

Older adults' satisfaction with a medication dispensing device in home care

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Abstract

Introduction: Older adults with multiple chronic conditions face the complex task of medication management involving multiple medications of varying doses at different times. Advances in telehealth technologies have resulted in home-based devices for medication management and health monitoring of older adults. We examined older adults' perceptions of a telehealth medication dispensing device as part of a clinical trial involving home healthcare clients, nurse coordination and use of the medication dispensing device.

Methods: Ninety-six frail older adult participants who used the medication dispensing device for 12 months completed a satisfaction survey related to perceived usefulness and reliability. Results were analyzed and grouped by themes in the following areas: *Ease of Use, Reliability, Medication Management Assistance, Routine Task Performance and Acceptability.*

Results: Nearly all participants perceived the medication dispensing device as very easy to use, very reliable and helpful in the management of their medications. Eighty-four percent of participants expressed a desire to use the machine in the future.

Conclusion: The technology-enhanced medication management device in this study is an acceptable tool for older adults to manage medication in collaboration with home care nurses. Improved usability and cost models for medication dispensers are areas for future research.

Keywords: *Evaluation, medication dispenser, medication management, older adults, telehealth*

1. Introduction

The success of advances in public health and modern medicine has resulted in unprecedented levels of life expectancy in population segments of older adults that introduce challenges of how to efficiently care for older adults worldwide. Population aging has accelerated in recent years, with estimates that the annual net global gain of adults aged 65 and older will exceed 10 million every year until 2015 and over 60 countries will have at least 2 million people in this cohort by the year 2030 [1]. Predictions for those over the age of 65 as a percentage of the total population for eight countries in the year 2020 are: Australia, 16.8%; Canada, 18.2%; France, 20.1%; Germany, 21.6%; Japan, 26.2%; New Zealand, 15.6%; United Kingdom, 19.8%; United States, 16.6% [2]. One challenge of this population aging phenomenon is the expected shortage of gerontological healthcare workers as the workforce ages with the general population [3,4]. Another challenge is the certain rise in healthcare costs as the baby boomer cohort enters old age. For

Correspondence: Blaine Reeder, Biobehavioral Nursing and Health Systems, University of Washington, Box 357260, Seattle, WA 98195, USA. Tel: +1 206 619 3911. Fax: +1 206 543 4771. E-mail: breeder@uw.edu

example, benefit payments through Medicare – the federal program in the United States that provides health insurance to individuals over 65 years of age and those with disabilities under the age of 65 years of age – are expected to rise from 509.7 billion in 2010 to 904.6 billion in 2020 [5]. Innovative, cost-effective ways to meet the healthcare needs of older adults and the gerontological healthcare workers who support them become more urgent with each passing year. Due to differences in sub-groups of older adults, gerontology researchers often stratify older adult sub-groups into loose cohort classifications based on chronological age that can be defined as middle-aged (45–60 years of age), young old (60–70 years of age), middle old (70–80 years of age) and oldest old (80+ years of age years of age) [6–10]

Older adults with multiple chronic conditions face the complex task of medication management involving multiple medications of varying doses at different times [11–13]. A number studies found that the prevalence of multiple chronic conditions in older adults exceeds 60% [14]. Medication errors and medication non-adherence are a significant cause of illness, hospitalization and death among older adults [15–17]. A systematic review of studies from seven different countries suggests that more than half of the preventable drug-related admissions (PDRAs) are the result of medication errors with estimated prevalence of PDRAs in older patients more than twice that of younger patients [18]. A recent study of older adult medication self-management found that the majority of errors occurred in the activities of administering the right medications at the proper dose and time (31.8%); following clinical advice regarding medication use (21.7%) and modifying medication use based on clinical advice and self-monitoring (41.9%) [19]. Another recent study showed that community-dwelling older adults without a medication management intervention are 2.94 times as likely to be admitted to a nursing home as those with the medication management intervention [20]. The annual cost of medication non-adherence may be as high as 300 billion dollars in the United States [21].

