choice of location (typically placed in kitchen). Light set to automatically turn on and off for one to two hour windows around participants choice of medication times (participants did not manipulate light).

Instrument and Device Pre-testing

Two elderly volunteers, one male and one female, pre-tested the interview instruments.

The female pre-tester also tried out all of the devices in her home environment over a compressed period of three days total. Pre-testing revealed the need to use a colored light bulb in a night light device. Original plans were to use a timer on an existing lamp in the home, however, the tester was unable to distinguish this as an alert because it blended in with the environment. The device tester also noted that using the lamp as a programmed alert disrupted the household's normal lamp use pattern. Interview instrument testing resulted in minor adjustments instruments to improve comprehensibility. Space was also added to journal forms to allow more writing space to accommodate elders' decreased hand mobility. Journal forms were further revised after first round of device testing to include prompts to report both participant and device location because location information emerged as consistent theme (challenge) to device usability.

⁴ Participant who used device for two days was married to fellow participant who had used the device in shared area already for three days, evaluated device during entire time, and requested shorter test period.

Interviews

Each participant completed a total of eight semi-structured interviews:

- One pre-device use interview about general medication management and reminding practices and attitudes and current medication regimen (followed by initial device introduction);
- Six interviews (once for each device) after device use, regarding device use experience (followed by new device introduction after interviews 1-5);
- One post-study interview to rank devices, describe preferences, and answer follow-up questions regarding medication reminding practices observed during study.

A scenario-based technique was utilized in final interviews to elicit medication management and device preferences based on three possible situations:

1. “Life as it is”
2. “Life with new medication or diagnosis” (theoretical or previously experienced scenario)
3. “Life with cognitive difficulties” (theoretical or observational scenario regarding someone participant might know who was experiencing cognitive difficulties)

Interviews were conducted between July 31 and September 25, 2008. Interviews averaged approximately two hours each. All interviews took place in participants’

homes; many included tours of participants' home environments to view medication reminder tools and settings.

Participants tested each device for approximately three to four days, with about four to fourteen days between device changes (typically closer to five to seven days between changes). The researcher was on call between scheduled home visits via telephone and occasionally, via supplementary in-person visits to check device performance/set-up, or coach participants in device use.

Data collection included participants' device use journals (handwritten text), audio tapes of home visit and telephone conversations and interviews, and researcher's field notes (text). Approximately seventy hours of interview data were recorded and transcribed. Photographs of participants' existing medication management tools, tool location, and personal cell phones and watches (to record preference details) were also collected.

Analysis

Categorically reported interview responses were coded using content analysis. Due to small sample size, this data afforded no meaningful statistical analysis. The narrative interview data analysis is being analyzed with a grounded theory approach and remains in process. At present, the author is the only person who has analyzed study data. Two other researchers will analyze study data as we finalize our work. Categorically reported data from participants' final device preference interviews is emphasized below, followed by a summary of emerging qualitative (open-ended) response data themes.

Results

Participant Characteristics

Participants lived independently in their own homes (one married, heterosexual couple; one single female) or apartments (two single females). No participants stated that they were taking medications that required precise reminders or environmentally sensitive storage. Most described taking their medications or supplements during one to three hour “windows of time.” Two of the five participants self-reported hearing problems; one wore hearing aids, the other was prescribed hearing aids but chose not to wear them and thought that she could function without them in most settings. One participant experienced intermittent periods of low vision due to eye treatments; she used magnifying devices successfully to compensate. Most participants recounted occasional use of visual magnifying devices in their everyday life. While we hoped to recruit more participants, we discovered that taking more time for each interview yielded richer data and allowed us to expand our knowledge of methods for collecting everyday life health behavior.

Device Ratings

Device Preferences for “Life as it is” and Devices “as is”

Participants were asked to list each of the seven devices in rank order, from (1) most to (7) least favorite, based on current device condition (i.e., no suggested modifications) and on which device worked best for them. Based on raw total means, the group ranked the devices as follows (Table 1):

Table 1

Favorite to least favorite device “as is” (1= most favorite)

Rank	Device/reminder type
1	CADEX watch - leather band + beeping + text reminder
2	Cell phone - see individual reminder mode ranks below
3	MeDose watch - leather band + vibrating reminder
4	Landline phone - automated voice reminder
5	Night light
6	Pillbox + choice of voice, light, or beeping reminder
7	MeDose watch - Velcro band + beeping reminder

Table 2 provides details regarding participant device preference rankings reported above:

Table 2

Detail of device preferences per participant “life as it is”; device as is (1 = most favorite; 7 = least)

Participant ID	CADEX Watch	MeDose watch + vibrating reminder	MeDose watch + beeping reminder	Cell phone	Landline phone	Pillbox	Night light
P1	1	2	5	3	4	6	7
P2	3	5	6	1	4	2	7
P3	1	4	6	1	7	3*	5
P4	4	3	5	6	2	7	1
P5	4	2	4	4	3	7**	1
Mean	2.6	3.2	5.2	3.0	4.0	5.0	4.2

Note: *No #2 due to two-way tie for #1; **No #5-6 due to three-way tie for #4.

