Interfaces of Medication Reminder Applications: An Analysis Aimed at the Elder Age

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Abstract. Despite how technologies are, nowadays, becoming integrated to several branches of society, there are still many groups with trouble to follow these technological advancements. Among them, the group that most likely suffers from this difficulty are the elders. An area strongly benefited by technology is health, currently counting with multiple mobile applications for smartphones, designed to upkeep the users' health. In this context, the current paper proposes an analysis of interfaces from medication reminder apps focused on the elderly. The following techniques were implemented: An Usability Test through Exploration (UTE) to evaluate easiness in learning by exploration, the System Usability Scale (SUS) method to ascertain the usability level of said applications and the Heuristic Evaluation of their Interfaces. With those techniques, it was possible to build a solid benchmark to evaluate the level of elder-friendliness of an app in the given context. Results from the case study have shown that the apps lack a design focused on the elder public, which might have led to troubles during the tests performed with volunteers. The expert-based results have also found general interface issues on these apps that may need to be improved.

Keywords: Technology · Elderly · Interface analysis · Applications

1 Introduction

In Brazil, as stated by the Brazilian Institute for Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*, IBGE), the number of people over 60 years old has surpassed the milestone of 30.2 million in 2017, presenting a 18% growth in the group over the last five years [1], which means that, in a growing motion, this group contains more than 14% of the country's total population.

A distressing characteristic related to the advanced age is the considerable loss in cognitive skills, specially those related to memory [3]. On top of this populational ageing, and all that comes with it, the number of people with

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chronic diseases is also increasing and, therefore, the consumption of drugs and the use polypharmacotherapy among said people [2].

Associated with the consumption of drugs, there is a problem that has become a matter of concern. According to reports by the World Health Organization (WHO), it's estimated that around half the patients with chronic diseases don't actually take their medication as prescribed [4].

In this context, the adoption of technology may be an alternative solution to the correct usage of medication and also a useful tool for health professionals to follow their patients along their treatment. In contrast to that, barriers of cognitive, motion and, in some cases, financial origins may be limiting factors to the access of new technology by the elderly [5].

Facing what has been exposed, and considering the special needs of the elderly, as well as the increase in smartphone usage by them, the current paper aims to perform a mapping of market solutions for mobile apps, regarding medication reminders. By using the SUS method, UTE and Nielsen's heuristics, evaluations were performed in terms of interface usability and easiness of learning from the users.

The remainder of this paper is organized as follows: In Sect. 2, we discuss weaknesses found in related works on the field as some justification for the proposed methodology; In Sect. 3, we present the apps evaluated in this paper and the techniques used on said evaluations; Followed by Sect. 4, which describes, in detail, the actual procedure of evaluation; Afterwards, in Sect. 5, we present the results obtained through the process and how they are interpreted; Finally, in Sect. 6, we give our final thoughts on the matter approached, on the methods applied and on the results obtained.

2 Related Works

By researching the state-of-art, some deficiencies were verified along related works dealing with evaluation of medication reminder apps regarding the elderly. Among those deficiencies, the most proeminent were the small number of apps evaluated per work and the lack of details on some of the methods used and results found.

To give context, there were chosen three papers related to the approached theme, that were used as basis to develop the methodology of this article.

The first paper, entitled *Medication Management Apps: Usable by Older Adults?* [6], performed its analysis solely on the *Medisafe* app, with two usability experts applying Nielsen's heuristics. Results obtained show that the app present a couple of usability problems related to layout and interface design, as well as difficulties found by the experts in relation to certain features of the app, like the *Medfriend* feature, that allows the register of trusted contacts to aid the users in their treatments.

The second work, entitled *Acceptance Factors of Mobile Apps for Diabetes by Patients Aged 50 or Older: A Qualitative Study* [7], is a study focused on the acceptance of elder people in relation to the usage of mobile apps for aiding

in diabetes control. The evaluation had 32 participants with an average age of 68.8 years. In total, two apps were evaluated, *OnTrack Diabetes version 2.8.8* and *Glucose Monitor Version 2.7*. Difficulty on interacting with the applications was among one of the main reports of the evaluation group, which resulting in resistance by them on using solution proposed by the researchers, as well as complaints about the lack of additional benefits and resources on the presented apps.

The third article, with the title *Design and Evaluation of a Medication Adherence Application with Communication for Seniors in Independent Living Communities* [8], proposes the development of a tablet-based app focused on the elderly with the purpose of reminding them of medications that must be consumed. In addition to that, a web platform was also developed, with the purpose of helping caretakers and guardians in keeping up with the ingestion of medication by the elders. During the tests with the app, sixteen participants were recruited with an average age of 66 years. During three months, those participants used tablets provided by the developers with the app installed on them. In this period, users were instructed to answer all medication reminders and report changes in medication. Resulting from this work's feedback, a series of recommendations were defined that can be used when developing apps focused on the elderly.

3 Materials and Methods

Apps that promise to help in the control of medication are pretty common, with many available solutions in Apps Stores. Among the better reviewed, there are apps who stand out with functionalities such as stock control, posology and reminder notifications. However, as it is common in commercial products, its development is not design for a niche, meaning that it doesn't seek to attend to the needs of a specific group, but instead to reach the largest number possible of people.