Response to drug therapy for older adults is often unpredictable and requires careful drug dosing, administration and monitoring [22,23]. However, adherence to prescribed medication regimens by older adults can vary from 26 to 59% [24]. Studies have found that the young old tend to be more adherent with medication regimens than middle-aged adults [10]. However, frail elderly and the oldest old appear to be much more at risk for problems with medication [25–27]. As a result, there is an urgent need for interventions to promote effective medication management among frail older adults. Telehealth technologies offer the potential to meet this need.

Telehealth technologies are used in home and community settings to enable monitoring of older adults' well-being (for example, by capturing vital signs) [28] and communication with healthcare providers (using video or other synchronous communication platforms) [29]. Advances in such technologies have also enabled the development of devices that can be used in residential settings to assist with medication management and monitoring of elderly adults using cost-effective methods. Medication e-management applications are electronic tools for patient empowerment, enhancing accuracy of medication administration through reminder services and promise to lower costs and involve patients in the care delivery process. These tools include medication dispensers, wrist watch alarms and smart phone applications [30]. In addition, integrated environmental sensing applications have been developed for prompting of patients in different contexts to improve medication adherence [31]. Since patients and their caregivers are called upon to operate these tools, their perceptions of and satisfaction with these devices and applications must be assessed. When examining patients' satisfaction with technology-enhanced interventions, a multitude of issues need to be examined including issues concerning the actual operation of devices (ease of use, adjustability to changing

needs); perceived impact on lifestyle; impact on medication burden; sense of control, confidence in the system; perceived impact on cost and quality of care [32–34].

Consumers' perceived advantages and disadvantages of technological innovations can inform the improvement of the design of current and future systems and help predict the extent of their success. When evaluating technological innovations in health care, what may first appear as simply technical barriers are really the particular social and cultural influences of how consumers acquire and use information, operate a device and the degree to which they perceive the innovation to be of benefit to their own situation [35]. The decision to adopt a technology is influenced by the ability of the consumer to judge whether the benefits of using the innovation will outweigh the risks of using it and whether the innovation improves upon the existing tools [36]. The theory of diffusion of innovations [37] states that the diffusion of an innovation is determined to a great extent not only by the innovation itself but also by the circumstances into which it is being introduced and how consumers perceive the innovation. In this context, it is important to recognize the targeted end user when designing instruments to assess end user acceptance; frail older adults have different usability concerns and barriers to acceptance and adoption of IT solutions in health care than their younger or healthier counterparts [38–41].

Among informaticians and designers, there is wide agreement that stakeholder participation is critical to usability and adoption, particularly to accommodate the needs of older adults [38–41]. One perspective is to take a universal design or 'design for all' approach to create barrier-free designs for the widest audience possible [42]. An alternative perspective is that the large degree of variability in the overall health, functional status and cognitive status of older adults precludes such an approach. Thus, design approaches and methodologies to accommodate heterogeneity in older adults as target users of technology have been developed [34,43].

Evaluations that are conducted at various stages of a project are important to incrementally and iteratively validate the design, function and impact of informatics interventions. Friedman and Wyatt define a hierarchy of nine evaluation types to achieve different aims that can be conducted at any time during the implementation cycle of an informatics intervention [44]. The nine types of informatics evaluations are labeled as *needs assessment*, *design validation*, *structure validation*, *usability test*, *laboratory function*, *laboratory user effect*, *field function*, *field user effect* and *problem impact studies* [44]. The evaluation reported here encompasses the aspects of a usability test related to how older adults interact with a medication dispensing device and a field user effect test to explore how the system changes participant behavior.

1.1 Primary objectives

We examined frail older adults' satisfaction with a telehealth medication dispensing device as a secondary outcome of a clinical trial involving a home care medication management program that included nurse coordination and use of the medication dispensing device. The primary aim of the clinical trial was to determine whether a home care medication management program that included nurse coordination and use of a telehealth medication device, the MD.2 medication dispensing machine [30,45], would affect frail older adults' health outcomes, use of health care services and cost of care over a one-year period. This prospective, longitudinal, three-arm randomized controlled trial (RCT) was conducted over a one-year period in persons discharged from home health care from three Medicare-certified home healthcare agencies in Milwaukee County. The study consisted of a control group and two intervention groups: one that received the MD.2 medication dispensing machine and nurse care coordination and one that received a

medplanner and nurse care coordination. The survey presented here (which was part of the larger clinical trial) aimed to examine the level of frail older adults' satisfaction with a medication dispensing device and assess perceived usefulness of the device by older adult home care patients.

