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A Qualitative Assessment of an Ambient Display to Support In-Home Medication of Older Adults †

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Abstract: Studies on ambient computing technologies have shown their potential for assisting older adults to manage medications. However, their results cannot be generalizable, since they were conducted in different settings. We assessed the feasibility of a Medication Ambient Display (MAD) to improve the medication adherence of low-income Mexican older adults with mild-cognitive impairment (MCI). Through semi-structured interviews to 11 dyads of older adults and family caregivers who used MAD, we identified the effects of the setting conditions in the adoption and use of our technology. Our results showed that older adults forgot less to medicate. However, we observed that seniors have risky medication-related behaviors as a consequence of the challenges impose by our setting, such as the lack of adequate pharmaceutical policies regarding the rational use of medicines and the follow-up on patients' medication regimens. We outline design implications for developing ambient computing technology to reduce drug adverse events associated with these challenges.

Keywords: older adults; assistive technologies; medication adherence

1. Introduction

Older adults are susceptible to having risky medication-related behaviors. The most common reasons for non-adherence among older adults is forgetfulness, which has been associated with the fact that multiple cognitive processes associated with prospective memory, are involved in remembering to follow a medication regimen [1,2]. Problems with prospective memory cause deficits in basic and instrumental activities of daily living, such as taking medications, which increments caregiving demands [3,4].

Additionally, the lack of appropriate health-care and pharmaceutical policies to manage medicines and provide appropriate follow-up on patients' treatment, contributes to making older adults vulnerable to medication errors. When patients are discharged from hospitals or after a physician consultation, they are very often left to deal with medication variances without the support of hospital staff, a situation that may increment adverse drug events, such as taking drug combinations with interactions that should be avoided [5]. Also, both medication regimen complexity and number of medications taken by older adults, are associated with unplanned hospitals admissions, and adverse drug events [6,7]. Mexico like other developing countries, lacks of appropriate regulatory mechanisms to deal with the different dimensions of the harmful use of medicines, such as, self-medication and inequitable access [8,9]. That is, patients do not "receive medications appropriate for their clinical needs, in doses that meet their individual requirements for a period of time" [10]. These circumstances of the setting might remain unperceived by older adults, and lead them to have risky medication-related behaviors. In this paper, we show how several of these circumstances affected the use and adoption of our technology.

Different technological approaches have been proposed to facilitate older adults to manage their medication regimens with the main focus of providing reminders through mobile phones [11], and digitally augmented pill containers and dispensers [12–14]; while others aim at keeping older adults motivated to take their medications [15,16]. These studies do not discuss how actually people manage their medication to cope with the adverse effects that might emerge due the latent circumstances of patients' settings. Some of these studies focus on assessing ambient computing technologies to demonstrate their potential for improving older adults' medication adherence [12,15,16]. The main aim of this paper is to report how the qualitative evidence collected through two formative evaluations of our Medication Ambient Display (MAD), enabled us to outline a set of design implications for developing ambient computing technologies that cope with medication safety challenges faced by low-income older adults in Mexico.

The following section describes the MAD design, deployment and evaluation. Next we describe the study design and findings obtained from 11 older adults-caregivers dyads that used the MAD. Finally, we discuss new MAD design implications and the study limitations; and conclude by presenting the future directions for our project.

2. Medication Ambient Display (MAD)

An Ambient Display is characterized by presenting relevant information in an unobtrusive way, unless it requires user's attention; additionally, it should enable users to easily monitor the display to obtain the desirable information [17,18]. To this end, ambient displays use abstract modalities to represent information, such as pictures, sounds and movement.

To develop the Medication Ambient Display (MAD) presented in Figures 1 and 2, we followed an iterative methodology based on user-centered design [19,20]. It is based on the premise that system usability is evaluated throughout its development life cycle [21]. The study reported in this paper is part of a broader project, which included several evaluations conducted to incrementally validate the design and functionality. Thus, previously we have conducted ethnographic studies and heuristic evaluations to inform the design of MAD. MAD's design rationale and further technical details are presented in [19] and [20]. This section explains the functionality of MAD to be deployed in the older adults' homes.

2.1. Ambient Modalities

MAD uses the following ambient modalities to aid the medication of older adults:

- ***Abstract representations of the daily medication taking***: The MAD implementation shows a virtual bird, which has the aim of raising elders' consciousness about how they have to take the responsibility for caring for their own health, in a similar way that they gladly take care of their pets. As presented in Figure 1a,b, the abstract representation is an animated parakeet that symbolizes the daily medication adherence. Each day a new pet hatches to represent the medication adherence. Additionally, by touching any point of the virtual parakeet, the MAD presents detailed information of the daily medication adherence by using the notation presented in Figure 1d. For instance, in Figure 1c, MAD shows the 4 medicines that a senior needs to take 3 times a day: during morning, afternoon and night. Additionally, it presents that a morning medicine (e.g., Losartan) was not taken; and that the afternoon and night doses are still pending.
- ***Auditory and pictograms-based notifications to remind taking medications*:** The auditory notifications (i.e., a parakeet whistle) call the older adults attention when they have to take

medications; while the pictograms-based notifications present critical information to follow the medication regimen as described in Figure 2a).