Caution is required when interpreting these rankings. Note that two of five participants ranked three devices “most preferred”: the CADEX watch, the cell phone, and the night light. This “most preferred” ranking is complicated by the fact that one participant chose two “most preferred devices (CADEX watch and cell phone). Two of five participants identified the night light and the pillbox reminder as “least preferred”; one participant chose the landline phone as “least preferred” (Table 3):

Table 3

Most and least preferred device per participant

Participant ID	Most preferred	Least preferred
P1	CADEX watch	Night light
P2	Cell phone	Night light
P3	CADEX watch or cell phone	Landline phone
P4	Night light	Pillbox
P5	Night light	Pillbox

The above combinations of most/least preferred devices reveal a preference from three of five participants for mobile over more stationary devices (as per participant comments regarding the pillbox attached reminding device). Though the remaining two participants (married to each other) chose two stationary devices, further analysis revealed the possibility that preference may be tied to routine. Both participants choosing the night light as the most preferred device appeared to value this device for providing a reminding signal when and where they needed it most, according to their morning and evening pill-taking schedule.

Comments from participants while ranking the devices and answering further interview questions revealed that their rankings were based on a complex combination of preferences discussed below and in future work. Participants were instructed to evaluate the devices based on their dominant features (type of device and reminder mode). The above rankings reflect three of five participants' preferences for a wearable, portable device that was familiar to them and thus required little learning. When talking about device "familiarity," participants explained that a familiar device was something that did not take much time or effort to learn how to use and was already integrated into their everyday routine. This "definition" fit the preferences of the remaining two of five participants, who favored the night light as "most preferred" device.

Despite expressed preference for devices that seemed "familiar," when asked, "*Which device (and device mode, as applicable) was easiest (or) hardest ... (to learn how to*

use)?” -- some participants indicated that a higher learning curve may be worth the effort for some devices (Table 4).

Table 4
Easiest/hardest device to learn + participant’s related preference rating
(1=most preferred; 7=least preferred)

Participant ID	Easiest	Preference rating	Hardest	Preference rating
P1	Watch	1	Night light*	7
P2	Landline phone	4	Cell phone	1
P3	Night light	5	Cell phone	1
P4	Night light	1	Cell phone	6
P5	Night light	1	Cell phone	4

Note: *Hard to find place to plug in or see light.

Ease of learning did not always appear to relate directly to preference. Qualitative data analysis should yield some insight into this observation.

Selected Device Preference Details

Details regarding preferences for reminder modes within the cell phone and MEDGlider pillbox-reminder devices will be analyzed in-depth later work. However, it is important to note that participants generally preferred the idea of using either the pillboxes or the accompanying reminder device separately. Between the two, they preferred using the pillboxes over the reminder device. As shared below, a few participants chose to combine the pillboxes alone (one day’s separate pillbox unit, with four pillbox slots) with another device such as a watch. Several participants stated that the tested pillbox was superior to their existing pillboxes due to number of doses it could carry per day (four) and larger pillbox size. However, all suggested that even wider or deeper slots were needed to better accommodate supplements, which are often larger than prescription pills.

Participants generally found the MEDGlider light to be too small and of too short duration to signal a response. Several suggested that the MEDGlider as a reminding device was only suitable for the bedridden to use, because they would be in close enough proximity and position to hear or see all modes of the system.

Reminder Types and Strengths

None of the devices tested were “perfect” as is. We anticipated this would be the case. Participants confirmed this by suggesting a mix of device features or modes tested before we asked them about it.

In response to the question, “*Is it OK to have a mix of reminder strengths and types (e.g., soft light, blinking light, soft, loud, or increasingly louder or stronger beeps or vibrations, etc.), or should there just be one reminder strength?*” -- four participants answered yes; one said no.

Narrative comments accompanying this answer supplement data about desired features reported below. Signal combinations participants proposed included (in random order):

- vibration + ring (2 responses)
- pillbox + watch
- pillbox + voice
- vibration + text
- watch that lights up as reminder
- depends on device + physical ability
- light + vibration
- only need/want (night) light

Because the cell phone set in vibration mode was so difficult for participants to detect, most rated this mode last and it is likely that “vibration” modes described above do not refer to cell phones. The “light” signal suggestion is interesting, given how low most participants rated both the night light and the pillbox reminder light mode. According to the above comments, vibration mode is popular. Participants who liked the vibration mode noted the privacy this mode afforded them while in public or while entertaining visitors at home.

What About Picture Reminders?

When asked, “*Would it be helpful/nice to have pictures or photographs of pills (& pills with a voice reminder) on a device?*” -- no participants answered “yes.” Two said “maybe” and three said “no.” Accompanying comments revealed that participants felt that using a picture/photo reminder signified poor physical or mental health status.

Participants commented:

- “(I’m) not there yet!”
- “Not appealing”
- “Maybe for the visually-challenged”
- “Right now, no -- depends on visual ability”

In retrospect, the wording of this question might have prompted some participants to focus on negative connotations of pill photo reminders. A better way of phrasing the question might have been: “*Would you be interested in a reminder that includes photographs of your pills? -- and with voice or any other reminder mode?*”

Designing a Medication reminder System “From Scratch”

When we asked participants what features they would include if they could design a reminder system from scratch, they offered several suggestions, and listed some exclusions (Table 5). Participants offered additional suggestions throughout qualitative interviews; these will be detailed in later work. Each of the suggestions below were mentioned by at least three of five of the participants, either in answer to the question above, or in other research conversations.