2. Methods and procedures

2.1 Participants

Participant criteria for enrollment were based on a frailty construct that included the following characteristics: were 60 years of age or older; had Medicare as primary payer for health services; were discharged from home healthcare services; had a working telephone line; had Impaired Medication Management ability as indicated by a score of 1 or higher on OASIS discharge assessment item M0780 [46]; and had Impaired Cognitive Functioning but were able to follow directions with prompting as indicated by a score of 1 or 2 on OASIS discharge assessment item M0560 [46]. Exclusion criteria were: used other devices to manage medications; used a private home care agency for medication management; were enrolled in managed care through Medicaid (a health program for low-income adults and families); had a terminal diagnosis or hospice care; and were non-English-speaking. All procedures were approved by the Institutional Review Board of the University Of Wisconsin-Milwaukee. All participants provided informed consent as a condition of study enrollment. Target enrollment for each arm of the study was 113 participants.

2.2 MD.2 medication dispensing device

The MD.2 medication dispenser is a commercially available device that automatically dispenses pre-loaded medication and gives alerts to individuals about medication times [30,45]. At the time of the study, the device was available for a monthly leasing fee of \$90 USD. However, the fee did not cover the filling of the machine or coordination activities of the nurse between the prescribing providers, pharmacy and participant to ensure that the prescribed medication regimen was accurately loaded into the machine.

The device dimensions are 13" wide × 12" deep × 14" tall but it comes in an oversized box to avoid damage during shipping. A medication holding tray in the machine has 42 cup holes. Each medication cup has 1-3/4 inches (44 mm) top diameter and is 1-5/16 inches high (33 mm). Depending on the medication needs of the older adult, the MD.2 can deliver doses in a range of one medication cup per day to six cups per day.

The front of the device has a medication delivery ramp, an alert light, an LCD message screen and a dispensing button. The MD.2 dispenses allocated doses of medication in cups when the dispensing button is pressed. The device has an 'early dose' features that allows early dispensing of medications for flexibility in leaving the house during dosing periods. The MD.2 uses an existing phone line in the home and automatically notifies remote caregivers if medications have been missed or if the machine needs to be refilled. During this study, the MD.2 was refilled by nurses at least every two weeks. Participants did not refill the medication dispensing device.

2.3 Data collection

Participant satisfaction with the MD.2 medication dispensing device was assessed using a satisfaction questionnaire we developed to determine the underlying facilitators or barriers to adoption. Issues such as operation of the MD.2 device (ease of use, adjustability to changing needs), perceived impact on lifestyle, impact on medication burden, sense of control, confidence in the system, perceived impact on cost of and quality of care were included in

the instrument. Face validity of the instrument was tested through feedback from experts in home care and survey development. The satisfaction questionnaire was pilot-tested for feasibility, improved readability and comprehension with 10 older adult study participants prior to its administration in the intervention arm of the clinical trial.

The final version is a nine question satisfaction survey with two Likert scale questions and seven yes/no questions. Likert scales ranged from 1 to 5 to assess *ease of use*, where 1 indicated 'very difficult' and 5 indicated 'very easy,' and *reliability*, where 1 indicated 'very reliable' and 5 indicated 'very unreliable.' In addition, the survey provided space for participant comments regarding problems or observations about the dispenser. The survey was administered by an interviewer.

2.4. Data analysis

Survey results were loaded into SAS [47] 9.12. A frequency procedure was run against all responses for each question in the survey instrument. Survey results were grouped by themes, and participant comments were summarized by one researcher to provide context for themes. Results and themes were reviewed by a second researcher involved with the development of the survey instrument.

3. Main outcome and results

The participants recruited for the three-arm RCT were frail older adults, and it was anticipated that the attrition rate would be at least 25% since the intervention was conducted over a one-year period. Minimum enrollment needed for each arm of the study was 113 participants. One hundred fifty-two participants were randomly assigned to the medication dispensing machine intervention arm, 137 enrolled and 98 completed the study. One hundred thirty-seven participants enrolled in the planner group and 125 in the control group. One hundred two finished the study in the planner group, and 101 in the control group.