2.2. MAD Deployment

To assess its effect, we implemented a MAD for Android tablets to be placed as a portrait frames in the older adult's home. In order to track the medication adherence, we attached Near Field Communication (NFC) tags to the containers (e.g., box) of each of the prescribed medicines. So, older adults were asked to move pills containers closer to the tablet after taking them (see Figure 2b). Afterwards, the parakeet acknowledged that the medication was taken and registered, as illustrated in Figure 2c. We also implemented an administration application (Figure 3), which we used to tailor MAD to participants' medication prescription and the timetables that they reported to follow. Since evaluating the ease for adapting and configuring MAD was out of the scope of this study, participants did not used MAD administrator. So, we tailored MAD which included: entering the medications name and health problem to address (Figure 3a), selecting the images that best represent the pills and their container (Figure 3b), attaching and configuring NFC tags to each of the pills containers, and the timetables and frequency that they should be taking (Figure 3c).

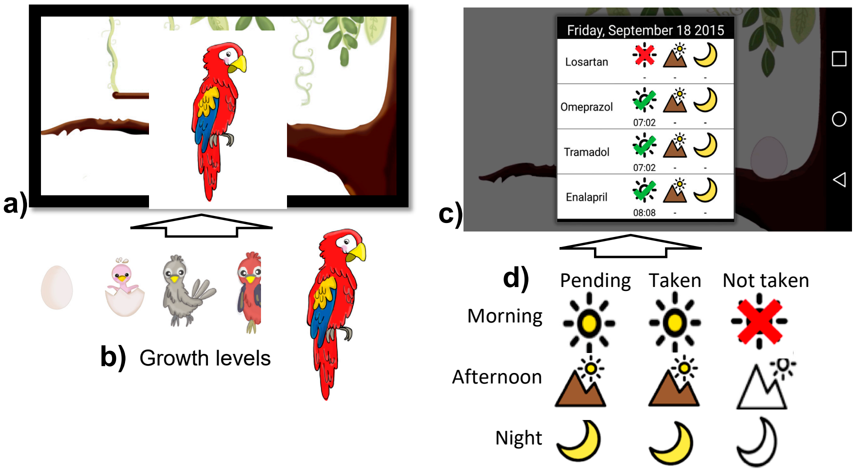

Figure 1. Medication adherence representations: (**a**) Abstract representation based on the parakeet growth; (**b**) Growth levels that a parakeet may reach during the day; (**c**) Detailed information about the medication adherence corresponding to the current day; elder or caregiver may choose a different date to consult; and (**d**) notation used to represent when medicines were taken on time, missed to take, or are pending to take diagram of the participants' progress through the stages of each field evaluation.

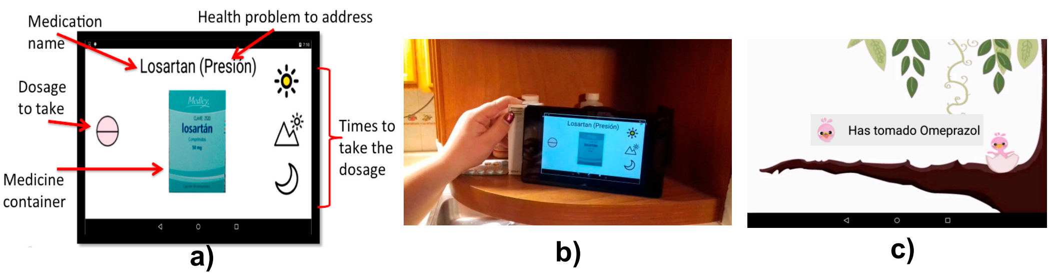

Figure 2. MAD reminding to medicate: (**a**) Pictogram-based reminder; (**b**) When each visual reminder is presented, senior should medicate and then move the corresponding medication container closer to the tablet in order for the NFC attached to it to be recognized by the tablet NFC reader; (**c**) MAD acknowledging that the medicine was registered as taken on time.

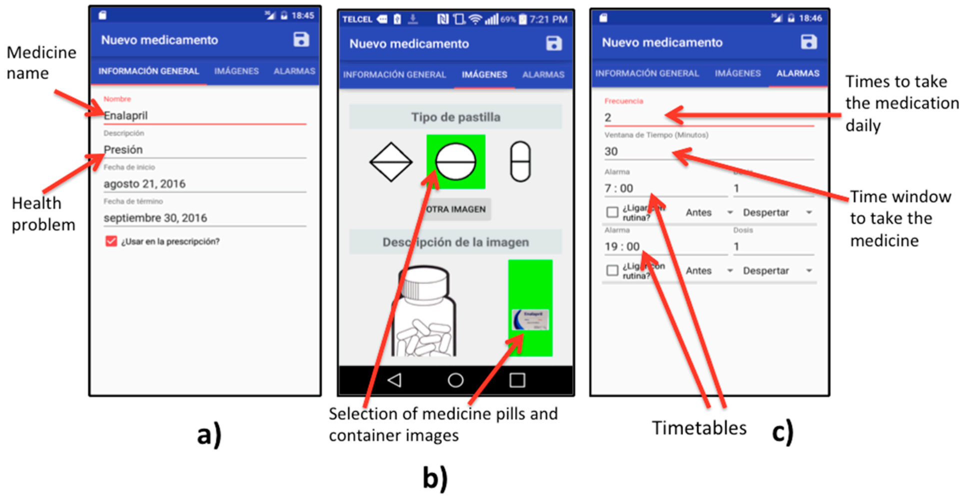

Figure 3. User interface of the administration component, which shows how it enable us to register information of each medication, such as: (**a**) pills to take; (**b**) images representing the pills and its containers; and (**c**) the timetables to take each medication and its daily frequency.

