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Older Adult Preferences of Mobile Application Functionality Supporting Medication Self-Management

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Running head: Functionality of medication self-management mobile applications

Abstract

Health systems and insurers alike are increasingly interested in leveraging mHealth (mobile health) tools to support patient health-related behaviors including medication adherence. However, these tools are not widely used by older patients. This study explores patient preferences for functionality in a smartphone application (app) that supports medication self-management among older adults with multiple chronic conditions. We conducted six discussion groups in Chicago, Miami, and Denver (N=46). English-speaking older adults (55 and older) who owned smartphones and took five or more prescription medicines were invited to participate. Discussions covered familiarity with and use of current apps and challenges with taking multi-drug regimens. Participants reviewed a range of possible mobile app functions and were asked to give feedback regarding the acceptability and desirability of each to support medication management. Very few participants (n=3) reported current use of a mobile app for medication support, although all were receptive. Challenges to medication use were forgetfulness, fear of adverse events, and managing medication information from multiple sources. Desired features included (1) a list and consolidated schedule of medications, (2) identification and warning of unsafe medication interactions, (3) reminder alerts to take medicine, and (4) the ability record when medications were taken. Features relating to refill ordering, pharmacy information, and comparing costs for medication were not considered to be as important for an app.

Key Words: adherence, medication, mobile health

Older Adult Preferences of Mobile Application Functionality

Supporting Medication Self-Management

Introduction

Nine out of ten older U.S. adults report taking prescription medications regularly and more than a third take five or more prescribed drugs (Charlesworth, Smit, Lee, Alramadhan, & Odden, 2015; Gu, Dillon, & Burt, 2010). Despite being one of the most common health behaviors, taking medication can be challenging for patients. A large body of literature has investigated this issue and consistently finds in order to take medication safely and correctly, people must interpret complex drug warnings and instructions for use (Gellad, 2009; Kindig, 2004; Rudd 1999), navigate varying doses and daily schedules (Ingersoll & Cohen, 2008), and maintain a regimen despite frequent medication changes (Greene & Kesselheim, 2011). While numerous interventions have been developed and evaluated to promote medication adherence and safe use, few low-cost and simple strategies are readily available to patients (Haynes et al., 2005).

Information and communication technologies have emerged as a potential solution for helping patients manage complex drug regimens and access needed prescription medication information ("mHealth Technologies: Applications to Benefit for Older Adults," 2011; Mistry et al., 2015; Park, Howie-Esquivel, & Dracup, 2014; Steinhubl, Muse, & Topol, 2013). Smartphone applications (apps) in particular have been heralded for their ability to provide health support through individual customization, compatibility with body-wearable sensors, and real-time information exchange (Chatterjee & Price, 2009), especially in the context of chronic illness (Goldberg & Levy, 2016; Heintzman, 2016; Parmanto et al., 2013). Despite their promise, many health management apps fail to be patient-centered. A recent review of the usability of medication

self-management smartphone apps found that although over 14,000 apps were available to download, the most highly rated apps lacked key functionalities, such as assisting patients with organizing their medication regimen, checking for drug interactions, or documenting medication use, which may support older adults to safely manage complex drug regimens (Bailey et al., 2014).

Perhaps more problematically, many smartphone apps have not been designed with the older patient in mind. Although older adults have historically delayed the adoption of new technologies, recent national surveys have shown that smartphone ownership is rising rapidly among this population (Archer, Keshavjee, Demers, & Lee, 2014). Older adults are more likely to be prescribed multiple medications, are at risk of cognitive deficits, and are at greatest risk for adverse, medication-related outcomes (Field et al., 2001; Housley, Stawicki, Evans, & Jones, 2015; Marcum et al., 2012). Ensuring that health management smartphone apps are designed to effectively support prescription medication use among this population is essential.

While some studies have found older patients have positive views towards health-related smartphone apps (Grindrod, Li, & Gates, 2014; Mercer et al., 2015; Parker, Jessel, Richardson, & Reid, 2013), there is limited evidence pertaining to the use of apps to support medication management among older adults with complex drug regimens. This study sought to obtain input from older adults with multiple chronic conditions and taking multiple medications regarding a series of app features. Rather than testing an app prototype, this study explored participants reactions to individual app features and encouraged participants to suggest edits or adjustments to enhance a feature to be more relevant to their needs. These findings can be used to inform the future development of mobile apps to meet the specific needs of this population.