In that case, to select the scope of evaluated apps, it was considered only those developed for smartphones with Android as their running operational system, available to download at the Google Play service, from which only three were selected. These three apps, *Medisafe*, *My Therapy* and *Cuco Health* were chosen according to their number of downloads and number of positive reviews by users.

The *Medisafe* app has, until the writing of this paper, more than 1 million downloads and over 167 thousand reviews. It allows its users to add medication, receive reminders and learn how to correctly use this resource. According to the developers, their goal is to offer tools and support so that users may correctly take their medication.

MyTherapy, until now downloaded by more than 500 thousand users, having over 13 thousand reviews, has the unique feature of Drug Stock Control, where users may register their medications in use.

Cuco Health, a Brazilian app that counts with more than 50 thousand downloads and over 3.2 thousand reviews. It offers the feature of Health History, which logs all data of previous treatments done with the app, besides also allowing the

creation of a team of "caretakers", with messages and tips about treatments and diseases.

Of all three apps evaluated, none possess in their description or in their advertising any explicit usability features aimed at the elder public. All three propose mildly similar solutions for medication reminding, however they show no engagement in attending a specific demographic.

3.1 Selecting the Evaluation Techniques

In order to evaluate usability, three techniques were used. The first was the SUS method, proposed in *SUS - A quick and dirty usability scale* [9]. On this paper, the author states that, in many cases, when in need of evaluating the general usability of a system, it is desirable to have measurements that aren't too complex or extense and also don't demand too much effort to apply, but also present a certain level of reliability. Thus, in his work, a simple system its proposed, containing ten items that offer a global view in subjective evaluations of usability based on a Likert scale [10], that is, using a scale built on that model, the evaluator may indicate his degree of agreement or disagreement to certain statements about the subject evaluated, with values ranging from 1 (strongly disagree) to 5 or 7 (strongly agree) (Fig. 1).

Fig. 1. An example of likert scale application

In order to calculate the SUS score of a system, the evaluator must use the following equation:

$$S = [\sum_{o=1}^{5}(Q_o - 1) + \sum_{e=1}^{5}(5 - Q_e)] \cdot 2.5 \quad (1)$$

Where S is the normalized SUS score obtained on a single evaluation, Q_o is the individual value of an odd answer and Q_e is the individual value of an even answer.

It's highly suggested to perform multiple evaluations for each systems, to obtain a more realistic average score, where:

$$S_{avg} = \sum_{i=1}^{k}(\frac{S_i}{k}) \quad (2)$$

Where S_{avg} is the average SUS score, S_i is the value of a single score and k is the total number of evaluations performed on that system. This average normalized score may range from 0 to 100 [9].

Through the use adjective ratings, based on statistical results, a survey score may be considered above average (over 50% of statistical results), if bigger than 70.5 and it may be considered good it if bigger than 71.4 [11].

According to Research Collective [12], there are a couple of advantages in using the SUS method, which are:

- It has a Cronbach's Alpha rating of 0.92. This coefficient is rated from 0 to 1 and measures the level of reliability in a research-oriented survey;
- It might be used for a plethora of different systems and products to aid and evaluate the users' experiences;
- It can be used even with small sample sizes;
- It's cost less and it's questions may be easily found on internet researches, being heavily mentioned and/or utilized by works focused on usability scale.

The core objectives of a system with good usability include, a raise in productivity, a shortage in training costs, reduction of user errors, a precision increase during use and interpretation of data and the decrease in technical support necessity. With that in mind, the second technique approached was the User Based UTE.

The goal of this evaluation was to analyse the easiness in learning through exploration in mobile apps and to observe which main difficulties the volunteers may face. This technique was implemented by following a set of four basic steps [14,15]:

1. **Preparation:** Where the tasks that will integrate the evaluation are defined;
2. **Gathering and Interpretation of Data:** Part where the execution of tasks is observed;
3. **Consolidation of Results:** Where the data produces conclusive information;
4. **Result Reporting:** When information is formally registered and submitted as feedback or guidelines.

The employment of this technique facilitates the identification of day-by-day issues faced by the average user. An user based evaluation is also more prone to produce unbiased results, as the lack of expertise offers a less subjective and more practical view of the system. And although sometimes it isn't possible to find willing volunteers to perform evaluations for free, this is a method without any cost of elaboration, requiring only the planning of which activities are going to be performed.