Of the 152 participants randomized to the MD.2 group, 15 people refused to enroll in the study because they did not want the machine in their home. We learned as the study progressed better ways to introduce the MD.2. For example, participants who saw the nurse wheeling up the large box often refused to be in the study. Refusals decreased significantly after we started removing the machine from the box before carrying it into the participant's home. Satisfaction with the machine was measured at month 9 of the study. We chose this time period so that the participants surveyed would have at least 9 months of experience with the machine.

Ninety-six of the 98 participants who completed 12 months of the study also completed the satisfaction survey (2 were hospitalized at the time of the survey). Mean age was 80 years of age (SD 7.93), 66% were female, 55% lived alone, 80% were white and 20% were black. Thirty-two participants provided additional comments beyond the standardized responses available in the survey. Participants were taking an average of 11.5 medications per day and had an average of seven medical diagnoses. Chronic conditions present included diabetes (39%), depression (20%), COPD (14%), dementia (16%) and heart disease 14%.

Summarized satisfaction survey results are shown in Table I (Likert scale questions) and Table II (yes/no questions). Survey results are explained with a narrative below. Results are grouped according to five themes: *Ease of Use*, *Reliability*, *Medication Management Assistance*, *Routine Task Performance* and *Acceptability*. Percentages and numbers of participants in relation to the total sample size are reported for each survey response. Participant comments are presented to illustrate important points.

Table I. Satisfaction survey questions – Likert scale.

Theme and question	1	2	3	4	5
	Very difficult			Very easy	
<i>Ease of use</i> (<i>n</i> = 96)					
How easy was it to use the machine?	2 of 96 (2%)	0 of 96 (0%)	1 of 96 (1%)	3 of 96 (3%)	90 of 96 (94%)
	Very unreliable			Very reliable	
<i>Reliability</i> (<i>n</i> = 96)					
How reliable was the machine?	1 of 96 (1%)	0 of 96 (0%)	1 of 96 (1%)	3 of 96 (3%)	91 of 96 (95%)

Table II. Satisfaction survey questions – yes/no answers.

Theme	Question	Yes	No
Medication management assistance	Did the machine help you manage medications?	95 of 96 (99%)	1 of 96 (1%)
Routine task performance	Did the machine affect your ability to do things for yourself?	10 of 96 (10%)	86 of 96 (90%)
Routine task performance	Did the machine affect your ability to get around or leave the house?	8 of 96 (8%)	88 of 96 (92%)
Routine task performance	Did the machine affect your ability to talk with or get ahold of your nurse?	2 of 96 (2%)	94 of 96 (98%)
Routine task performance	Did the machine interfere with other activities?	1 of 96 (1%)	95 of 96 (99%)
Acceptability	Did the machine give you peace of mind?	91 of 96 (95%)	5 of 96 (5%)
Acceptability	Would you like to use the machine in the future?	81 of 96 (84%)	15 of 96 (16%)

3.1 Ease of use

On a scale of 1–5, where 1 indicated ‘very difficult’ and 5 indicated ‘very easy’, 94% (90 of 96) the participants rated the medication dispenser as ‘very easy’ to use and 2% (2 of 96) rated it ‘very difficult.’ In addition, 3% (3 of 96) of the participants rated it a ‘4’ and 1% (1 of 96) rated it a ‘3’ on this same scale. Five participants commented on the need for the nurses’ help if they were to continue to use the machine due to difficulty with pill set up. As previously described, participants did not fill the machine during the course of the study. One participant observed a liking for the dispenser but preferred the use of a pill box with help from a nurse to manage medication.

3.2 Reliability

On a scale of 1–5, where 1 indicated ‘very reliable’ and 5 indicated ‘very unreliable,’ 95% (91 of 96) the participants rated the medication dispenser as ‘very reliable’ and 1% (1 of 96) rated it ‘very unreliable.’ In addition, 3% (3 of 96) of the participants rated it a ‘4’ and 1% (1 of 96) rated it a ‘3’ on this same scale.