Methods

Recruitment

Participants were recruited from general internal medicine clinics in Chicago, IL, Miami, FL, and Denver, CO either with flyers or through participation in prior studies. Flyers describing the study were posted in clinics at each of the sites, and interested patients were asked to contact a researcher to learn more about the study. In addition, recruitment letters were mailed to participants from prior studies who agreed to take part in future research. People were eligible if they were (1) age 55 or older, (2) English-speaking, (3) smartphone owners, and (4) responsible for administering (either to themselves or another person) at least five daily prescription medications. A researcher assessed participant eligibility and availability, and scheduled discussion groups at each site.

Measures

Participants completed two separate surveys pre- and post-discussion group. The pre-discussion group survey was administered by an interviewer with measures including socio-demographic characteristics (age, sex, race/ethnicity, education, work status, and income), medical history (number of daily prescription medications and chronic conditions), and use of technology (ownership of a cell phone, use of a text message plan, use of email/internet on a smartphone). Interviewers also assess participants' health literacy through the Rapid Estimate of Adult Literacy in Medicine (REALM). The REALM consists of a list of medical words that participants are asked to read aloud and is graded on pronunciation accuracy (Davis et al., 1991). Participants are categorized as having adequate literacy skills (≥9th grade reading level), marginal literacy skills (7th-to-8th grade reading level), or low literacy skills (≤6th grade reading level). At the conclusion

of the discussion group, participants were asked to briefly rank the top five features that they found most desirable.

Procedure

Prior to discussion groups, interviewers administered the pre-discussion survey and health literacy assessment. The discussions were led by one moderator (MW) with support from study authors (AP and LB). To begin, older adults were asked to describe difficulties they faced when managing multi-drug regimens and their strategies to support medication use. They were also asked about their experience with apps for medication support. The second half included a discussion of twenty-one features that could be included in a medication management app. The facilitator presented the features one at a time to the group and encouraged participants to review and comment on the perceived value of each feature. They were also asked to suggest improvements or alternative features that would support safe medication use. At the conclusion of the discussion groups, participants completed the post-discussion survey of feature preference ranking. The study lasted approximately one hour and participants were compensated. The discussions were digitally recorded and transcribed by the study team. The Northwestern University Institutional Review Board (IRB) approved these study procedures.

Features

The features presented to the groups were informed by the conceptual model of medication self-management which highlights the steps involved in successful medication taking (fill, understand, organize, take, monitor and sustain) and is founded upon principles identified in health literacy research (Bailey, Oramasionwu, & Wolf, 2013). This model, coupled with the findings

from the review of medication apps available for download (Bailey et al., 2014), served as the basis for the choice of features.

The features fell into six domains: medication education, regimen identification, refill management, provider and pharmacy information, reminders and alerts, and cost comparisons. Medication education features involved the ability to access additional need-to-know medication information within the app (individual medication information) or link to external, more comprehensive drug information (national drug database), and generate warnings based on the patient's medication list (drug interaction warnings). Regimen identification capabilities included a list of current prescriptions (medication list), past prescriptions (prescription history), and additional options for the lists (add photo of pill, add medication to list by barcode scan). Refill management features consisted of features ensuring prescriptions were refilled on time through app-generated reorder reminders (refill reminders), the ability to order refills through the app (prescription refill), and extra options for refill orders (refill by barcode scan, check order status, and transfer prescriptions). Provider and pharmacy information features enabled patients to take notes about encounters with doctors (doctor visit information) as well as store and search for contact information of doctors and pharmacies (doctor information, find a pharmacy, pharmacy information). Reminder and alert functions notified patients when they needed to take their medications (medication alerts) as well as enabled caregivers to receive the same notifications as the patient (caregiver alerts). Cost comparison features helped patients identify the most affordable options through comparing medication costs (drug prices), searching for available generic medications (generic medication recommendation), and the ability to search for the lowest cost prescription (lower cost prescription lookup).

Analysis

Descriptive statistics were summarized for socio-demographics and health characteristics. Participant self-report of mobile phone use including frequency of use of texting, email, internet access, general mobile app, and mobile apps used for medication management was described for the sample.