The third app evaluation technique was performed through the use of the ten Nielsen's heuristics. The heuristic evaluation is made by observing an interface and trying to obtain an opinion about what is good and bad on it [16]. Ideally, evaluations are conducted under certain rules, such as those listed in typical guideline documents. In this case, the heuristic evaluation follows the guidelines proposed below [17]:

- **Visibility of the system status:** the user is informed about system status, whether they are the current status or generated only after performing an action;
- **Compatibility of the system with the real world:** the system must be simple and use a vocabulary which is the closest possible from colloquial language;
- **Control and freedom for the user:** the system must provide ways so that the user may easily undo an action that he considers wrong;
- **Consistency and standardization:** the system must be consistent over the use of interface elements in a way that avoids causing confusion or influencing the user to commit mistakes, e.g., standardization of buttons, menus and etc;
- **Prevention of Errors:** the system must be designed in a way to minimize errors that users may commit;
- **Recognition instead of Memorization:** the system must be simple and intuitive, in a way that the user shouldn't need to remember steps to perform a task;
- **Providing shortcuts:** the system must provide ways that allow the user to have experience with the system in order to execute tasks more rapidly;
- **Minimalist design and aesthetics:** the system must be as simple as possible, avoid irrelevant functionalities and data;
- **Helping the user to recognize, diagnose and correct errors:** the system must provide clear error messages, that indicate to the user that something wrong has happened and also how to proceed to correct such errors;
- **Help and documentation:** the system must provide a help functionality for the user, be it in the form of system documentation or some sort of communication channel for questions and doubts.

To qualify the severity level of disagreement with the heuristics, a scale from 1 to 4 was used, on which:

1. It's not faced as a problem of usability.
2. Aesthetic problem, no need to be corrected, unless there is available time and resources.
3. Serious Problem, needs to be corrected and may cause problems on system usage.
4. Extremely Serious Problem, must be corrected at once, creates serious troubles in usage and might drive users to abandon the system.

The heuristics are largely consolidated when it comes to interface evaluation. It requires at least one professional familiarized with its guidelines and can be done with a small group of people. In a short window of time it's possible to obtain feedback about what works and what doesn't on an interface. The original guidelines proposed by Nielsen can easily be found online, facilitating the access. There are also variations on the heuristics focused to specific systems and products.

4 Performing the Evaluations

In order to proceed with the evaluations, thirteen elders from the city of João Pessoa, Brazil, were approached to join the research as *users* (also interchangeably referred as *volunteers* on the remainder of this paper). Their were all locals with ages ranging from 60 to 78 years old. Also, three of the authors also performed as *usability experts*.

The chosen research site was the Informatics Laboratory, at the Center of Exact and Nature Sciences of the Federal University of Paraíba (UFPB). While performing the tests, all volunteer evaluators used their own personal smartphones.

The participation of the selected *users* was part of a practical activity realized under the project of University Extension denominated "Basic Informatics for Elders", hosted at the UFPB in the period between March and December of the year 2018. Because of that, the evaluations that made use of results provided by volunteer evaluation followed the ethics guidelines present on the Official Submission Notice of the Institution's program of University Extension, called PROBEX/2018.

In a beforehand interview, several *users* reported to be using, at least, one type of medication, varying from two to ten pills a day and occasionally had difficulties reminding dosages of their medications. After being informed about the subject of the research, they presented themselves as interested, curious and surprised about the existence of applications focused on aiding with that kind of problem.

4.1 Usability Evaluation Through the SUS Method

The usability evaluations of the chosen apps (Medisafe, MyTherapy and CUCO Health) through the SUS method, were realized by all the thirteen selected *users*.

Each *volunteer* was guided in to the process of installing all three apps in their own devices. Prior to the beginning of the tests, they were deprived of any instructions on how to use the applications and were advised not to solve any questions they had during the whole process.

The *users* had the opportunity to choose one of their day-to-day therapy or to choose one fictitious therapy suggested by the researchers. After all of them had registered their selected medication prescription, they were instructed to answer a survey containing ten Likert-based questions in relation to the experience they had using the current app. This process was repeated with every *volunteer* for all the three apps evaluated.

The survey presented to the *users* contained the statements listed below. Odd-numbered statements take a positive view about the app while Even-numbered statements take a negative view:

1. I think I would like to use this app frequently;
2. I think it's unnecessarily complex;
3. I think it's easy to use;

4. I think I would need help from a person with technical knowledge to use it;
5. I think that many functions of the app are very well integrated;
6. I think that the app presents a lot of inconsistency;
7. I imagine that people will learn to use the app quickly;
8. I though the app was clumsy to use;
9. I felt confident while using the app;
10. I had to learn new things before I could use the app.

4.2 Easiness of Learning via Usability Testing Through Exploration

For the exploration usability text, three of the thirteen *users* were randomly selected. The objective of this evaluation was to determine the difficulty that users with zero to minimal background of mobile apps might face when learning how to navigate them.

Two tasks were selected as goals for the *users*. They had limited time to figure out the process on how to do them on each app. These tasks were:

– Finish the User Registration;
– Add a Medication Reminder.

Since these evaluators had the apps already installed on their smartphones and had a small knowledge on how to use them since they previously performed a SUS application, the test consisted on the usability experts following each *users*' walk-through during (x minutes) and observing the issues they faced to complete the proposed tasks.

4.3 Interface Evaluation Through Nielsen's Heuristics

The heuristic analysis of the apps' interfaces were performed by three usability experts, each evaluating all three apps. The application of Nielsen's heuristics occurred through expert-based usability walkthrough of pre-selected system features, from which the evaluators deemed which elements were out of usability standards.

The evaluated features on the apps were User Registration and Medication Adding/Insertion. In order to evaluate these, a worksheet was created, itemizing the Ten Heuristics. Screens on which no problems were found, according to the experts, received an "OK" pass and weren't included in the results described below.