3. Methods

3.1. Study Aim

The study presented in this paper had the aim to address two particular research questions:

Q1: What is the effect of using MAD on older adults and their family caregivers?
Q2: What factors are influencing the adoption of MAD by older adults?

To understand the scope of this study, we situated it within the usability specification and evaluation framework for health information technology reported by Yen and Bakken [21]. According to it, the interaction of the four usability components (i.e., user, task, system and environment) can be incrementally evaluated during the five stages of the system development life cycle (SDLC): (1) lab or field studies to specify needs for setting and users (i.e., task-user interaction); (2) lab evaluations of system performance (i.e., system-task interaction); (3) lab evaluations of interaction performance (i.e., system-user-task), in which usability aspects are assessed such as learnability and satisfaction; (4) field evaluations of an integrating system into a setting to assess quality aspects related to system effectiveness, efficiency and user satisfaction (i.e., system-user-task-environment); and (5) field evaluations to understand the impact of health IT beyond the short-term measures of system-user-task-environment interaction, such as patient outcomes, guideline adherence, and cost-effectiveness.

As illustrated in Figure 4, our study included two field evaluations corresponding to stage 4 of the SDLC, since both of them were designed to obtain an understanding of how the medication ambient display might change participants' behavior in a real setting, and how the setting might influence its adoption.

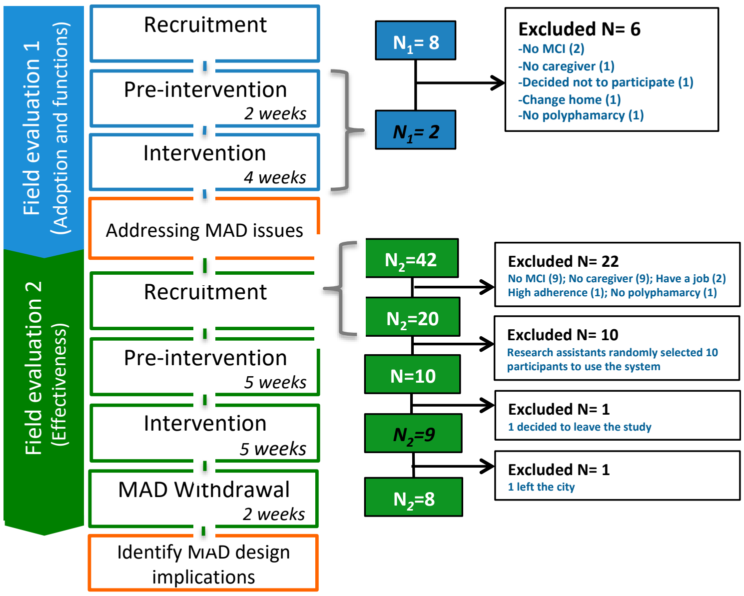

Figure 4. Flow diagram of MAD assessment: the right side represents the participants' (N) progress through the stages of each field evaluation depicted in the left side.

3.2. Study Flow

3.2.1. Field Evaluation 1

The first field evaluation was conducted during 6 weeks. To recruit participants, we used social web sites. Eight ($N_1 = 8$) older adults' caregivers contacted us, from which 2 were eligible. The aim of this evaluation was to assess the adoption of MAD, in addition to test its main functions. To reach this end, participants reported information regarding technical and usability problems, which we addressed as they were reported [19].

3.2.2. Field Evaluation 2

The second field evaluation was designed as an observational study to collect data to measure specific outcomes associated with the effect of using MAD in the older adults' medication adherence. It lasted 12 weeks. Thus, in addition to the techniques used to conduct the context inquiry, we used the pill count technique to measure the changes in older adults' medication adherence throughout the evaluation stages.

3.2.3. Field Evaluations' Stages

Each of the field evaluations included the following stages, which were approved by the Ethics Review Board of the Nursing School:

- *Recruitment*. To be eligible to participate, older adults had to be over 60 years old, live at their homes, present poly-pharmacy, i.e., taking at least three prescribed medications, have mild cognitive impairment (MCI), report medications forgetting events, and have a relative that assists them in following the medication routine, such as reminding to medicate or serving medications. We assessed the eligibility criteria through interviews and by administered validated clinical instruments, which are described in Table 1. Enrolled older adults signed an informed consent form and received roughly $14.00 USD as a weekly economical incentive. To contact potential participants, we used different strategies for each of the evaluations.
- *Pre-intervention* (*baseline*). To characterize participants, we conducted a contextual inquiry consisting of semi-structured interviews and observation. We collected data in three major aspects: problems faced in medicating adequately, help received by their relatives, and feelings of the family caregivers.