Thematic analysis was used to identify patterns within the discussion group data (Braun & Clarke, 2006). Transcripts and researcher notes from the groups were read several times by two independent researchers (LB and AR), and initial coding began when they were familiar with the data. Each researcher noted if participants tended to reach consensus regarding the features described. Then, each researcher consolidated participants' responses in discussion into representative, descriptive themes. The consensus and theme determination were discussed with the wider research team to confirm agreement and modifications were made. LB and AR resumed coding of all data with the finalized analysis plan.

Desirability of the features was defined as the frequency in which each feature was selected as among the participants top five. The percentage of participants who chose each feature as among their top five is reported with the highest percentages defined as the most desirable.

Results

Participant Characteristics

A total of 46 adults participated across six discussion groups in Chicago (n=19), Miami (n=15), and Denver (n=12). Two discussion groups were held at each site. As shown in Table 1, 61% (n=28) of participants were white, 30% (n=14) were male, and 11% (n=5) had marginal health literacy skills. The mean age was 65 years (SD=9) and 39% (n=18) had less than a 4-year college-

level of education, and 44% (n=20) had an annual household income <$50,000. On average, study participants were managing seven daily medications (SD=3) for themselves or others and had 3.3 (SD=2.5) chronic conditions. The most common chronic conditions among participants were high blood pressure (n=33), high cholesterol (n=29), heart disease (n=12) and cancer (n=12). Most participants (n=39) reported using mobile apps one or more times daily (85%). A minority (n=3) of respondents reported using a mobile app to support medication management.

Medication Challenges

Quotes illustrating common themes emerging during discussion groups are listed in Table 2. Participants reported confusion with frequently changing medications including the name, indication, and pill appearance. They worried about unknown contraindications for their medications and the potential for adverse events. Another major concern was the risk of adverse events resulting from double dosing. For example, participants reported they often forgot if they had taken their medicines earlier in the day and worried about the consequences of skipping doses or double-dosing with one patient summarizing these concerns as, “the unknown if you miss a dose, how close to the next one can you take it…its always kind of traumatic when that occurs, do you skip it entirely or does it not matter?’

Managing information and communication between multiple providers and caregivers was difficult for many patients, with one participant stating “if you see multiple doctors, they might not know everything you are taking.” Many had dual roles as patients and caregivers to others requiring them to manage the information of others in addition to their own,. For a small number of participants, refills of multiple medications were unsynchronized, frequent trips to the pharmacy were viewed as a burden.

Recommended Features.

Across the six domains, twenty-one features were presented to participants and discussed across the groups. Patient preferences emerged in the discussion of medication education, regimen identification, reminders and alerts, and caregiver involvement. A summary of the results of the survey by feature is available in Table 3.

Medication education. The most valuable feature was that the app could search medication lists and dosing schedules and generate improper-use warnings when applicable. As one participant stated, "If I could type in my new medicine and it would say [do not] take with my current medicine…that would be a nice thing to have." Many participants favored the ability to choose a medicine within their list and be directed to need-to-know medication information within the app (ex. indication and potential side effects). Participants didn't consider a feature linking their medications to a comprehensive, external drug information resource to be desirable.

Regimen identification. Nearly half of participants (n=22) found a list of their current prescription and non-prescription medicines highly desirable. The sample was divided between patients preferring to manually enter the information themselves or directly importing the information from a health source (either their insurer, provider, or health record). Participants favored direct import if the information could be updated in real time and expressed concern that manual entry would be time consuming, with one participant noting "most people wouldn't take the time to do that." Those who favored manual entry were concerned about accuracy, privacy, and wary of potential technology glitches. Rather than trust the app, one participant stated "I only

trust myself." All patients agreed editing the medication list after consulting their doctor would be critical. Features such as importing information by barcode scan, pictures of pills and record of previous prescription were discussed less among the groups and were reflective of medium to low desirability.

Reminders and alerts. A programmable alarm serving as a reminder to take medications was the third most highly desired function chosen in the top five by 41% of participants (n=19). Participants mentioned additional options such as the ability to "snooze" the alarm would improve the feature. A common opinion was that the alarm should be customizable, such as replacing the audio alert with a vibration for those with limited hearing.