After the expert usability test of the mentioned features, all three evaluations were confronted against each other, with the purpose of overlapping the issues found by each expert in order to obtain more fine results.

With these early results in hand, in order to apply the Heuristics, a fictitious *persona* was used, prescribed with a fictitious treatment, in order to create a standard for all evaluations to follow.

Persona: Maria Silva, 66 years old.

Maria has asthma and an early stage of pneumonia. In a checkup at her local Community Health Center (*Posto de Saúde da Família*, PSF), in the *bairro* where she lives, Mangabeira, in João Pessoa. Her doctor prescribed the following drugs and dosages:

– **Ventolin/Salbutamol:** One inhalation every six hours;
– **Amoxicillin:** One pill every twelve hours;
– **Budesonide:** One inhalation every eight hours.

5 Results and Discussions

The following results are presented and discussed separately for each method implemented in order to verify their degree of credibility and, afterwards, are crossed and combined in order to create a definitive diagnose for each evaluated app.

5.1 Results Given by SUS Method

Here, the obtained results from the evaluation of each app are represented. They are disposed in a table format, containing the individual grades from each *user* to each question, raw mean scores for each question (the mean of each raw score given to that question through all 13 evaluations), SUS score for each evaluation and, finally, the average SUS score (S_{avg}) for the app.

Table 1 contains data related to Medisafe app.

Table 1. Results from SUS evaluation on Medisafe.

User	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8	Q_9	Q_{10}	SUS score
1	3	4	5	2	4	3	2	1	5	3	65
2	5	1	5	1	5	1	5	1	5	1	100
3	3	1	5	1	5	1	5	1	5	1	95
4	5	2	4	2	4	2	5	5	2	5	60
5	5	1	5	1	5	1	5	1	5	1	100
6	5	1	5	1	5	1	5	1	5	1	100
7	4	2	4	1	2	2	3	1	3	2	70
8	2	2	5	1	4	1	4	1	5	1	85
9	5	5	5	5	5	1	4	4	5	5	60
10	5	1	1	5	5	5	5	5	5	5	50
11	5	1	5	1	5	1	5	1	5	1	100
12	5	1	5	1	5	1	5	1	5	1	100
13	5	1	5	1	5	1	5	1	5	1	100
Mean	4.38	1.77	4.54	1.77	4.54	1.62	4.46	1.85	4.62	2.15	83.46

According to the results shown above, the Medisafe app obtained very good raw mean scores on questions that evaluated easiness, functionality integration and confidence in use (questions 3, 5 and 9). Besides, on questions 2, 4 and 6, who deals with negative usability aspects, it obtained the lowest scores.

Table 2 contains data related to MyTherapy app.

Table 2. Table captions should be placed above the tables.

User	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8	Q_9	Q_{10}	SUS Score
1	5	4	5	3	3	1	4	2	5	1	77.5
2	5	5	5	4	5	1	5	1	3	1	77.5
3	5	2	2	3	2	2	5	4	5	2	65
4	2	3	5	2	2	5	5	5	5	1	57.5
5	5	5	5	5	5	5	5	5	5	5	50
6	5	5	5	5	5	5	5	5	5	5	50
7	4	2	5	2	3	2	4	5	4	2	67.5
8	2	5	5	5	2	5	2	5	5	5	27.5
9	5	5	2	1	5	5	4	3	5	1	65
10	5	5	5	1	5	5	5	5	5	5	60
11	5	5	5	2	5	1	5	1	5	1	87.5
12	5	5	5	5	5	5	5	5	5	5	50
13	5	5	5	5	5	5	5	5	5	3	55
Mean	4.46	4.31	4.54	3.31	4	3.62	4.54	3.92	4.77	2.85	60.77

On the evaluation of MyTherapy, the raw mean scores with highest values were from questions who deal with easiness, learning and confidence during use (3, 7 and 9). Questions who dealt with negative aspects, however, also received high scores, resulting in a negative feedback when it comes to using this app and, by consequence, a significant decrease in its SUS average score.

Table 3 contains data related to CUCO Health app.

In the CUCO Health evaluation, questions about easiness, learning and confidence during use obtained low scores in relation to the other two apps and, in addition to that, similar to what happened in MyTherapy, it also received high scores in questions about negative aspects, leading to the worst SUS average score among the evaluated apps.

According to the adopted SUS average score standard (70.5 for an overall positive result and 71.4 for an "Good" classification), only Medisafe obtained enough points to be ranked as "Good", presenting a remarkable level of usability.

The other two apps didn't obtained a satisfactory rank, altough, by Brooke's adjective ranking [9], they were defined as the "OK" neutral rank, meaning that, with minor improvements, they would be eligible to a positive classification.

Also regarding the reproved apps, both obtained similar point contribution on the even-numbered questions, since the sum of all even raw mean scores of those apps only differs by a value of 0.1, which means that both have presented resembling results in relation to their negative aspects of usability. This leads to the conclusion that, what made MyTherapy as the second place was it's good

Table 3. Table captions should be placed above the tables.

