

Potential Barriers in Adoption of a Medication Compliance Neckwear by Elderly Population

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Abstract—This paper presents results of a study to understand potential barriers of geriatric population with chronic illnesses towards adoption of a wireless wearable medication compliance system in the form of a neckwear. The neck being a critical part of the body can serve as a good source to collect a range of health related information on an individual. The primary research question we investigate here is this: for individuals with chronic illnesses especially amongst the elderly population how willing are they to adopt a neckwear system if it can monitor and mitigate health complications? Elderly patients deal with constant prescription changes over time and this further degrades medication compliance and thereby complicates an already wavering health status. A semi-structured interview was conducted to better understand medication adherence, regimen and issues encountered using reminder devices with the goal of informing the design of a new compliance monitoring system. Results show that preserving health is one of the primary concerns of people living with chronic illnesses therefore there is a promising potential for seamless adoption of a neckwear medication compliance system with additional capabilities to monitor general health status.

I. INTRODUCTION

Medication non-compliance is a critical issue that has been associated with increased healthcare cost, rehospitalization, complications, disease progression and even death [1]-[4]. Despite potential consequences, an estimated one third to one half of all patients in the U.S. do not take their medications as prescribed, leading to an estimated \$290 billion in avoidable medical spending every year [5]. There are many reasons why patients do not comply with a certain course of medication. Among elderly patients the most common reason is simply forgetfulness [3].

Senior patients with chronic conditions are often required to take more than one medication over extended periods for maintenance of the quiescent disease [6] such as hypertension, cardiovascular disease, arthritis and others. The combination of quiescent symptoms and need for long-term treatment may affect their daily use of these “maintenance” medications. Prior studies have demonstrated that patients with chronic diseases are likely to become less adherent with

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medications over time, and there is little doubt that adherence to maintenance medications has a direct effect on long-term outcomes and utilization of healthcare resources [7].



Figure 1. RFID-based Wireless and Wearable Event Detection and Adherence Monitoring System (WEAMS).

Various studies have used self-reporting with other surrogates such as a medication diary, pill counting, pharmacy refills and testing for drug levels as measures of compliance [8]. Doctors often make vital medical decisions based on patients' own report of their compliance to administered medication or based on the results of indirect monitoring methods. Considering the scale of this problem, if novel medication adherence monitoring systems (MAMS) are developed that help even a small fraction of those patients improve their adherence, it will have a significant impact on reducing their healthcare costs [4]. In addition, MAMS solutions have the potential to improve treatment results by providing doctors with more reliable information which can serve as an objective baseline for further consultations.

There are a variety of so called “smart” pill boxes commercially available which can monitor the patients' preparatory actions for taking a medication [8]. These devices can neither detect who has taken the medication out of the container nor what is actually done with the pill. Proteus Digital Health Feedback System is currently the only ingestion-based MAMS technology that uses a disposable stomach patch and custom chemically-activated edible application specific integrated circuits (ASIC) for tracking [9]. The WEAMS (Wireless and Wearable Event Detection and Adherence Monitoring System) solution (Fig. 1) is expected to be considerably more cost-effective and durable both for the end-user and healthcare provider because it is reusable and based upon the well-established and mass produced radio frequency identification (RFID) technology.

This paper lays the foundation for the WEAMS system in the form of a neckwear device. The neck is a suitable location for a health monitoring system because it aligns with the body trunk and provides easy access to majority of vital signs and ingestion indicators. The proposed system will not only remind patients when to take their medications and the proper dose of each pill, but also monitor medication ingestion in real-time. Aggregated compliance data will help doctors and

patients track adherence history, compare it to the health outcomes and follow-up with continued treatment or change/adjust the course of treatment.