Table 5
Desired features in a reminder system (in random order)

Features to include	Features to exclude
<ul style="list-style-type: none"> • A human, e.g., spouse or friend • Ring OK at home • “Make it loud enough” • “Depends on your location” (light at home; vibrating watch outside home) • Clamshell design for cell phone -- to protect keypad while carrying in pants pocket (male reported) • “More feminine (delicate) watch design” (females) • Neutral watch band colors • Better watch design (male) • Leather watch strap • Flexible watch band - easier to take on/off • Emergency contacts (names, phone numbers) • Variety of watch straps/colors to change as desired • Vibration • Wearable reminder • “Keep it lit until turned off” (for reminder; for night light, or watch (face lights as reminder), or other devices) • Larger “readout” (text) - all devices (time/numbers or text/letters) • Larger number (text) + keys (cell phone) • Wider &/or deeper pillbox compartments (especially for supplements) • Improved display contrast, contrast choices 	<ul style="list-style-type: none"> • Beep • No ringing in public! • No pendants • No pouches or clips (for carrying) • Clam design for cell phone -- for answering ease (female) • Too loud or too soft signal strength

Watch Device Comments and a Novel Suggestion from a Participant

Throughout the study, the most common complaints about watches were that people could not hear the watch beeps and that the watches were universally bulky,

uncomfortable, and unattractive due to high profile of watch faces and general design features. A few participants noted that elderly people typically have sensitive, thin skin and watch design for this population should take this into account. However, those that liked the watches as a general device type valued their portability and multitasking features (e.g., time/date, text/alert features for some). These participants also valued the watch vibration mode for its discreet nature. While participants wanted watches to have smaller scale, including on the watch face, they also wanted increased text/number size. One participant offered a novel way to increase watch font size: he suggested that we program a “pop up” screen that would supersede other displays on the watch face to allow maximum space and font size to temporarily show text or time/number as magnified.

Device Preferences for “Life with New Medications or Diagnosis”

Participants primarily took their medications when they were likely to be home, at either or both ends of the day. They indicated that precise pill timing was not important to them, so we asked them to imagine a scenario in which they had to take a medication at several specific times throughout the day.

Participants were asked to:

“Imagine ... that you need to take something like antibiotics three or four times a day (morning, once or twice during the day, and night). Also imagine that you spend part of your day outside the home.”

In response to the above scenario, participants described their preferred device types and modes (Table 6). With this scenario, all participants suggested increasing the frequency of reminders and three suggested utilizing multimodal reminders.

Device Preferences for “Life with Cognitive Challenges”

Participants frequently mentioned that their device preferences might be different if they were cognitively impaired. They also expressed some negative feelings and anxiety about being in such a situation, so we asked them to imagine this scenario:

“Imagine that someone you know is experiencing mild cognitive impairment and is having trouble remember things.”

In comments related to the above scenario, participants continued to suggest multimodal reminders. A few suggested that people with cognitive challenges may not be as concerned as they were as currently “normal” people about beeping reminders going off in public. In the “life as it is” scenario, participants demonstrated more concern about maintaining their medication management privacy (Table 6).

**Table 6
Top device/reminder choice for each scenario per participant**

Participant ID	“Life as it is” scenario	“Life with new meds” scenario	“Life with cognitive challenges” scenario
P1	CADEX watch	CADEX watch, set more times/day	Combination: Pillbox (w/out reminder) + CADEX watch w/ either beep or vibration + voice
P2	Cell phone	Cell phone, set more times/day	Novel idea: e-whiteboard in kitchen (perhaps on refrigerator) that requires you to check off when you take meds (report transmitted to caregiver or physician)
P3	CADEX watch (tie with) Cell phone	CADEX watch, set more times/day + use text reminder	CADEX watch + text reminder + beep or vibrating reminder + use alert features to help if person gets lost
P4	Night light	Combination: MeDose vibrating watch + landline phone, depending upon whether away or at home	Combination: Landline phone + night light (assume user restricted more to home)
P5	Night light	Combination: MeDose vibrating watch + night light	Combination: MeDose vibrating watch + night light

Ongoing Qualitative Data Analysis Report and Discussion

Preliminary analysis of interview data using grounded theory analysis reveals the following emerging themes (in **bold** type). Some themes appear to triangulate categorically reported data.

Device use and preferences appear to correlate with context of use, including changes in personal health situation, medication timing, medication storage location, and general environmental and social context.

Several participants recounted changing their medication regimen and reminding preferences either permanently or temporarily as a result of new or acute medical situations.

Participants' social lives appeared to strongly influence their preferences for reminding devices. A single participant described recruiting a friend to help monitor her intake of a particular medication. Similarly, the married participants engaged in "distributed" or shared responsibility for reminding each other to take medications, with one partner assuming dominant responsibility. This may suggest that participants employed distributed cognition to facilitate medication reminding and management.

Participants' physical environment, such as home layout or layout changes, or participant change in location due to partaking in outside activities (e.g., two participants swim regularly) seemed to affect what type of device was most useful to them.

Preference for a stationary light reminder appears mixed thus far. Stationary light preference may be related to home design/layout, spatial use patterns, medication and personal schedule (works best for AM and/or PM medications adherence and those generally home during medication time).