- *Intervention (use of the technology*). We visited each of the older adults to introduce MAD in the presence of their caregivers. For this training, we used the "spaced retrieval" approach that consists on the following activities sequence: teach, ask, wait, ask again, wait, ask again [19]. After the training session, which lasted 40 min. approximately, MAD was personalized according to older adults' prescriptions, and the timetables that they used to medicate. MAD was placed in the home's room where they usually medicate, mostly it was in the kitchen and living room. Similar to the pre-intervention stage, we conducted the contextual inquiry and centered it to find out if MAD produced changes in older adults' medication behavior, and caregivers activities and feelings.

The above-mentioned activities enabled us to identify opportunities for the MAD refinement, such as addressing technical and usability issues, not altering the concept design of MAD described previously; and finally, to identify new design implications reported in the Discussion section.

3.3. Data Analysis

To generate the study dataset, we transcribed the collected audio data from their original Spanish, and incorporated the handwritten notes and photographs taken during the interviews into the transcripts. Individual quotes were translated into English for use in this article. For the qualitative analysis, we followed the thematic analysis approach [22], which consists in generating initial codes from the data, searching for potential themes, contrasting the identified themes with the data, and iteratively refining the themes.

For the quantitative analysis, we estimated the medication adherence, which refers to the doses taken, in relation with what was prescribed. We calculated it as a percentage by summing all pills taken by each participant during a period of time, and dividing it by the sum of the total of pills prescribed for the same period of time. We used One-Way ANOVA with repeated measures and Tukey's HSD test to find significant differences in medication adherence between the evaluation stages.

3.4. Organizational Setting

The study was conducted in Mexicali, Mexico. All participants were primarily low-income and affiliated with the Mexican Institute of Social Security (IMSS), the largest medical institution in Mexico. Periodically, monthly or bi-monthly, they attended an IMSS clinic for a follow-up consultation and for receiving an updated prescription to get their medications from the clinic's pharmacy. Ten students from the Nursing School or our University participated as research assistants. They were enrolled in a social service program, which aims at providing older adults living in one of the municipality's oldest neighborhoods, with occupational therapy. The research assistants collected data through the pill count technique from the participants during all the stages of the second field evaluation; while the first, second and third authors of this paper collected the qualitative data through interviews.

4. Findings

As depicted in Figure 4, two ($N_1 = 2$) older adults used MAD in evaluation 1 and nine ($N_2 = 9$) during evaluation 2. Table 1 presents the characteristics of the 11 older adults participants (9 female and 2 male). Participants age range varied from 60 to 85 years (M = 69.64; SD = 6.71). We categorized our findings in themes that explain the positive effects of MAD on the older adults' medication behavior and their family caregiver involvement, and the challenges for incorporating MAD on their medication routines.

4.1. Possitive Effects of MAD

- **Reducing instances of forgetting**. MAD not only helped older adults remember medicating, but also to recall if medications had been taken. For instance, P1's wife reported that some risky behaviors diminished, e.g., she stated: "*one morning [before using MAD] I found two pills on the bed* *that he took out from the container and apparently forgot to take them, but now [while using MAD], he is more attentive to taking his pills*." Additionally, MAD helped caregivers ensure that older adults did not forget to take medication; e.g., P9 said: "*my children used to forget to remind me to take medications. Now, they hear the parakeet, and then check if I am taking them ...*". By calculating the weekly medication adherence of the 9 participants of the second field evaluation, and then the average of these weekly estimations for each evaluation stage, we found that it increased from M = 83.61% (SD = 15) in the pre-intervention to M = 95.97% (SD = 6.08) in the intervention. Nonetheless, with the withdrawal of MAD, it decreased to M = 76.71% (SD = 16.33). By using One-Way ANOVA with repeated measures, we compared the effect of MAD on the group of participants during the three phases. It showed a significant statistical difference between at least two of the phases ($F[2, 14] = 6.59$, $p = 0.0096$). With a post-hoc analysis using Tukey's HSD, we identified that there exists a statistical difference between the pre-intervention and intervention phases ($p = 0.02$), and between the intervention and post-intervention phases ($p = 0.0016$); and Cohen's effect size values (d = 1.35 and d = 1.72, respectively) suggest a high practical significance in both cases. This positive effect on the participants' behavior is also evident when estimating the cumulative medication adherence, as illustrated in Figure 5. It shows that the participants' medication adherence improved from 83.61% at the end of the pre-intervention phase, to 87.99% at the end of the intervention; and finally, it diminished during the post-intervention up to 85.82%. We asked older adults to explain their perception of their medication behavior during the post-intervention phase. Seven (7) older adults felt that it had been negatively affected. For instance, the participant P6 stated: "*I take them at any time, or until I remember to … Before [during the intervention], when the parakeet sang, then I came [to the kitchen] to take them, and noticed the missed pills*". On the other hand, two participants (P5 and P10) perceived that their medication adherence was not affected; however, their average medication adherence estimated for each phase, dropped from M = 89.10% during the intervention phase to M = 74.29% during the post-intervention for P5, and from M = 92.62% to M = 69.29% for P10.