II. SYSTEM OVERVIEW

WEAMS will utilize RFID tags that operate in very high frequency (13.56 MHz) bands [10]. Every medication dose will include an edible RFID tag pre-programmed with pertinent medication information including type of medication, dosage, manufacturer, expiration date, and a unique serial number. An inert polymer based coating material, such as medical grade epoxy, will protect the RFID tag from decomposing as it harmlessly passes through the patient's gastrointestinal (GI) tract within ~48 hours. The RFID tag not only allows tracking the exact dose of ingested medication but also protects patients against counterfeits. As the pill passes through the esophagus, an embedded RFID reader in the neckwear will be "awakened" by a trigger mechanism. Two candidates for triggering the RFID reader are the opening of the pillbox cap and the swallowing sound. Once the presence of an RFID tag in the esophagus is confirmed, a signal representing a 'dose-ingestion event' will be generated, date and time stamped by the neckwear control unit, and stored locally or wirelessly transmitted to a smartphone if/when it is within range.

III. METHOD

Twenty (9 men and 11 women) seniors aged from 66-96 years (mean 77.65, stdev 8.80), who take at least one prescribed maintenance medication for treatment of chronic conditions were interviewed. Interviews were semi-structured and conducted independently with the goals of:

- Gaining an understanding of the requirements/complexity of individual medication regimens
- Understanding methods/procedures of medication reminders that are currently used
- Identifying issues related to usability and acceptability of the existing medication reminders
- Gathering opinions, needs, and concerns about the proposed WEAMS technology

Audio recordings of each interview were made and independently transcribed by two transcribers to ensure accuracy. The transcription from each interview was then analyzed through the process of qualitative coding. Two primary coding approaches were used. The first is known as descriptive coding and is used to identify the basic topics present in a passage of qualitative data. The second is known as values coding which is used to identify the values, attitudes, beliefs or perspectives of a participant from a passage of qualitative data [11]. The coding analysis was managed through the computer assisted qualitative data analysis software MAXQDA by VERBI GmbH.

A code was created and associated with a block of transcribed text when a new topic or theme was described by a subject during an interview session. The code could be assigned multiple times within one transcript if the same topic/theme was brought up multiple times. This code was re-used if the same topic/theme was described by a different interviewee. This way, common ideas and opinions are

codified and tracked across all interviews. No weights were applied to the codes based on how often they appeared. The presence and frequency of common themes across interviewees was used for data analysis. Regardless of how often a particular code may have appeared in a single interview, it was only counted once in order to prevent the analysis from being skewed by a single interviewee that may simply have been more descriptive or verbose than another.

Interview text was not 'interpreted' when assigning codes. For example, a question such as "How do you like the current reminder method that you use?" was intended to prompt discussion of issues. A code such as "User is happy with current reminder method" was not applied unless the subject felt strongly enough to directly state in some way that he/she was actually happy with it. Even if the reminder method seemed to work well for a subject, this interpretation was not forced on the text. This approach was taken for all codes in order to reduce bias and to prevent the introduction of ideas that may not actually be held by participants.

IV. RESULTS

Analysis of interview responses resulted in a total of 218 descriptive codes. Many codes indicate individual preferences or opinions that were not specifically mentioned by another subject. A subset of the codes represents direct answers to interview questions and thus is present in a majority of the subject responses. Table I lists the frequency of responses to the following interview questions:

- How many physicians do you see?
- Do they all give you medicines to take?
- Do you remember the instructions of each medicine?
- Does your regimen change over time?
- Do you like the reminder method that you currently use?

Many of the other interview questions could not be answered as directly. They asked about common issues, but responses were often as varied and unique as each individual. Table II lists codes based on responses that were common across the interview sessions for questions such as:

- What method do you currently use to help you remember to take your medications?
- Are there any circumstances under which your reminder method does not work?
- What do you like or dislike about your medication reminder method?
- What other medication reminder methods have you used in the past?
- What are the consequences if you make a mistake?
- What do you think about the functionality of the proposed WEAMS idea?

No significant differences were found in the responses between genders. Due to time allotted to conduct the interviews and availability of volunteers, subjects were not demographically diverse. All participants were Caucasian. While these results are helpful in better understanding this particular portion of prospective users, it is likely that different issues related to medication adherence and reminders are present within other ethnic groups. Future

phases in the development of the new compliance system will be focused on identifying these differences.