User	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8	Q_9	Q_{10}	SUS Score
1	5	3	5	3	4	2	5	2	5	2	80
2	5	4	5	5	2	5	5	5	5	2	52.5
3	3	5	5	1	3	5	2	5	2	2	42.5
4	5	2	5	4	4	5	3	2	4	4	60
5	5	5	5	2	5	5	5	5	5	5	57.5
6	5	5	5	5	5	5	5	5	5	5	50
7	1	2	2	4	3	2	3	2	3	1	52.5
8	1	4	1	4	2	4	1	1	1	4	22.5
9	5	1	5	3	5	1	2	2	5	1	85
10	5	5	1	1	5	5	5	1	5	1	70
11	5	5	5	4	5	5	5	5	5	1	62.5
12	5		2	1	5	5	5	5	5	5	52.5
13	5	5	5	5	5	5	5	5	5	5	50
Mean	4.23	3.92	3.92	3.23	4.08	4.15	3.92	3.46	4.23	2.92	56.73

scoring in positive aspects of usability, showing that positive aspects have a slightly larger impact on the *user*'s experience.

5.2 Results Given by UTE Method

The first app evaluated through this method was CUCO Health. The first steps on the app induced volunteers to commit several, otherwise avoidable, mistakes, as they had trouble in finding the starting screen of the app, since it has three initial screens showing a little of how the app works, but only actually giving options for the *user* in the last one, with the button "Let's begin", which leads the user to a user registration screen. In said screen, two *volunteers* were able to find a smaller button to "Enter without Social Media" and the other one managed to register using the button to login using a *Google* account.

After performing the registration, the *users* were guided by an animated assistant called *CUCO*, which gave them instructions on how to access the main screen. None of the *users* reported trouble in this step, as well as in the next step of finding the Medication Register screen, due to a strong symbolic representation for that feature (a red button with an addition sign). Guided by the assistant CUCO, all three managed to perform both tasks easily.

The second app evaluated was Medisafe, which presented a smaller amount of steps to Medication Register in relation to CUCO Health and, due to that, was perceived as more intuitive, according to *users*. Their main issue was to write the name of the medication being added, since the smartphone touch keyboard didn't activated along with the screen. Two *users* tried to activate the keyboard by randomly touching the screen, while the third tapped directly

over the text box, activating the keyboard. To finish the therapy registration, the app presented the finishing button "DONE" in multiple locations of the screen, which facilitated the completion of the task, according to the users.

At last, MyTherapy was evaluated. And so as the one prior to it, MyTherapy conducted it's *users* very well to the medication register screen. However, there were issues with the lack of information when the *volunteers* tried to finish the insertion, as all three reported an error message appearing. The larger number of data required during registration led to certain confusion. The location of the "Save" button, which finishes the registration, localized on the top part of the screen, also caused trouble to the *users*, which took a notable amount of time to find it.

While performing the medication register, it was solicited that the reminder notification was set for 30 min after the evaluation, so that it's main core feature, the medication reminding, could also be evaluated. Due to time constraints, however, each *user* only evaluated the notification on a single app.

On the CUCO Health reminder, the *user* identified that the two buttons who appeared were to either confirm or not the ingestion. He stated to have found interesting that, when the "Don't Confirm" button was pressed in a therapy notification, the app visually represented that fact by decreasing the number on the Health meter.

On MyTherapy, the ingestion notification was selected by the *user* through the push of a button. A screen with a medication list was opened, but the *user* was unable to take any further actions, as the app didn't clearly specified that he should have informed about the ingestion.

On Medisafe, the notification appears with the name and color registered for the medication along with three buttons with texts "Ignore", "Take" and "Postpone". By clicking in "Ignore", the *user* faced a box on which he would choose one of few pre-defined reasons for the non-ingestion, of which he chose a random one and, afterwards, ender the app.

Although the amount of people selected to apply this method was quite limited, the election of which application was the easiest to use was unanimous, being Medisafe the favorite of all three evaluators. It showed the easiest interface to validate medication ingestion, with three very visible and intuitive buttons and identification by name associated with customizable color tags.

5.3 Results Given by Nielsen's Heuristics

From the results given from the SUS and UTE methods, an alarming issue with the sizing of screen elements, specially buttons, shows up. With that in mind, an eleventh heuristic was proposed, denominated *Screen Dimensioning Adaptation*, focused on evaluating the behavior of apps' screens based on an existing functionality in the *Android* Operational System (OS) 7.0 or newer.

In the Settings menu of *Android* smartphone devices there is an submenu of Accessibility Resources, where it's possible to find the option *Exhibition Size* (as shown in Fig. 2). The purpose of this feature is to increase the size of the screen's elements in order to allow better visualization to people with varying degrees of visual capacity.