Medication daily schedule and documentation of taken doses. Participants wanted to "check off" the medicines as they took them in order to document which medicines they had taken. One participant suggested this feature could assist specifically with complex regimens if "you are taking seven medicines in the morning in a handful, you would want to be able to check them all off at once." This feature could serve as a reference for which medicines they took and could alleviate their concerns about missed doses or accidental double dosing. They also favored having their medication schedule categorized into "time bins" for morning, noon, evening, and bedtime. However, participants agreed the schedule must be customizable to the exact times they took their medicines (i.e. morning set for 8am), as one participant described this as "being able to program it to my needs and schedule."

Caregiver involvement. There was variable interest in a feature enabling caregivers to receive the same alerts as those they cared for, and this was not chosen with high frequency among participants in the final survey. However, among interested participants, creating in-app permissions to share information was desirable to ensure privacy. Some suggested sharing access with healthcare providers or health professionals in emergency situations.

Refill management, Provider/pharmacy information, and Cost comparisons. Features associated with refill management, provider/pharmacy information, and cost comparisons were not significant topics of debate during the discussion groups. About one third of participants (n=17) wanted a notification when due for a refill, and 28% (n=13) wanted to request the refill through the app. The additional three refill features were chosen in the top five among only 8-13% of participants. Many participants felt their refill process was already streamlined.

Space dedicated to storing information discussed during doctor's visits was chosen in the top five by 30% of participants (n=14). No participants desired contact information for pharmacies or the ability to search for a pharmacy. The cost comparison options were only chosen by 15-18% of participants as among the top five features.

Discussion

In this study, we examined older adult patients' attitudes about managing medications with a smartphone app and identified their preferences and desired features. This sample of older adults who were all contending with significant regimen complexity, found it acceptable to use a mobile app to support medication use and believed it could help overcome many of their current daily challenges. The most desired features were drug interaction warnings, a comprehensive

medication list including non-prescription medicines, reminders to take medication, reminders to refill medications, and links within the app to additional medication information such as indication and potential side effects. The majority of the patients at the time of interview had not yet used an app to manage their medicines, but they were familiar with mobile technology. As the rapid, upward trend in smartphone use continues (Archer et al., 2014), our findings may help those considering using app interventions in older adults to prioritize the features that address the unique medication challenges in this population.

Many of the barriers to proper medication self-management described by adults in our study are well known in the adherence literature including forgetfulness (both in terms of remembering to take a medicine and recall of medication taken earlier) and difficulty organizing multiple medications that frequently change (Yap, Thirumoorthy, & Kwan, 2016). These challenges are particularly salient among the elderly, who have higher rates of multi-morbidity and complex drug regimens, and simultaneously contend with decreasing cognitive capacities as part of the natural aging process (Mira, Lorenzo, Guilabert, Navarro, & Perez-Jover, 2015). The use of mobile apps may be a powerful tool to minimize the cognitive burden of medication regimens which these results support. It is possible utilizing such an app in this population could improve adherence, reduce medication errors, and achieve treatment benefits.

Technology-driven interventions have shown promise to support disease self-management in recent years. Some usability testing among older adults of smartphone apps has been detailed in the literature for promoting exercise (King et al., 2013), cardiovascular medication management (Lee et al., 2014), and self-management of multiple chronic illnesses (Zulman et al., 2015). Even basic mobile functions such as medication reminders have just recently been found to greatly improve adherence and other health outcomes (Park et al., 2014; Perri-Moore et al., 2015). Other

electronic health platforms that collect clinical characteristics, medication histories, and support medication reconciliation have the ability to reduce medication errors (Allison et al., 2014; Pevnick et al., 2016) and detect potential drug interactions to prevent adverse drug events (Heyworth et al., 2014; Mueller, Sponsler, Kripalani, & Schnipper, 2012). Applications combining these functionalities of medication reminders, medication history records, and the ability to generate drug interaction alerts are promising options for addressing safety concerns and medication adherence (Sarzynski et al., 2017). In addition, with increased uptake of patient portals that provide remote linkage to one's medical record, many of which now include a mobile platform, our findings could inform the design of these technology interfaces to promote patient engagement and safe medication use.