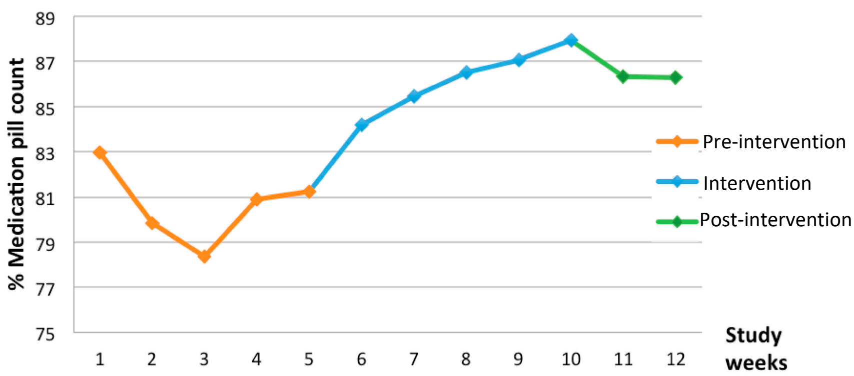

Figure 5. Cumulative pill-count adherence across the 12 weeks of evaluation 2.

Table 1. Characteristics of the older adults (N = 11) who used MAD.

Characteristics	N = 11
Age (years)	69.64 ± 6.71
Cognitive impairment	Mild (MCI) [a]
Formal education completed (years)	6.73 ± 2.87
Caregiver relationship	Spouse: 4 Child: 6 Grandchild: 1
Medication Adherence (Pill Counting)	81.04 ± 15.01 [b]
Reported Medication self-efficacy [c]	4 reported low adherence 7 reported mild adherence

Cognitive impairment: [a] It was assessed with MMSE [23] in field evaluation 1; and with SPMSQ [24] in field evaluation 2 since it is more appropriate to be administered to low-literacy persons. Medication adherence: [b] Calculated through the pill count technique based on the 9 older adults who used MAD during field evaluation 2. [c] We used self-reported instruments for recruiting participants with low-mild adherence medication. In field evaluation 1, we used SEAMS [25], and in evaluation 2 we used MAQ-8 [26], which is shorter and simpler than SEAMS [26].

- **Preventing symptom based-medication:** We found that for some older adults, symptoms acted as cues for realizing that they had forgotten to take their pills. For participant P1, who took medications for pain relief, the system helped him take them on time and prevent under-medication, which increased his physical pain, or overmedication, which highly worried his wife. Regarding this, he reported: "*… I used to skip the doctor instructions, now I obey the system and I feel more supported and responsible*". Similar benefits of using MAD were reported by P9: "*[before using MAD] I realized that I have forgotten to take the pills for controlling my blood pressure, until I felt dizzy*".
- **Better awareness within informal care network:** MAD enhanced the awareness within the informal care network of the care recipient's day-to-day medication intake. The system changed the patterns of caregiving, which were influenced by the particular family context. For instance, P1 lived with her husband and an adolescent grandchild. However, P1's daughter was the relative concerned for her medication adherence, who did not live in the same home but used to visit P1 every day to prepare lunch, while checking and advising her to remember medicating. During the intervention phase, P1's daughter reported consulting the system once a day, every day: "*If I don't check it in the morning, I check it in the afternoon. Now, I don't have to ask my mom about her medications*". A more relevant result was that the system made P1's adolescent grandchild get more involved in her medication routine. During the first week, he got familiarized with the system functionality. During the following weeks of the study, the afternoon auditory notification made him aware about helping her apply the glaucoma eye-drops, which was an issue that worried P1's daughter. Different circumstances influenced the system's adoption by P9, who lives with her grandchildren. P9 reported: "*Before [using the system] I used to forget to take medications, and my children forgot to remind me. Now, when they hear the parakeet whistle, they ask me: 'Mom, have you taken your pills?'*". Similarly, P8's husband commented: "*When my wife is in the backyard, and the parakeet sings, then I call her, prepare the medications and approach the tablet to register them*".

4.2. Challenges for Adopting MAD

- **Accumulation of medications:** Four (4) participants reported that physicians authorize medications refilling on each visit, causing them to accumulate medications. For example, one of the participants had an inappropriate control of her medications since she stored and ordered her medications as illustrated in Figure 6a; she was initially reluctant to use the system since she had to adopt a new way to manage her medication, which included to take pills from the containers with the attached NFC.
- **Similar medication containers and pills:** Participant P3 was illiterate and used to identify medications through the physical appearance of their containers, and pills' shape and color (see Figure 6b,c). However, she reported that some containers of different medications look alike, and that containers design may change, which incremented her dependency on her husband for recognizing medications.
- **Complex medication routines:** Additionally, participant P3 had a complex medication routine since she took several (6) medications on different timetables, and decided not to combine any of them. Therefore, she felt that receiving many reminders daily was overwhelming, causing her to decline to use the system at the beginning of the intervention stage as depicted in Figure 4.