Participants may have different device preferences for at-home use versus public use. Relatedly, participants prefer discrete reminders when in public, particularly a vibrating reminder. All participants expressed some preference for privacy in communication of reminders and implied that this may be related to a desire to preserve their "mental fitness" as perceived by others. Interestingly, younger people's reminder use seemed acceptable to participants. It appeared to be "a badge of honor" for younger people to be so busy that they might need a reminder for certain things, while device use for older people was seen as signifying a mental (and secondarily, physical) decline. This could present a potential barrier in the entire product lifecycle (design to marketing to adherence/use) for devices intended for elders.

For public situations, or when entertaining visitors at home, participants registered a preference for either a vibrating watch reminder or a phone call during which they could hear reminder messages, but those around them could not. Participants thought that a more public reminder (including, for some, a cell phone text message others might see) would require explanation about why they were using a reminding device or medication.

Participants also appeared to value private or “silent” reminders because they did not interrupt the flow of social interactions or disturb other people.

Participants prefer persistent reminders (e.g., light that stays on until turned off, or reminders that operate as “snooze” alarms or follow-up reminders). Additionally, **participants may desire multiple reminder devices and/or multiple reminding modes that can either be combined (signaled simultaneously) or used separately.**

Participants suggested a variety of “multiple solutions” for reminder needs, including: combining one device for use in-home, with another device for use outside the home (e.g., landline and cell phone reminders, etc.), or employing one device that incorporated a beep or vibrating alert plus text reminder, etc., simultaneously or sequentially.

Participants typically have established routines that they feel do not require reminding devices. However, participants see the value in using a reminding device temporarily, when their medication schedule or regimen changes, such as those related to:

- a change in their own circumstances (e.g., during or after hospitalization)
- an acute illness requiring temporary medication
- a new diagnosis accompanied by new medication regimen, or a change or increased urgency in medication regimen (e.g., related to existing chronic disease)
- a cognitive decline.

Participants appear to value devices that integrate easily into everyday activities

and do not require much extra thought or attention. While some participants were open to learning how to use new devices, a principal criterion they utilized for predicting future use was whether device use would integrate into their everyday life with a null or minimum increase in cognitive load. Perhaps related to this, some participants mentioned recruiting other people in their social network to help with either primary (daily medication use) or secondary (prescription management, decision-making tasks related to medication use). While most participants saw little value in sharing their medication adherence information with others at present, they appeared receptive to both this and to receiving input from others as reminders or organizational helps.

Regardless of income, all participants have expressed concerns regarding cost of devices, and little desire to spend out of pocket money on them, citing fixed

income, even if they felt financially comfortable. They also demonstrated little interest in paying for a service, such as cell phone service, and clear preference for one-time, up-front charges for devices. This could affect desire to use a device whether participants felt they needed one currently or not. To explore this, we added a probe, asking "would your concerns about device cost change if insurance paid for all or part of the device or service?" Most interviewees enthusiastically stated they would have no reservations using devices as needed if insurance paid for them. Several participants also mentioned concern regarding having to remember to pay a monthly device service bill. Further data analysis will try to determine whether preference for up-front device-related expenditure is also related to cognitive load concerns.

All tested devices presented visual, aural, and physical usability challenges to elderly participants (e.g., text too small, contrast insufficient for visual displays; beeping devices inaudible; watch bands uncomfortable, etc.) These varied usability challenges, especially those related to manual dexterity, were particularly a problem with the cell phone tested, and other cell phone models discussed with or currently owned by participants. Relatedly, all five participants described the watches tested as uncomfortable and desired modifications to watch bands and profile of watch (thinner, smaller watch and variety of band preferences, "feminine" design for females, neutral colors in general design, increased contrast for text/numbers, etc.)

Physical cell phone problems detail (weight, key size, etc.) may be addressable via specific comments for improvement elicited from participants to be explored in further work. Concerns shared by participants regarding either permanently or temporarily losing the cell phone suggest both physical and cognitive challenges to cell phone use. Even participants who liked the cell phone tested, and placed it among their top device choices, articulated concerns about losing or reported trouble locating the cell phone when reminders activated.

To augment earlier themes, **participants indicated that cell phone use required added mental work to locate or keep the cell phone nearby, and to remember to check it** as needed for reminders. This appeared to conflict with their preference for seamless reminders, or reminders that supplement rather than interfere with their established routines. This added cognitive load could not be helped by carrying options offered to

participants (pocket pendant, belt or purse clip, etc.) intended to facilitate cell phone accessibility. In addition, participants appeared to desire reminders that augmented or at the very least did not compromise their personal or social cognitive fitness. A few found the cell phone challenged their self-efficacy (e.g., "it made (them) feel stupid"), though they thought that an extended training and testing period might overcome this. However, most seemed dubious that training would reduce their need to remember to carry the cell phone or keep it nearby, especially at home, thus adding to their cognitive load with not enough perceived accompanying benefit.

Most participants offered predictions that the "next waves" or generations of retirees would be far more likely to want to use cell phones as medication reminder devices because they would have already integrated them into their everyday life for other purposes.