Despite the considerable volume of existing medication management apps and the large potential market, uptake by consumers has been variable. In our sample of smartphone owners who found a self-management app acceptable, only 7% reported ever using an app to manage medications. At the same time, engagement of older adults in the development and testing process is rarely detailed and often neglected altogether (Bailey et al., 2014). This likely results in apps that do not adequately meet the needs of individuals, improve behaviors, or improve outcomes. Grindrod and colleagues investigated the usefulness of mobile apps for older adults with regard to medication adherence (Grindrod et al., 2014). The author's concluded mobile apps may indeed benefit more elderly individuals if they clearly demonstrate the potential to remedy a present deficit experienced by the older patient in their self-management role, a finding consistent with mobile health literature (Kruse, Mileski, & Moreno, 2017). In addition, they found older adults benefited from additional orientation and training to the app. This is critical from a health system perspective

as these tools can likely address the unmet needs of many older patients, but clinical practices may need to "onboard" individuals to these new tools.

While not directly studied here, it may also be in the interest of app developers to not only include older adults but other key stakeholders (e.g. clinicians, pharmacists, or insurers) throughout the design and testing of apps to make them more patient-centered (Mercer et al., 2015). The majority of the literature of smartphone apps for managing medications tests the feasibility of their use but stops short of a full evaluation. To gain a better understanding of the long-term effectiveness of these apps, pilot trials need to be done with older adults who experience these mobile tools over time.

Our investigation has clear limitations. Common in qualitative research, this study relied on a smaller sample to gather data. We were not powered to examine differences in preferences as they might relate to characteristics such as income or health literacy. The sample was also English-speaking with higher levels of health literacy, which limits generalizability. However, these demographic characteristics could be a reflection of actual older adult users of smart phones as education and health literacy skills are strongly correlated with socioeconomic status. Our findings may not reflect the preferences of older adults who are not smart phone users and who may need more training to understand the benefits of these mobile apps. This group had an average regimen of seven medications and three chronic illnesses. These findings may not apply to older adults taking fewer medicines and/or having fewer chronic conditions. Finally, this study was not intended to test the acceptability of a specific app prototype against other alternatives (i.e. patient portals, simple smartphone alarms), therefore we cannot draw conclusions about the comparative benefits of these different options.

Conclusion

The capabilities of mobile technology and smartphone apps provide potential for assisting older adults with multiple chronic conditions to manage complex drug regimens. This study was able to identify preferences for the most desirable features that should be included in these apps. Future research should aim to test smartphone apps with larger, more diverse samples and clinical outcomes to determine the effectiveness of smartphone medication management apps on patient health. In the end, the value of any of these mobile health tools may depend on the degree of input sought throughout their development and testing among target audiences.

Competing Interests: We report no conflict of interests.

Table 1. Sample Characteristics (N=46)

Variable	n (%)
Age, mean (SD)	65 (9)
Male	14 (30)
Education	
Less than college	18 (39)
College graduate	28 (61)
Race	
Black	12 (26)
White	28 (61)
Other	6 (13)
Income	
< $10K	3 (7)
$10K – 24.9K	8 (17)
$25K – 49.9K	9 (20)
> $50K+	26 (56)
Employment Status	
Full-Time	6 (13)
Part-Time	8 (17)
Unemployed/Retired	32 (70)
Health Literacy Status	
Marginal	5 (11)
Adequate	41 (89)
Comorbidities	
0	2 (4)
1	11 (24)
2	9 (20)
3	11 (24)
4+	13 (28)
Chronic Disease	
High blood pressure	33 (72)
High cholesterol	29 (63)
Cancer	12 (26)
Heart disease	12 (26)
COPD	10 (22)
Diabetes	7 (15)
Other	11 (24)
Site	
Chicago	19 (41)
Miami	15 (33)
Denver	12 (26)
Number of medications. mean (SD)	7 (3)
Technology Use	
Smartphone use	44 (96)

Application use	39 (85)
Uses app to manage medication	3 (7)