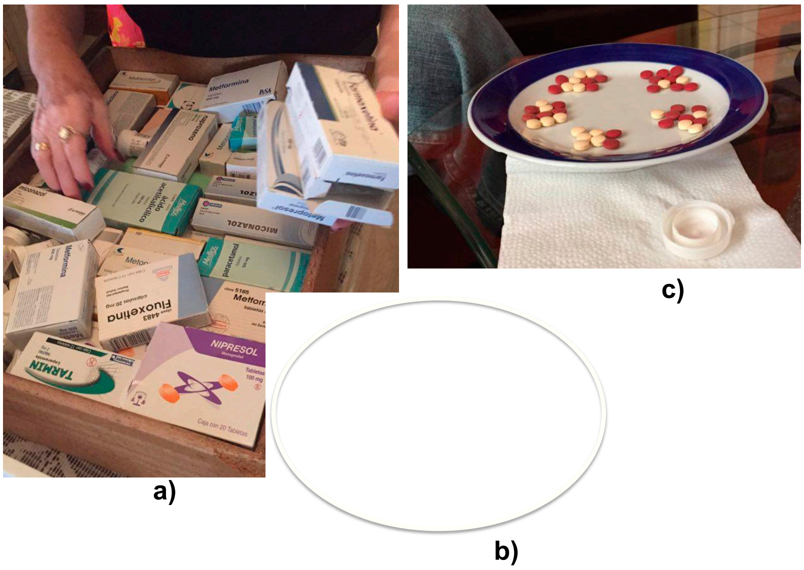

Figure 6. Unsafe medication management due to: (**a**) older adults accumulating medications; (**b**) medication containers have similar appearance and (**c**) illiterate older adults identify pills by their shape and color.

5. Discussion

Based on the study results, we identified new design implications in order for ambient technology to fit into Mexican older adults' settings to provide more robust adherence support. Afterwards, we will discuss some limitations of our study and results.

5.1. Design Implications

- **Ambient stylized representations encourage relatives to assist older adults:** Receiving direct family assistance is the main approach to ensuring that older adults with cognitive decline follow their prescribed medications regimens [27]. On the other side, a related line of research shows that caregivers are slow to assume responsibility for administering patients' medications and often wait until safety issues are apparent [27]. We found that MAD enhanced the awareness within the family care network of the older adults' medication intake, which made caregiving patterns change, such as motivating relatives to provide older adults with direct assistance. We attributed this effect to the fact that MAD was designed: (i) to be integrated into the home as an ornament, which attracted the attention of relatives; and (ii) to reveal the older adults' medication behavior through stylized and dynamic representations. However, MAD did not enable both older adults and relatives, to be aware about the effect of the medication management strategies adopted to cope with specific contextual conditions, such as being illiterate or accumulating medications. Consequently, further design features should be incorporated into MAD. To this end, the following are our recommendations to develop ambient technologies that cope with risky medication-related behaviors of older adults.
- **Persuading strategies for supporting the rational use of medications:** Technologies may perform a retrospective assessment of the number of doses dispensed over the dispensing period (i.e., medication possession ratio) [28], and used it to persuade older adults about making appropriate utilization and management of medication. For instance, the gamification [29] approach could be implemented to incentive older adults when they have an appropriate control of their medications; or by explicitly informing older adults and family caregivers about the quantity of medications they possess which may help them discuss with their physicians the pertinence of prescriptions refill.
- **Intelligent recognition of medications:** To enable older adults to identify medication containers with similar appearance, medications technologies may incorporate algorithms to recognize objects. Belongie et al., 2014 [30], proposes the shape matching algorithm to identify

correspondence between shapes; however, its computational efficiency may be high since it requires an images database for the algorithm training stage. A more appropriate algorithm to be executed in Tablets PC may be the proposed by Jiang et al., 2014 [31], to recognize the characters of medications' labels. It uses methods such as contour tracking, projection and back-propagation neural networks for character recognition.

- **Knowledge based-systems to adjust the medication regimens to older adults' daily routine:** To cope with the lack of appropriate and regular professional assessment for planning how to follow medication regimens [32], we propose that intelligent agents assist older adults at home to adjust their medication routine to fit into their lifestyles. Agents may propose a medication schedule based on their daily activities; suggest how to pair daily routines with the prescribed medication regimen since routines may act as additional cues for remembering medicating [2,11,32] and finally, recognize potential drugs interactions to assess if they could be combined. To provide this personal assistance, agents need a knowledge base to make inferences and decisions about a medication regimen. In this sense, ontologies can be used to enable agents to accomplish a semantic reasoning about a particular domain. Ontologies have been used for empowering computing systems with ambient intelligence to personalize non-pharmacological interventions for patients with dementia [33]. The advantage of using ontologies is that domain knowledge can be reused; thus, system designers may take advantage of medical ontologies that describe diseases [33], and drug-drug interactions [34].