Limitations

As exploratory research, this study was a fruitful formative evaluation and successful in identifying several research questions for further study, noted below. Though our sample was small (five participants), prolonged engagement in the field with participants yielded rich and confirmatory data regarding participants' device preferences and medication management practices due to lengthy and repeated visits. Such repeated exposures to participants and their in-home environments also informed findings regarding the impact of participants' physical and social environment on medication adherence and reminding device preferences. However, a follow-up study utilizing a larger, systematically-

recruited elderly population could improve the generalizability of current results. It also would likely improve our understanding of device preference rankings, particularly where two or more devices were closely ranked.

It will be important in further related studies to include more married couples, or participants living with others. This could increase our understanding of the social dynamics we began to observe related to medication management. It is possible that the fact that study participants' general behavior and preferences regarding medication reminding were influenced by their existing medication regimens and perceived lack of urgency regarding precise medication dosing. It will thus be important to include participants with more complicated (requiring multiple dosing times throughout the day) and vital or urgent medication reminder needs in future studies to test this.

The cell phone study segment presented several challenges, which were resolved or ameliorated, but should be addressed in future work. These challenges included the need for more pre-cell phone-use training, including participant practice using the device. It would be best to design or use a cell phone that has more of the preferred attributes mentioned, including longer illumination of the cell phone screen (one of the most frequently described usability challenges). Also, it was discovered that the cell phone used blocked subsequent reminders once a reminder was missed. However, when participants were queried regarding the impact of such challenges, they generally indicated that these challenges did not directly affect their device evaluation. This appeared to be borne out by the fact that a few participants who experienced several cell

phone problems also rated the cell phone as their most or more preferred reminding device.

Regardless of assurances we made to participants that they would not be held responsible for device damage or loss during the study, their concerns regarding such outcomes were evident. These concerns could have influenced participants' final preferences, though when queried about this, participants assured us this was not the case; their narrative comments regarding each device's pros and cons (reported elsewhere) supports their assertions.

Conclusions and Next Steps

This project aimed to improve medication management device design to support medication adherence via 1) an exploration of elders' medication management behavior, 2) elicitation of elders' reminding device type (mode) preferences, and 3) improved understanding of which reminder modes/strength combinations work optimally for elders. During the study, we observed the importance of both intrinsic and extrinsic contextual factors on participants' device preferences and general medication management behavior, including adherence. We use an excerpt of Case's general definition of context here, as "the particular combination of person and situation" related to participants' medication and device use [8]. Intrinsic contextual factors are those that originate internally, within the patient. External contextual factors are those that originate externally, outside the patient.

These factors will be categorized in future work as four contextual factor types:

- affective - related to emotion, or feelings (primarily intrinsic);
- cognitive - related to cognitive health, but also education, literacy, etc. (primarily intrinsic, although opportunities for education may be considered extrinsic sociodemographic/social factors);
- physical - related to physical health, and also to physical environment (e.g., home environment) or situation (e.g., weather) (both intrinsic and extrinsic), etc.;
- social - related to a patient's social world, network, and activities, and sociodemographic factors (could be both intrinsic and extrinsic).

Such expanded consideration of contextual factors in medication management, health behavior, and human-computer interaction studies, in particular, appears to break new ground. Prior work has typically focused on intrinsic factors such as feelings of self-efficacy, or general cognitive health rating, and additional behavioral theories when analyzing information system user needs and health behavior.

General Design Implications

In addition to the importance of investigating the relationship of the described contextual factors to reminder device design, several other general implications for device design have emerged in this study. These include the need to consider distributed cognition in medication management device design, a finding corroborated recently by other researchers [9, 10]. Also important is the need to differentiate between device design that is *usable* and design that is *useful* [11]. It remains to be seen, for example, whether cell

phones, even if usable, are useful to elders, or whether they may be useful only to certain elders, based on contextual factors.

The most important general design implication may be the need to consider how diverse elders are in their needs and preferences [12]. For instance, there is a fine line between what level or type of “beep” is audible, and what level or type of beep becomes strident and annoying. Similar design challenges relate to identifying the most helpful type of voice reminder (gender, tone, enunciation have been identified in qualitative results thus far as factors affecting “usability.” Beyond these two examples, various factors were discussed in the Results section that appeared to be favorable or unfavorable to participants. Perhaps, rather than identifying specific preferences, the strength of this investigation, once completed, will be in asserting that multiple preference options are important. We hope that subsequent data analysis will help define which reminder options to include in devices, and suggest approaches to facilitate tailoring of devices to patients’ potentially changing needs.

Next Steps

Several future research questions have emerged from this preliminary analysis. Some of these questions will be addressed in the final project data analysis, particularly those related to preference options. Others will be considered in future work. Future research questions include:

1. Can we categorize or build predictive profiles of patients' medication management and medication reminder device preferences based on physical, social, affective, and cognitive contextual factors? Which of these factors appears most important in medication adherence and device use?
2. How is a patient's social network involved in the patient's medication management and reminding practices? How do network members help (or hinder) medication adherence?
3. Can device design incorporate aspects of social network helps and relationships to facilitate better medication adherence?
4. What role does distributed cognition play in medication reminding for various groups of patients? Would it help to model these functions in reminder device design?

Next steps include completion of qualitative data analysis and in-depth comparative analysis of categorical study data. In addition to a more detailed analysis of participants' medication reminder device preferences, future work and publication will focus on findings and implications related to participants' medication management practices. Other data analysis and publication will report how the present study's methodological approach augments current understanding of best practices for studying human health and medication management behavior in everyday environments.