3.3 Medication management assistance

Ninety-nine percent (95 of 96) of the participants responded ‘yes’ that the medication dispenser helped them manage their medications. According to one participant, the dispenser ‘does not let you forget.’

3.4 Routine task performance

Ninety percent (86 of 96) of the participants indicated that the dispenser did not affect their ability to do things for themselves. Ninety-two percent (88 of 96) of the participants indicated that the dispenser did not affect their ability to get around or leave the house. Ninety-eight percent (94 of 96) of the participants indicated that the medication dispenser did not affect their ability to talk with or reach their nurse. Ninety-nine percent (95 of 96) of the participants indicated that the dispenser did not interfere with their other activities.

Six participants commented that they used the 'early dose' feature to accommodate their medication management schedules when they left the house, whereas another participant indicated the use of a pill bottle instead of the machine to do so. Two participants indicated the need to plan ahead when using the machine. One participant noted difficulty in using the machine related to hand and vision problems. Although two participants indicated that the dispenser affected their ability to talk with or reach their nurse, there were no comments as to how the machine affected this communication ability.

3.5 Acceptability

Ninety-five percent (91 of 96) of the participants responded positively that the dispenser gave them peace of mind. Eighty-four percent (81 of 96) of the participants indicated that they would like to use the medication dispenser in the future.

Three participants commented that they did not like the machine or were not interested in it. One participant 'loved it,' one participant was 'very interested' and four were undecided about future use. One participant noted that she could manage her medication herself but might use the machine if she were ill. Another participant explicitly disliked the talking feature of the machine. One participant specifically noted 'it breaks too much!' but would use the machine in the future if it were reliable.

Seven participants commented about cost as a barrier to future use of the machine. One participant observed that 25 dollars a month was too much while another noted willingness to use the dispenser if the costs were covered. One participant indicated a plan to buy the medication dispenser after the study was over.

4. Discussion

Our results show that nearly all participants perceived the medication dispensing device as very easy to use, very reliable and helpful in the management of their medications. In addition, nearly all participants reported that the machine did not interfere with other activities or the ability to reach their nurses. To a lesser degree, most participants reported that the device did not interfere with their independence or their ability to get around or leave the house. A future area for inquiry should seek to determine the characteristics of those older adults for which automated medication management interferes with independence and ability to get around.

Many participants were initially not comfortable with the machine. However, as the study progressed their comfort increased. For some participants, the machines became a key part of their home environment. One participant crocheted dolls that sat on top of her machine which she changed with the season or holiday. Also, the machine announced the time of day, providing additional orientation to time for those participants with more advanced cognitive impairment.

Although a strong majority of participants indicated that the machine helped with medication management and gave them piece of mind, a smaller majority reported a willingness to use the machine in the future. In light of these results and participant

comments, *cost*, *usability*, *perceived need* or other, unidentified issues may be interacting factors that contribute to willingness to use the medication dispensing device. In addition, wider dissemination of health IT tools will depend on the extent to which *standards and interoperability issues* in distributed health applications are addressed. This challenge is inherent to tools that require data exchange between a diverse set of hardware, software applications and stakeholders that are not limited to institutional settings.

Informatics tools that support medication management are one of the many potential examples of patient-centered applications. These systems enable a partnership among practitioners, patients and their families (when appropriate) to ensure that the procedures and decisions respect patients' needs and preferences. These types of partnerships provide a means to solicit patients' input about the education and support they need to make decisions for participation in their own care [48]. While such systems can facilitate disease management for home healthcare patients and their families, they often fail to address the needs of older adults even though older adults are the primary end user group. Considerations for design are even more important for the frail elderly or the oldest old [34].

In this study, we assessed older adults' acceptance of a medication dispensing system for one point in time. In addition, it is important to continuously assess the users' experience over time to better understand the potential obtrusiveness of technology, defined as the 'summary evaluation by the user based on characteristics or effects associated with the technology that are perceived as undesirable and physically and/or psychologically prominent' [49]. The obtrusiveness concept includes several dimensions such as physical, usability and privacy dimensions. It also includes a dimension of self, namely concerns about dependence on the technology or over-reliance on automation, which are often revealed after extensive exposure to a technology application for longer periods of time.