5.2. Study Limitations

The sample size included in this study was small, so the quantitative assessment does not enable us to provide conclusive results of MAD effectiveness. However, we argue that our study provides evidence of the feasibility of MAD for supporting the medication adherence of older adults. The qualitative assessment added rich description to help determine the factors that influenced the adoption of MAD by both, older adults and caregivers; in addition to new design implications for supporting the adaptation of ambient technologies to cope with some of the complexities of the setting. On the other hand, we are not able to state that our results are generalizable to the whole Mexican senior population. This is due to the fact that participants were primarily from a low-income socioeconomic stratum; therefore, exploring this technology among higher income elders who have access to private health-care services, might produce different findings. Furthermore, although recruitment of older adults yielded a high level of participation in this study, most of the elders contacted during the recruitment were women, i.e., 9 out of the 11 were female participants.

6. Conclusions

We presented evidence of the potential of our approach to improve participants' medication adherence. Including, how our ambient medication display helped improve and encourage the involvement of older adults' relatives in assisting them. However, we observed that older adults have risky medication-related behaviors as a consequence of the challenges imposed by the national public health system due the lack of adequate pharmaceutical policies for the rational use of medicines and follow-up of patients' medication regimens. Some of the risky medication-related behaviors that participants presented were: accumulating medications, confusing medications that look alike, tending to give unused medications to others, and following inappropriate timetables for taking their medications which contributes to the medication complexity. The qualitative findings enabled us to outline design implications to be used as hints for developing ambient computing technology to reduce drug adverse events associated with these risky behaviors. We plan to extend MAD with the intelligent capabilities that we envisioned, such as agents, and then assess their effectiveness for coping with risky medication-related behaviors of older adults.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Murray, M.A.; Morrow, D.G.; Winer, M.; Clark, D.O.; Tu, W.; Deer, M.M.; Brater, D.C.; Weinberger, M. Conceptual framework to study medication adherence in older adults. *Am. J. Geriatr. Pharmacother.* **2004**, *2*, 36–43.
2. Insel, K.; Einstein, G.O.; Morrow, D.G.; Hepworth, J.T. A multifaceted prospective memory intervention to improve medication adherence: Design of a randomized control trial. *Contemp. Clin. Trials* **2013**, *34*, 45–52, doi:10.1016/j.cct.2012.09.005.
3. Chasteen, A.L.; Park, D.C.; Schwarz, N. Implementation intentions and facilitation of prospective memory. *Psychol. Sci.* **2001**, *12*, 457–461, doi:10.1111/1467-9280.00385.
4. Kang, H.S.; Myung, W.; Na, D.L.; Kim, S.Y.; Lee, J.H.; Han, S.H.; Choi, S.H.; Kim, S.; Kim, S.; Kim, D.K. Factors associated with caregiver burden in patients with Alzheimer's disease. *Psychiatry Investig.* **2014**, *11*, 152–159, doi:10.4306/pi.2014.11.2.152.
5. Vira, T.; Colquhoun, M.; Etchells, E. Reconcilable differences: Correcting medication errors at hospital admission and discharge. *Qual. Saf. Health Care* **2006**, *15*, 122–126, doi:10.1136/qshc.2005.015347.
6. Wimmer, B.C.; Bell, J.S.; Fastbom, J.; Wiese, M.D.; Johnell, K. Medication regimen complexity and number of medications as factors associated with unplanned hospitalizations in older people: A population-based cohort study. *J. Gerontol. A Biol. Sci. Med. Sci.* **2016**, *71*, 831–837, doi:10.1093/Gerona/glv219.
7. Doubova, S.V.; Reyes-Morales, H.; Torres-Arreola, L.P.; Suarez-Ortega, M. Potential drug-drug and drug-disease interactions in prescriptions for ambulatory patients over 50 years of age in family medicine clinics in Mexico City. *BMC Health Serv. Res.* **2007**, doi:10.1186/1472-6963-7-147.
8. Mahmood, A.; Elnour, A.A.; Ali, A.A.; Hassan, N.A.; Shehab, A.; Bhagavathula, A.S. Evaluation of rational use of medicines (RUM) in four government hospitals in UAE. *Saudi Pharm J.* **2015**, *24*, 189–196, doi:10.1016/j.jsps.2015.03.003.
9. Arriola-Peñalosa, M.A. The role of health regulations in the rational use of medicines. *Gac. Med Mex.* **2015**, *151*, 640–647. (In Spanish)
10. WHO Policy Perspectives on Medicines-Promoting Rational Use of Medicines: Core Components. World Health Organization. September 2002, Geneva. Available online: http://www.who.int/medicines/publications/policyperspectives/en/ (accessed on 30 May 2016).
11. Stawarz. K.; Cox, A.L.; Blandford, A. Don't forget your pill! designing effective medication reminder apps that support users' daily routines. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (2014), Toronto, ON, Canada, 26 April–1 May 2014; pp. 2269–2278.
12. Hayes, T.L.; Cobbinah, K.; Dishongh, T.; Kaye, J.A.; Kimel, J.; Labhard, M.; Leen, T.; Lundell, J.; Ozertem, U.; Pavel, M.; et al. A study of medication-taking and unobtrusive, intelligent reminding. *Telemed. J. E Health* **2009**, *15*, 770–776, doi:10.1089/tmj.2009.0033.
13. Reeder, B.; Demiris, G.; Marek, K.D. Older adults' satisfaction with a medication dispensing device in home care. *Inform. Health Soc. Care* **2013**, *38*, 211–222, doi:10.3109/17538157.2012741084.
14. Vitality. (n.d.). GlowCaps. Available online: http://www.glowcaps.com/ (accessed on 30 May 2016).
15. De Oliveira, R.; Cherubini, M.; Oliver, N. MoviPill: Improving medication compliance for elders using a mobile persuasive social game. In Proceedings of the ACM International Conference on Ubiquitous Computing (2010), Copenhagen, Denmark, 26–29 September 2010; pp. 2259–226.
16. Lee, M.; Dey, A. Real-time feedback for improving medication taking. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (2014), Toronto, ON, Canada, 26 April–1 May 2014; pp. 2259–2268.
17. Pousman, Z.; Stasko, J. A taxonomy of ambient information systems: Four patterns of design. In Proceedings of the ACM working Conference on Advanced Visual Interfaces (2006), Venezia, Italy, 23–26 May; pp. 67–74.