References

1. National Institute on Aging. Why population aging matters: a global perspective. Bethesda, MD: National Institute on Aging, National Institutes of Health, 2007.
2. Lehane E, McCarthy G. Intentional and unintentional medication non-adherence: a comprehensive framework for clinical research and practice? A discussion paper. *Int J Nurs Stud.* 2007 Nov;44(8):1468-77.
3. MacLaughlin EJ, Raehl CL, Treadway AK, Sterling TL, Zoller DP, Bond CA. Assessing medication adherence in the elderly: which tools to use in clinical practice? *Drugs Aging.* 2005;22(3):231-55.
4. Civan A, Skeels MM, Stolyar A, Pratt W. Personal health information management: consumers' perspectives. *AMIA Annu Symp Proc.* 2006:156-60.
5. Moen A, Brennan PF. Health@Home: the work of health information management in the household (HIMH): implications for consumer health informatics (CHI) innovations. *J Am Med Inform Assoc.* 2005 Nov-Dec;12(6):648-56.

6. Carey RF, McKechnie LEF, McKenzie PJ. Gaining access to everyday life information seeking. *Library & Information Science Research*. 2001;23:319–334.
7. Nielsen J. Why you only need to test with 5 users. Jakob Nielsen's Alertbox [Internet]. 2000 Mar 19 [cited 1 Dec 2008].
<<http://www.useit.com/alertbox/20000319.html>>.
8. Case DO. Looking for information: a survey of research on information seeking, needs, and behavior. 2nd edition. London: Elsevier. 2007. p.13.
9. Wu M, Birnholtz J, Richards B, Baecker R, Massimi M. Collaborating to remember: a distributed cognition account of families coping with memory impairments. *CHI 2008*. 2008 Apr;825-834.
10. Palen L, Aaløkke S. Of pillboxes and piano benches: “home-made” methods for managing medication. *CSCW '06*. 2006;79-87.
11. Coughlin JF. New expectations from older users: five lessons for product design & innovation in an aging marketplace. *AgeLab*. 2007(1);1-7.
12. Kimel J, Lundell J. Long-term deployments of pervasive technology into the homes of older adults. *Interactions*. 2007 Jul-Aug;38-41.

Appendix 1: Devices Studied

- e-pill® CADEX® Alarm Watch, e-pill Medication Reminders: www.epill.com
- e-pill® MeDose Watch, pediatric and adult models, e-pill Medication Reminders: www.epill.com
- Home landline telephone in use in participants' homes
- MEDglider Talking Reminder System, MEDport: www.medportinc.com
- Programmable Lamp & Appliance Timer TN811C, Intermatic: www.intermatic.com
- T-Mobile phone and text service with Nokia model 2610

Appendix 2: Instructions Left With Participants During the Study

ID: _____

Medication Plan:

Prescription Drugs:

Over the Counter Drugs:

In-Home Medication Management Device Study

This is a study regarding your preferences for medication reminding systems. You will try out different reminding devices. While these devices are not intended to replace your normal mode of medication management, please use each device to the best of your ability as a medication reminder during the study dates assigned below. Note throughout use your comments in the accompanying journal sheets as each alarm goes off. Unless the device is attached to a wall outlet (as in the lamp reminder), you may carry the device with you or place it in any location you find helpful to you for use.

Please do not alter the alarms or device set-up in any way unless directed to do so by researchers. You will want to turn off each alarm as it sounds, or when you notice it, whichever occurs first. These alarm turn-off instructions are on each device sheet (attached).

Researcher contact information:

Should you have any questions or concerns regarding the study or devices you are using, you can contact [**The researcher**] at [phone number] (leave message if needed). On Monday – Sunday 9 am - 5 pm, your call will be returned as soon as possible. Calls received after 5 pm may be returned the next morning.

Appointment Dates:

At the end of the study, we will ask for your suggestions regarding your ideal medication reminding device. You may use this space to keep notes regarding your thoughts on this throughout the study as needed.

Appendix 3: Device Instructions Left with Participants

Device: Cadex Watch

Dates of Use: _____



What to expect and how to turn off reminders:

- 1) Alarm will beep continuously at first, followed by intermittent reminder beeps if you do not turn alarm off. When alarm beeps, press either “forward” or “reverse” button to turn off
- 2) Device then enters reminder mode and displays text message regarding your medication to take across top of watch face until you press either “forward” or “reverse” button to turn off. Device will beep intermittently until you turn off this reminder mode for each alarm

Devices: MeDose Watches: Red/blue Velcro watch band (beeping alarm) & Black watch band (vibrating alarm)

Dates of Use: Red/blue Velcro watch band (beeping alarm)

Dates of Use: Black watch band (vibrating alarm)

What to expect & how to turn off reminders:

Alarm will either beep or vibrate for about 20 seconds. Press any of the four buttons surrounding the watch to turn off alarm.

Device: MEDGlider reminder with pillboxes

Dates of Use: _____

Day 1: Voice reminder _____

Day 2: Beeping reminder _____

Day 3: Blinking light reminder _____

What to expect & what to do:

- **Alarm function & stopping the alarm:**

When the pill time is reached, the alarm will turn on. Each pill time will give three alerts at one minute intervals.

To stop the alarm: Press the large “alarm stop” button on front of the device.