TABLE I. DIRECT SUBJECT INTERVIEW RESPONSES

Code	SubjectResponses (n=20)
User sees single physician	3
User sees multiple physicians	17
Single prescriber of medications	13
Multiple prescribers of medication	7
Regimen Instructions are understood	17
Regimen – Once per day	6
Regimen – Twice per day	11
Regimen – Three or more times per day	3
Regimen has changed over time	14
User is happy with current reminder method	6

TABLE II. COMMON RESPONSES ACROSS INTERVIEW SESSIONS

Code	SubjectResponses (n=20)
Occasionally non-compliant	16
Regimen missed - long term consequences	12
Regimen missed - short term consequences	2
Reminder method integrates with normal routine	11
Reminder method relies on memory	10
Reminder method gives visual feedback	10
Pill sorter	8
Environment changes can make compliance harder	10
User likes WEAMS concept	17
Does not like neckwear	6
User would wear WEAMS if instructed by doctor	14
User views WEAMS as appropriate for more serious medical conditions	7

V. DISCUSSION

One of the primary issues to be considered in designing a new compliance tool is gaining an understanding of the care environment of target users. Most seniors who were interviewed (17/20) see multiple physicians regularly and nearly half (7/20) receive prescriptions from more than one physician. Results show that for most, medication regimens tend to change over time. This includes dose, medication and frequency changes. Majority of participants (17/20) were well informed about their medication regimen. This was more than just knowing when to take a medication; most were well aware of the specific medications they take (or have taken in the past), the purpose and benefits of each, as well as potential side effects and risks.

Although most interviewees were well aware of their regimen requirements, most also reported that they have had an issue with adherence in the past, represented by the code 'Occasionally non-compliant'. There are a number of possible reasons for this. It is well understood that people tend to be less compliant with a medication regimen over time and many subjects reported that they have taken maintenance medications for many years. Therefore, the tendency of

compliance is likely to fall over time. Very few of the participants indicated that missing a dose would result in any immediate consequences. Most participants did not indicate a great deal of concern if they occasionally did not exactly follow their prescribed medication schedule. If consequences of non-adherence were more immediate or severe, it is possible that this attitude may have been different. Finally, failure of the reminder system was a factor in some cases of non-compliance.

A clear trend among participants is the connection between their system and normal routine in order to make their regimen as easy to follow as possible. The most common approach was to integrate taking medications with their meal and/or sleep schedule. Most subjects (17/20) reported that their regimen requires them to take medicine either once or twice per day. In cases where the medication was required to be taken with food, their medication schedule naturally revolved around mealtimes. In cases where food was not a requirement, people still tended to take their medicine with meals or with their normal sleep/wake routines. Reasons for choosing one over the other varied greatly based on the individual. Only 3 subjects reported a need to take medication three or more times per day. Further input from subjects with more complex regimens will be needed to discover if/how their adherence strategies differ from people with simpler requirements.

Integrating the medication regimen with normal activities has many advantages but can be the source of most compliance issues. These strategies seem to work very well provided that a person is actually able to follow their normal schedule. Travel, such as for an extended trip, a visit to relatives, short day trips or even running errands can easily disrupt regular routines. Since the reminder depends on regularity, when the routine is interrupted the reminder system can easily break down. This is true not only for trips outside but any change to a person's normal environment. This can include visitors in the home as well as any kind of activity or project that can cause distractions that can prevent them from seeing a note or hearing an alarm that they normally would notice.