18. Mankoff, J.; Dey, A.K.; Hsieh, G.; Kientz, J.; Lederer, S.; Ames, M. Heuristic evaluation of ambient displays. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (2003), Fort Lauderdale, FL, USA, 5–10 April 2003; pp. 169–176.
19. Zárate-Bravo, E.; García-Vázquez, J.P.; Rodríguez, M.D. An ambient medication display to heighten the peace of mind of family caregivers of older adults: A study of feasibility. In Proceedings of the Pervasive Computing Paradigms for Mental Health (MindCare 2015), Milan, Italy, 24–25 September 2015; pp. 274–283.
20. García-Vazquez, J.P.; Rodríguez, M.D.; Andrade, A.G.; Bravo, J. Supporting the strategies to improve elders' medication compliance by providing ambient aids. *Pers. Ubiquitous Comput.* **2011**, *15*, 389–397, doi:10.1007/s00779-010-0362-0.
21. Yen, P.Y.; Bakken, S. Review of health information technology usability study methodologies. *J. Am. Med. Inform. Assoc.* **2012**, *19*, 413–422, doi:10.1136/amiajnl-2010-000020.
22. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101, doi:10.1191/1478088706qp063oa.
23. Folstein, M.F.; Robins, L.N.; Helzer, J.E. The mini-mental state examination. *Arch. Gen. Psychiatry* **1983**, *40*, 812–812, doi:10.1001/archpsyc.1983.01790060110016.
24. De la Iglesia, J.M.; Dueñas, R.; Onis, M.C.; Aguado, C.; Albert, C.; Luque, R. Adaptación y validación al castellano del cuestionario de Pfeiffer (SPMSQ) para detectar la existencia de deterioro cognitivo en personas mayores de 65 años. *Med. Clin.* **2001**, *117*, 129–134.
25. Risser, J.; Jacobson, T.A.; Kripalani, S. Development and psychometric evaluation of the self-efficacy for appropriate medication use scale (SEAMS) in low- literacy patients with chronic disease. *J. Nurs. Meas.* **2007**, *15*, 203–219.
26. Morisky, D.E.; Green, L.W.; Levine, D.M. Concurrent and predictive validity of a self-reported measure of medication adherence. *Med. Care* **1986**, *24*, 67–74.
27. Kaasalainen, S.; Dolovich, L.; Papaioannou, A.; Holbrook, A.; Lau, E.; Ploeg, J.; Levine, M.; Cosby, J.; Emily, A. The process of medication management for older adults with dementia. J. Nurs. Healthc. Chronic Illn. 2011, 3, 407–418, doi:10.1111/j.1752-9824.2011.011114.x.
28. Steiner, J.F.; Prochazka, A.V. The assessment of refill compliance using pharmacy records. Methods, validity and applications. *J. Clin. Epidemiol.* **1997**, *50*, 105–116.
29. Deterding, S.; Dixon, D.; Khaled, R.; Nacke, L. From game design elements to gamefulness: Defining gamification. In Proceedings of the 15th International Academic MindTrek Conference: Envisioning future Media Environments 2011, Tampere, Finland, 28–30 September; pp. 9–15.
30. Belongie, S.; Malik, J.; Puzicha, J. Shape matching and object recognition using shape contexts. *IEEE Trans. Pattern Anal. Mach. Intell.* **2001**, *24*, 509–522, doi:10.1109/34.993558.
31. Jiang, Y.; Jin, C.; Gao, H. Study of highly efficient algorithms for the character recognition system of medicine bottle label. *J. Softw.* **2014**, *9*, 991–998, doi:10.4304/jsw.9.4.991-998.
32. Cramer, J.A. Optimizing long-term medication compliance. *Neurology* **1995**, *45*, S25–S28.
33. Navarro, R.; Rodríguez, M.D.; Favela, J. Intervention tailoring in augmented cognition systems for elders with dementia. *IEEE J. Biomed. Health Inform.* **2014**, *18*, 361–367, doi:10.1109/JBHI.2013.2267542.
34. Doulaverakis, C.; Nikolaidis, G.; Kleontas, A.; Kompatsiaris, I. GalenOWL: Ontology-based drug recommendations discovery. *J. Biomed. Semant.* **2012**, *3*, 1–9, doi:10.1186/2041-1480-3-14.