By one home-based monitoring technology categorization schema, medication dispensing devices such as the one described in this study fit into a category of 'cognitive and sensor assistance' interventions that also includes items such as lost key locators and computer text enlargement programs [50]. Other types of home-based health technologies include systems to detect declines in physical activity (for example: motion sensors embedded in the environment [51]), to detect changes in vital signs (for example: wearable sensors [52]) and to support social interaction (for example: video communication technologies [53]). Taken together with these other home-based health technologies, medication dispensing devices can form part of an integrated solution to holistically support the health of older adults in their homes.

Health informatics research on the care of older adults is an expanding topic area but there is much to understand about the specific needs of older adults with regard to supportive technology and its design [54]. With regard to medication management, usability barriers for older adults related to child-resistant containers and drug packaging are well documented [55,56]. Hayes et al. developed and tested a 7-day pillbox for monitoring medication adherence ('MedTracker'), reporting that 37 of 38 older adult participants (mean age 82.2) found the system easy to use [57]. Other enhanced pillboxes that implement sensors to monitor tasks are in earlier stages of development [58,59], but new approaches to longitudinally engage older adults in the design process through reflection about their activities are being tested [59]. Alternative technology-enhanced medication management solutions, such as robotic reminding assistants [60] or medication management systems integrated into smart homes [61] are in the early stages of development. Ingestible electronic systems are in the early stages of development but the long-term safety and usefulness of these systems have yet to be demonstrated [62]. In addition, the idea of 'telepresence,' the remote presence of a caregiver made available through

information and communications technology, has been proposed to facilitate medication adherence in older adults [63]. Our results contribute to technology-enhanced medication management knowledge by characterizing the usability and user effects of a commercially available medication dispensing device using a comparative study design with a statistically significant sample of older adults.

5. Limitations

This study enrolled frail older adults over the age of 60 years (with a mean age of 80 years) who met our study inclusion criteria. Furthermore, we examined only one medication management product for the purposes of this intervention. Thus, study results may not generalize to other populations with chronic disease or other medication management solutions.

6. Conclusion

This study introduced a medication dispensing device as a medication management intervention to older adults discharged from a home healthcare program. Medication management is a complex task, and older adults have different usability concerns than younger counterparts with regard to vision, cognitive ability and physical function. The medication dispensing device was designed to simplify the complex task of medication management with the aim of reducing medication errors and improving communication with providers. Medication error reduction and better communication are important to reach the larger goals of improved outcomes in older adult health status, rates of hospitalization, rates of nursing home admission, total costs of care and costs per quality adjusted life year.

Older adults in this study accepted the medication dispensing device as reliable, easy to use and useful in coordinating personal medication management. These results indicate that technology-enhanced medication dispensers can be acceptable tools for older adults to help manage their care in collaboration with home care nurses. These results are encouraging because acceptance of technology-enhanced medication management is a requirement toward improved monitoring of unpredictable responses to drug therapy in older adults.

Design and cost were indicated as areas for improvement. Design is an iterative process and implementations in a real-world context often reveal opportunities for better design. With older adults, it is particularly important to match personal abilities to device controls for medication management activities. Although workarounds – actions taken to circumnavigate a barrier in an information system to achieve a goal – are sometimes required to solve problems when clinicians face challenges in the use of hospital medication management systems [64,65]; the home is not a clinical setting and older adult patients may lack the experience, motivation and problem-solving skills to overcome barriers in the use of a medication dispensing device. To identify and overcome barriers in person-technology fit, older adults should be engaged using participatory design strategies for the creation of new technologies that support their needs.

With regard to cost, new cost models based on demonstrated savings must be devised for widespread implementation and adoption of technology-based medication management interventions for the growing population of older adults. Toward this end and the goals of the larger clinical trial, future research should include: (1) design studies for medication management devices; (2) research into new cost models that enable better access to medication management devices; (3) comparison of medication management devices with and without home services and; (4) integration studies of medication management

interventions and data bundled with other informatics interventions for holistic support of older adults.

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