- **You will try out three different alarms and change alarm types at end of days one and two:**

Day 1: Voice reminder (pictured as lips on device display)

The device will automatically be set to this reminder mode. At end of day one (after last alarm goes off), open the green cover (top right of device) and press the top right button (labeled alarm/“alarm select”) ONCE. This will change the reminder type to the Beeping Reminder (the bell symbol will show on device display). Close the green cover and wait for the next day’s reminders to go off.

Day 2: Beeping reminder (pictured as a bell on device display)

At the end of day two (after last alarm goes off), open the green cover (top right of device) and press the top right button (labeled alarm/“alarm select”) ONCE. This will change the reminder type to the Blinking Light Reminder (the light bulb symbol will show on device display). Close the green cover and wait for the next day’s reminders to go off.

Day 3: Blinking light reminder (pictured as a light bulb on device display)

At the end of day three, do nothing. The light alarms will continue to go off until we return to pick up the device.

You may choose to use this device with or without the pillboxes provided. If you do use the pillboxes provided, please check to be sure your pills are not sensitive to light or other environmental factors.

- **IF YOU MISS TURNING OFF THE REMINDER ALARM:**

If the “alarm stop” button is not pressed after the third reminder, a box with a crossed line will form over the pill/reminder number on bottom of display to alert you that you missed a reminder.

Also, a second message will appear saying “missed pill.”

PRESS THE ALARM STOP BUTTON (large button on front of the device). Once the “alarm stop” is pressed, the “missed pill” message will disappear but the boxed number will remain. The crossed boxes and missed pill message will automatically disappear after 23 hours.

Device: Night light reminder

Dates of Use: _____

What to expect:

The pink night light will turn on automatically within a few minutes of your chosen reminder times. The light will remain on for approximately one hour for each reminder, then it will turn off automatically. You do nothing to the device. Please DO NOT turn off the light or the attached timer; it simply signals a reminder that it's time to take your medication.

[Device: Cell phone - device instructions not included here]

Appendix 4: Participant Journal Template

Journal for ID: _____

Reminding Device(s):

Please comment on the following: Did you remember to take your medication? Did the device help? Did it interfere with other activities? What were you doing and where were you when the device went off (for example, “vacuuming in other room, could not hear device” or “preparing breakfast in kitchen next to device when it went off”). Was the device annoying? Were there any other related issues?

Date	Time	Comments
		Your location:
		Device location:
		Comments:
		Your location:
		Device location:
		Comments:
		Your location:
		Device location:
		Comments:

Your location:

Device location:

Comments:

Your location:

Device location:

Comments:

Your location:

Device location:

Comments:

Your location:

Device location:

Comments:

Your location:

Device location:

Comments:

Your location:

Device location:

Comments:

Your location:

Device location:

Comments:

Overall Impression / Suggestions for this device:

Appendix 5: Semi-structured Interview Scripts

Interview Form Prior to the Study:

(to be filled out by researcher)

Date: _____

Subject ID: _____

Time: _____

1. [Please] Describe the pills you take each day (what kind, when do you take them, with or without food, etc.). (Researcher – Fill in the back of the journal form. Also note how well they know their regimen and why they're taking the medications) [Prompt: What do you think the medications are for and why are you taking them?]
2. Where do you keep your medications? Do you use a dispenser or a reminder device? Please describe.
3. Does anybody help you manage your medications? How do they help? Do you help anybody else manage their medications? How do you help?
4. What do you use when you travel or are out of the house? [Prompts: Do you work outside the home or have other regular activities outside home? --please describe impact on medication regimen].
5. Do you have any trouble taking your medications? Please describe.
6. How often do you miss, or are you late taking your medications?
7. What are some typical reasons?
8. What helps you remember? [Prompt: Who helps you remember?]
9. What makes it hard to remember?
10. Do you feel that it is important to take each of these medications? Why or why not? Do you ever decide not to take your medications, or otherwise change from your prescribed medication schedule? Do you ever stretch your medications so your prescriptions will last longer?
11. How expensive are these medications / month? What part is covered by insurance and what do you pay out of pocket?
12. Do you have side effects from any of these medications? Please describe.
13. Do you feel that your medications are working for you? Please describe.

14. Are there any medications that have been prescribed for you that you have decided not to fill or not to take?
15. For friends that you know who need to take medications, do any of these issues apply to them? Anything else we should know about helping people to take their medications?
16. Do you use a cell phone? How often? How long? What features (text message, etc.) do you use on cell phone?
17. Do you wear a watch? Digital or analog [show watch faces/explain]?
18. Do you have any hearing or vision challenges that might affect your use of these devices?
19. Is there anything else you think we should know?

Interview Form After Finished Using the Device:

(to be filled out by researcher)

Date: _____

Subject ID: _____

Time: _____

Device Tested: _____

1. Was this device useful? Please describe specifics.

2. How often was it useful? Please describe.

[Researcher prompt as necessary and circle one: Not at all / A little / Somewhat /
Very / Extremely useful?

3. Was it ever annoying? Please describe.

[Prompt: How annoying? Researcher prompt as necessary and circle one: Not at
all / A little / Somewhat / Very / Extremely annoying?]

4. Was it difficult or easy to understand how to use it? Please describe.

Researcher prompt as necessary and circle one: Not at all / A little / Somewhat /
Very / Extremely easy?