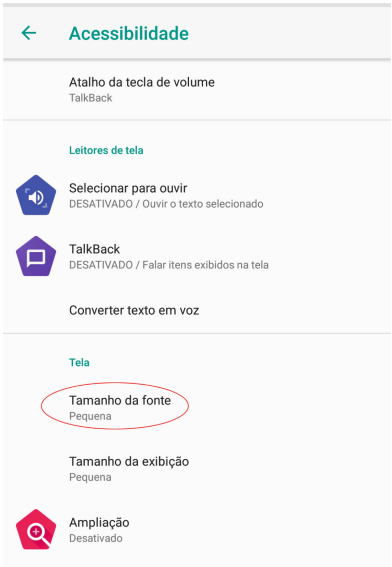


Fig. 2. Exhibition size adjustment feature on Android 7.0+ systems

The results from the evaluations of each app was subdivided as follows: (1) Expert-based Usability Walkthrough; (2) Presenting unattended heuristics and justification; (3) Screen Captures; (4) Severity of Issue; (5) Proposal of Solution.

MyTherapy. Both walkthroughs were troubled, on which five problems were found.

Walkthrough: User Registration Screen.

IV - Consistency and Standardization: When the user clicks the *Start* button, he's directed to the next screen (Fig. 3b), but from there he is unable to return to the previous one. In case the user tries to use the *Return* button, he's is directed to a third screen (Fig. 3c), related to Medication Registration.

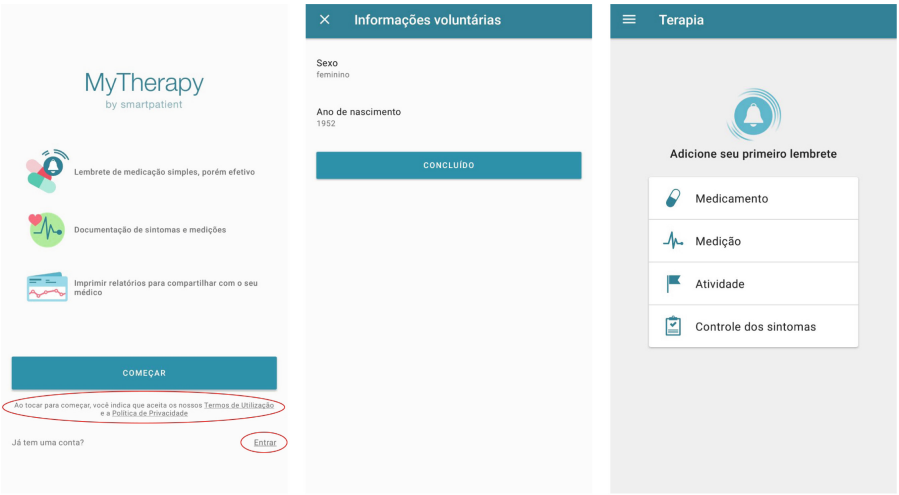
Severity of Issue: 4 - Considered an Extremely Serious Problem.

Solution: Provide return path to the first screen in a way that the user might choose another entry option to the app, e.g., from the small "Enter" button shown in Fig. 3a, used only in case the user already has an account for the app and wishes to recover previous data.

V - Prevention of Errors: The *Enter* button is small in size and badly polished, which might lead to difficulties to the user at the moment of clicking or confusion under the functionality of the button itself (Fig. 3a).

Severity of Issue: 4 - Considered an Extremely Serious Problem.

Solution: Provide better sizing and signalization for the button, as well as placing Privacy Policies terms on a lower portion of the app screen.



(a) (b) (c)

Fig. 3. MyTherapy app issues with navigation. (a) MyTherapy main screen. The blue button reads "Start"; and the circled small button on the bottom right reads "Enter"; (b) screen after the "Enter" button is pressed, requesting basic info from the user; (c) "Therapy" menu screen that pops-up if the user tries to return to the main screen, showing it's four main features (Color figure online)

Walkthrough: Screen to Register Medication.

IV - Consistency and Standardization: The screens of *Today* (Fig. 4a) and *Therapy* (Fig. 4b) menus both have similar sections with the exactly same name (*Add Medication*). However, on the *Therapy* menu, this feature is focused on medication taken regularly, where as in the *Today* menu, this functionality is focused on medication which the user must take only once. This ambiguous usage of terms and menus without further clarification may lead to severe confusion and induce the user to commit mistakes.

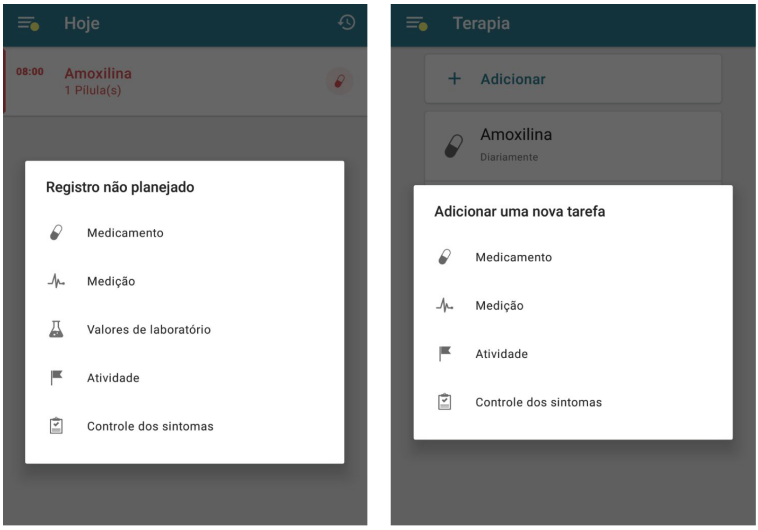
Severity of Issue: 3 - Considered a Serious Problem.