A large component of current reminder systems is inclusion of visual or audio feedback. Visual feedback might include a reminder list placed by the sink, in a medicine cabinet or on a nightstand to give the reminder to take a certain medication. Specific locations varied by individuals, but the reminder was always placed in a location where it would not normally be missed (such as when a person gets dressed, brushes his/her teeth, prepares a meal, etc.). Some visual reminders tend to be better than others. A simple list provides a reminder but does not indicate whether the medication was taken. Approaches such as using pill organizers do provide this type of feedback (if the container is empty, assume the medication was taken) but these require periodic setup and can fail if a user is not diligent with refilling them. Interestingly, half of the participants said that they relied on their own memory to confirm if they have taken a medication and were often unable to give a clear answer when asked how they knew for sure. Most said that they trust their memory or they expected that they would 'feel' differences in their body if a dose was missed.

Memory reliance was common for those using lists or alarms for reminders which do not provide any confirmation.

A number of opportunities and barriers are evident from understanding current reminder methods. An important aspect of any new device is that it can be easily integrated into the user's normal life. At the same time it has to do so in such a way that it is not likely to fail when a normal routine is interrupted. It must be easy to use and able to gracefully handle changes in regimen that may come from multiple sources. It also should be something that users will want to use. While most people interviewed do not necessarily love their current reminder method, most feel that their current approach 'works for them.'

The last few questions of the interview were dedicated to asking about the WEAMS concept. A storyboard was shown while the concept of the device was explained, followed by a few simple questions asking about the opinion of the device and about situations where wearing the device would or would not be acceptable. Most users indicated that they liked the idea of a device that would help remind them what they should take, what they have actually taken and that could give them a connection to their doctors. While they seemed to appreciate the potential benefits, a high percentage (7/20) stated that they did not personally need such a system because they viewed it as more appropriate for people with more serious conditions than their own.

A few interviewees raised important concerns that were not addressed directly during this interview but require more study. The first is privacy. Some people felt that persistent monitoring of exact times and dosages might remove the control they have over their regimen or that it could become an unwanted invasion into their personal lives. Even in this small sample, some mentioned that they really do not like doctors or taking medications very much. If a device is viewed as an unwanted intrusion it could be a significant barrier to adoption or could lead users to find ways to intentionally circumvent it. It is easy to imagine some concerns, from a simple 'scolding' from a doctor that might be unpleasant to concerns over potential impacts to insurance coverage based on data gathered about adherence levels. Another concern shared by several is related to cost, both of the device and the service. This is a relevant to many seniors who live on fixed incomes. The way the infrastructure and reporting service of such a system is supported could also have hidden privacy concerns, such as who has access to the data, where is it stored, etc.

A number of important design issues were raised that will need to be overcome. Neckwear is not a preferred style for many of those interviewed. For these users being able to hide the device in some way is important. For those that do not wear neckwear or jewelry in general, this is a significant barrier. Many of these same people did indicate that they would wear it if instructed by their doctor, but for others this would prevent adoption and use of the device. For those that would wear the device, voluntarily or if instructed, there were few situations where they would absolutely not wear it. Several indicated that they would not wear it for very important occasions such as weddings. Others had concerns about wearing it in places such as the shower, while exercising or being outdoors but would not have any

problems as long as the design was waterproof and comfortable in those situations.

VI. CONCLUSION

Medication non-adherence with seniors is influenced by patient, medication and healthcare-related factors such as cognitive and functional decline, inadequate contact with healthcare professionals, poor social support, and lack of assistance with medication administration [12]. Adherence interventions can also take many forms, and successes through technical, behavioral, educational or multi-faceted approaches have been shown [12]. New technological solutions alone are unlikely to lead to significant improvements. They may, however, reduce loopholes and bring greater ease of use to users in order to lower the incidence of unintentional non-compliance. Technology is often easily defeated if it is not used or not used correctly. So as with any new product, new adherence monitoring systems should be something that people will want to use. The results show an interest in the WEAMS concept and also reveal important issues to be overcome through innovative design and education of the importance of adherence. The initial data from this study will be used to inform the design of multiple potential concepts. Future work will involve multiple focus groups which will be used to compare and iteratively refine concepts. The most successful will be selected, fully functional prototypes fabricated and then field tested to assess real world effectiveness and acceptability.

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