Table 2 Select quotes about medication challenges and suggested features

Challenges	
Dosing	*'I have a [pillbox], but I just take it and use it one per day. My problem is I stick all the pills in there for one day and I take it all at one time. I don't know what time they are supposed to be taken, how they are supposed to be taken. If I remember, I take them. If I don't remember, then I just skip a day.'*
	'The unknown if you miss a dose, how close to the next one can you take it…its always kind of traumatic when that occurs, do you skip it entirely or does it not matter?'
Manual Checking	*'Sometimes when I can't remember [if I took my medicine], you know what I have to do? I empty out the medication and count them, and then count the days.'*
Contraindications	*'If you miss a pill or if you take an extra pill… that [can] cause a really bad reaction.'*
	'Sometimes you need to take them before or after a meal and within a certain amount of time you have to take one and then the other"
Changing Pill Color or Shape	*'When they change the color or shape of the drug once I've been taking it a while…All of a sudden it's a different manufacturer, I'm not used to the name'*
	'I have to struggle with the issue…with the pharmacy continually changing suppliers…'
Refills at the Pharmacy	*'Having to go to the pharmacy every 30 days for refills and not being able to get them lined up so they pop up at the same time and I can do one trip'*
Desired features	
Medication Interaction Warning	*'If I could type in my new medicine and it would say [do not] take with my current medicine…that would be a nice thing to have'*
	'I once had a bad reaction and my hemoglobin went down to 3.5…so that could have been flagged'
Double Dose Warning	*'I don't know if there are rules somewhere [about taking too much medicine], but that should be put in there.'*
Comprehensive Medication List	*'You just have medications/prescriptions, you don't have anything for all my vitamins, that I would like to add, so I would like to click on another button for that'*
	'I would want to be able to remove a medicine. Sometimes you take a medicine and it isn't working for you and they have to switch it to a different one'
	'What if you had a pill history…if you switch a pill it would store the change and the date'
	'When you go to different doctors and they don't all know the prescriptions you are taking and if you don't tell or show them, they won't know'
Reminder Alerts	*'I might have a senior moment and forget about it, and I can have [a] reminder in it, to go 'hey, go take your medications.'*
	'If you are taking seven medicines in the morning in a handful, you would want to be able to check them all off at once'
	'I would want it to let me know when I've missed taking my medicine'
Caregivers	*'All of a sudden you get so old and you have a caregiver in your house taking care of you and she can go to the app and see exactly what you should be taking and I think it's important'*
	'My wife had a stroke, so I carry around a list of the meds she takes and she carries around mine'

Table 3 App features and desirability indicated by percent of sample who listed feature among their top five

App Feature by Domain	Description	Participants who rated feature in Top Five n (%)
Medication education		
Drug interactions warnings	Warning is generated when app identifies two medications or doses that may cause interactions	25 (54)
Individual medication information	Important, need-to-know information, such as name, indication and common side effects for each individual medication should be accessible through the app	16 (35)
National drug database	Information in the patient's medication list is linked to a national drug database with more comprehensive information such as rare side effects or adverse event reporting	4 (9)
Regimen identification		
Medication list	List of current prescriptions and OTC medicines	22 (48)
Add photo of pill	Image of the pill stored in the app and linked with medication name and information	12 (26)
Add medication by barcode scan	Ability to scan QR code on product or prescription to import information into app	11 (24)
Prescription history	List of prescription history	7 (15)
Refill management		
Refill reminders	Notification sent when it is time to refill medication	17 (37)
Prescription refill	Ability to order a refill of medications from the app	13 (28)
Refill by barcode scan	Ability to scan QR code on prescription to order the refill	6 (13)
Order status	Ability to look-up in real-time the status of the refill order	4 (9)
Transfer prescriptions	Ability to send a prescription from one pharmacy to another	4 (9)
Provider and pharmacy information		
Doctor visit information	Record notes from during doctor visits	14 (30)
Doctor information	Record contact information for doctor	10 (22)
Find a pharmacy	Ability to find pharmacies close by in an unfamiliar area	0 (0)
Pharmacy information	Record of pharmacy contact information	0 (0)
Reminders and alerts		
Medication alerts	Notification sent at the time the patient is supposed to take medications	19 (41)
Caregiver alerts	Caregiver able to receive the same alerts (reminders to take medications or order refills) as the patient	5 (11)
Cost comparisons		
Drug prices	Ability to view and compare prices of similar drugs	8 (17)
Generic medicine recommendation	When a generic medicine exists, app notifies patient a cheaper option is available	7 (15)
Lower cost prescription lookup	Ability to search for the lowest cost prescription	7 (15)

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