Solution: Standardize two different section types to insertion of medication, one for each screen, in order to minimize possible confusions from the user's part.

X - Help and Documentation: The *Help* menu (Fig. 5a) is found inside the *Settings* menu (Fig. 5b) and is, ironically, of little help, since the user is only provided with a single channel of communication through e-mail, also lacking any sort of documentation about the app.

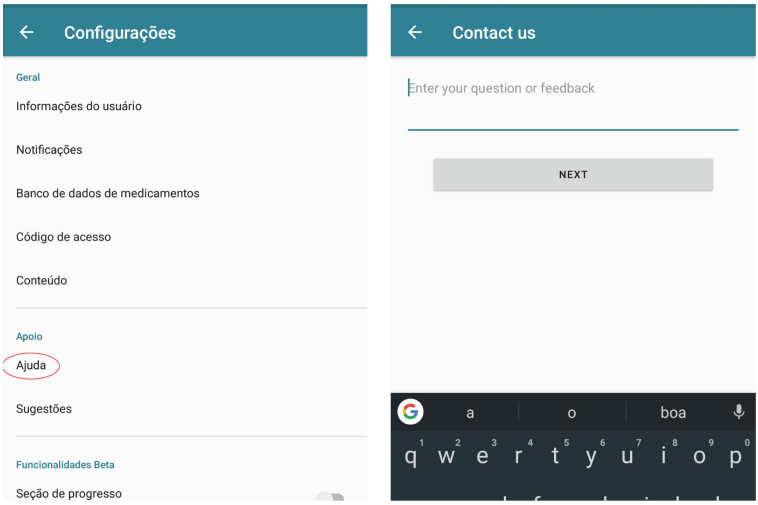
Severity of Issue: 4 - Considered an Extremely Serious Problem.

Solution: Detach the *Help* menu from the *Settings* menu, with a direct button for it on the lateral quick menu, facilitating it's acess by the user. Also providing documentation with at least basic usage information or a How-to-Use tutorial.



(a) (b)

Fig. 4. Redundant screens on MyTherapy app. (a) "Add Medication" screen on the "Today" menu; (b) "Add Medication" screen on the "Therapy" menu



(a) (b)

Fig. 5. Channel of communication on MyTherapy app. (a) "Configuration" menu screen, where the "Help" submenu is shown; (b) "Help" submenu screen

IV - Consistency and Standardization: The *Help* menu (Fig. 5b) has texts in english, but all other screens are in brazilian portuguese.

Severity of Issue: 3 - Considered a Serious Problem.

Solution: Provide consistent use of a single language in all screens.

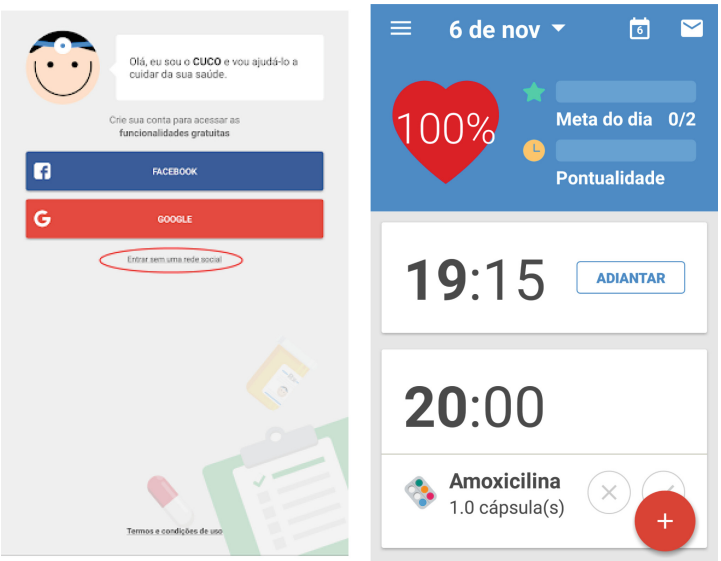
CUCO Health. Both walkthroughs were troubled, on which two problems were found.

Walkthrough: User Registration Screen.

IV - Consistency and Standardization: The placing of buttons to *Register* and *Login* on the application are disproportionate (Fig. 6a). The entry option of login without a social network becomes totally shadowed by all the other network-based entry options.

Severity of Issue: 4 - Considered a Serious Problem.

Solution: Provide better sizing to a non social network register option to facilitate access.



(a) (b)

Fig. 6. CUCO health app. (a) user login/register screen; (b) main user screen, showing "Health Meter" and registered therapies

Walkthrough: Screen to Register Medication.

XI - Screen Dimensioning Adaptation: The medication adding button (+) prevents the visualization of the Therapy Timeline when it's full (Fig. 6b).

Severity of Issue: 4 - Considered a Serious Problem.

Solution: Provide automated adequation to screen size in order to prevent information loss and so that the user is not impaired when the screen sizing is altered.