5. What did you like the best about this device, if anything?

6. What did you like the least?

7. How could it have been improved? [Prompt: Can you recommend any additional
features, etc.?)

8. Would you want to use it in the future?

9. How much would you pay out of pocket for something like this?

10. Would you recommend it to any of your friends?

11. How does this device compare to how you usually remember to take your medications? Do you feel it made you more or less successful at taking your medications? [Prompt: please describe.]
12. Is there anything else you think we should know?

Final Interview

Date: _____

Subject ID: _____

Time: _____

Scenario 1: life as it is

- I. Now that you've had a chance to try out a variety of medication reminding devices, what worked best for you? Place in rank order, your favorite at the top [note that this is for your current situation] :

	Device Name	Comment
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____

- II. Is it OK to have a mix of reminder strengths and types (soft light, blinking light, soft, loud, or increasingly louder or stronger beeps or vibrations, repeating or continuous reminders (stop only when turned off) or should there be just one reminding signal? [Prompt which reminder signals and strengths do you prefer, and why?]
- III. Is it OK to remind at various times or places when the reminder thinks that it would be most helpful? Or should it just remind at a particular set time?
- IV. Would it be helpful/desired (would you want) to have pictures or photographs of pills (& pills with a voice reminder) on a device?

- V. Imagine that we have a reminder that's pretty smart about your needs, and can track your location inside and outside the home ... Should the reminder remind you only if it thinks that you are going to forget your medications? Or always give an alert at a specific time? Should it remind differently when other people are in your home? What about when you are outside the home? Should it remind you differently when you are out in public? Please describe (how, why, etc.)
- VI. If you could design a reminder system from scratch, what features would you include? [Prompts: encourage multiple answers if applicable, and also invite to draw using paper and pencils provided.]

Repeat the same for the following two scenarios:

Scenario 2: life with new medications and/or diagnosis

What if you were taking a new medication that was critical to your health or healing?

... Or, you have just returned from the hospital for some reason. This might also happen when you are newly diagnosed with a health condition such as asthma, diabetes, or heart disease. Has this ever happened to you (please describe)? How did you remember to take your medications? Have you ever had any trouble remembering to take medications during an acute illness or while your diagnosis was new (please describe)?

Imagine for our purposes that you need to take something like antibiotics three or four times a day (morning, once or twice during day, at night) to get over a sinus or other infection. Also imagine that you spend part of your day outside your home.

Would your choices for your favorite device change compared to how you answered (for life as it is)? How? Why?

If you could design a reminder system from scratch for this situation, what features would you include? [Prompts: encourage multiple answers if applicable, and also invite to draw using paper and pencils provided.]

Scenario 3: Life with cognitive challenges*

Imagine that someone you know is experiencing mild cognitive impairment and is having trouble remembering things. This can happen for a variety of reasons. People of all ages may experience cognitive overload resulting in an inability to remember things when under stress. In this case, we are thinking of someone who has developed Parkinson's disease, a "chronic, progressive movement disorder" which can also result in "problems with memory." In addition to having some trouble remembering various things, this person also experiences hand tremors, and problems with walking and other movement and coordination challenges. Imagine that this person is not restricted solely to his or her home, but goes out for everyday activities at least three or four times each week.

Would your choices for your favorite device change compared to how you answered (for life as it is)? How? Why?

If you could design a reminder system from scratch for this situation, what features would you include? [Prompts: encourage multiple answers if applicable, and also invite to draw using paper and pencils provided.]

Additional questions for current situation:

1. Which device (and device mode, as applicable) was easiest for you to learn how to use? Which was hardest?
2. Tell me about how you developed your current medication or supplement routine. Do you remember having any trouble getting into a routine? How long did it take, and what helped you along away? How would you remember if we added a new medication or supplement to your routine?
3. When (in what situations), if ever, do you think it's important to use a medication reminding device? [What general and specific situations?
4. How do you feel about taking medications in front of other people?
5. Do you think a device should be something you can use right away, without having to learn anything, or is it something that it's OK to take some time to learn how to use?
6. Where are you, usually, when you take your medications?
7. How would you describe your use of the devices we tested – were you able to keep to your normal routine? [Did you use the devices in public or in front of other people? Did other people make any comments about your device use?]

8. Do you have any comments or concerns regarding how easy or difficult setting the devices appears to be? Did [this] affect your evaluation of the devices?
9. Do you have any comments or concerns regarding the cost of reminding devices? How would you feel if insurance covered cost of the device?
10. What do you think about sharing or reporting your medication taking behavior? [Give cell phone text message responses or logging responses as examples]. When and why might it be useful to you or to others (if at all)?
11. Do you feel like you had enough time to form opinions about each device? [Prompt re time needed for each device (compare); ask what affected speed of evaluation; were there any that you needed more time with?]
12. Do any of your medications or supplements require precise timing for taking them [due to food or other interactions, or physical reasons?] What happens if you don't take your medications or supplements [prompts: short term, long term; what difference do they make; what if you did not take your medications for a week]?
13. Is there anything else you would like to add about medication reminding and reminder devices?
14. Is it OK if we contact you by phone or email to check on our understanding of your answers with you?

**Parts of cognitive challenges scenario quoted directly from: Parkinson's Disease - MS info wiki: http://www.msinfowiki.ca/index.php?title=Parkinson's_Disease*