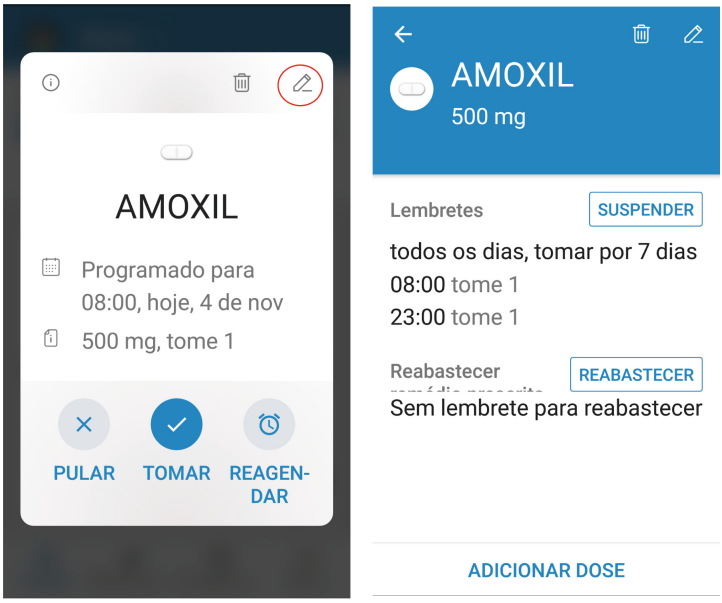
Medisafe. Only one walkthrough was troubled, on which two problems were found.

Walkthrough: Screen to Register Medication.

V - Prevention of Errors: Using purely icon-based representations may induce users to error, leading them to dubious interpretations, like the case with the "pencil" icon to represent "Edit" but without any proper text caption (Fig. 7a).

Severity of Issue: 3 - Considered a Serious Problem.

Solution: It's important that icons, even those considered intuitive by a certain group of users, have clear and simple captions, in order to avoid any errors.



(a) (b)

Fig. 7. Medisafe app. (a) warning screen of a scheduled therapy, containing time and dosage of medication; (b) warning settings screens, containing storage for dosage and resupply of medication

XI - Screen Dimensioning Adaptation: The Add *Medication/Posology Edit* screen (Fig. 7b), whenever the screen sizing is enlarged, suppresses some titles and important information, e.g., the resupplying medication feature.

Severity of Issue: 4 - Considered a Extremely Serious Problem.

Solution: The disposition of elements in a screen must follow a certain spacing standard, considering all elements, so that the user don't suffer information loss on the resizing.

6 Conclusion

The UTE with the *users* allowed for the diagnose of some deficiencies appointed during the text, such as trouble with finding the "Enter" button on the apps' main screens, a large amount of information required to be inserted during medication register and the issue of touch keyboards not appearing by default on screens which demanded text typing.

The application of the SUS survey made possible to identify the degrees of usability of the apps. Some positive points were listed, such as easiness of use, which was scored positively for all the apps, as well as, learning and confidence of the *users* during the time of evaluation. However, even though all three reached reasonable scores on positive aspects of usability, only Medisafe was able to overcome the adopted standard, thus, being the only one already owning enough usability features to be considered Elder-friendly.

Results shown on the methods above created the need of a new Heuristic of number 11, denominated "Screen Dimensioning Adaptation" and adopted during the heuristic evaluation along with the ten traditional heuristics, having the purpose of making applications more accessible to people with varying degrees of visual capacity.

From the implementation of Nielsen's Heuristics, it was possible to enumerate a couple of issues found in the apps' interfaces. The most serious, located on CUCO Health and MyTherapy, were a few disproportionate screen elements, which also caused issues on the usability tests performed by the *users*, as well as others such as screens with similar design but different functionalities or an disadvantaged location of the Help menu, both presented on MyTherapy app.

The addition of the new heuristic also brought its own results. The apps Medisafe and CUCO Health had screens rated as problematic for showing responsiveness flaws when utilized on larger Screen Sizes options, through accessibility resources from the Android OS.

In a general sense, the response of the methods employed was very satisfactory. The employment of three distinct methods revealed results that, sometimes overlapped and sometimes contrasted, in a way that the final result was more complete and, thus, more closer to reality.

From the research presented in this paper, further studies must be made, with a larger pool of users and with a broader set of applications in order to precisely quantify the level of certainty that this method presents while evaluating how elder friendly an medication reminder app can be.

Also, in continuity of this work, a set of guidelines of good practices for app development in medication reminding apps will be made, based on the results presented, which may improve programmers and software engineers in creating services that also take in to consideration the elder public and its limitations.

Thus, it's believed that this developed methodology is capable of determining the level focus on the elder public, based on subjective, qualitative and technical parameters.

The employment of such methodology on the evaluation of other medication reminder apps is totally feasible, as well as its application in a general way to any kind of mobile application involving registrable reminders and/or other populations with cognitive skills similarly reduced to the elders.

It's also believed in the potential of this methodology to be implemented in the accessibility evaluation of any type of application, in a broad sense. However, it's important to emphasize the need pf adapting the methodology accordingly to the specific characteristics and needs of the target audience and of the evaluated service.

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