Developing a Digital Application for Patient Medical History

Gualter Ferrada, Lisbon School of Architecture, University of Lisbon

Mafalda Casais, CIAUD, Research Center for Architecture, Urbanism and Design, Lisbon School of Architecture, University of Lisbon

Abstract
The value of a patient-centered care (PCC) approach should be considered in the context of the Portuguese healthcare system, particularly because several structures are being used but not properly interlinked, to the detriment of the patient. The patient should be considered the most important element in the healthcare system, among other reasons because of the impact on the patient's treatment efficiency. This paper aims to encourage PCC by exploring ways to facilitate the exchange of medical records. A Research through Design (RtD) approach helped us define a possible strategy to a wicked problem—the patient's access to medical records in Portuguese healthcare facilities. The development phases of this project are divided into: 1) literature review; 2) research; 3) exploration; 4) design; and 5) evaluation. This paper presents the development of a mobile application—Olhar Clínico [Clinical Viewpoint]—for sharing patient medical history and discusses its implications for the healthcare context. Results of an evaluation with end users show that the solution brings value to the patient and can potentially soften the distinction between the public and private practice, promoting a cohesive healthcare system.

Keywords: mobile application; interaction design; research through design; research through interaction design; healthcare design

1. Introduction

The Portuguese healthcare system is divided into public and private, and it is often the case that individuals seek assistance in both. The value of a patient centered care (PCC) approach (McCracken et al., 1983) should be considered in this context, particularly because several structures are being used but not properly interlinked, to the detriment of the patient. The patient should be considered the most important element in the healthcare system, not only because of their satisfaction and individual needs, but also because of the impact on the patient's treatment efficiency (Groeneveld et al., 2019).

This paper aims to encourage PCC by exploring ways to facilitate the exchange of medical records. It involves patients enrolled in the Portuguese national healthcare system who seek second medical opinions in public or private sectors. Accordingly, we identify as our research question: "How can interaction design facilitate the access to clinical information in public and private institutions by patients in the Portuguese healthcare system?"

The methodology used includes Research through Design (RtD) and User-Centered Design (UCD). The main objective was generating insights about the solution presented and answering the research question. "RtD is an appropriate research approach to study the features, acceptance, and impact (…) of a design" (Groeneveld, 2020, p. 44).

This research intends to develop a mobile application that considers the motivations, frustrations, and goals of potential users. The development phases of this project (Figure 1) are divided into: 1) literature review; 2) research; 3) exploration; 4) design; and 5) evaluation. The literature review phase focuses on healthcare, data privacy and security, and adequate research approaches. The research phase is

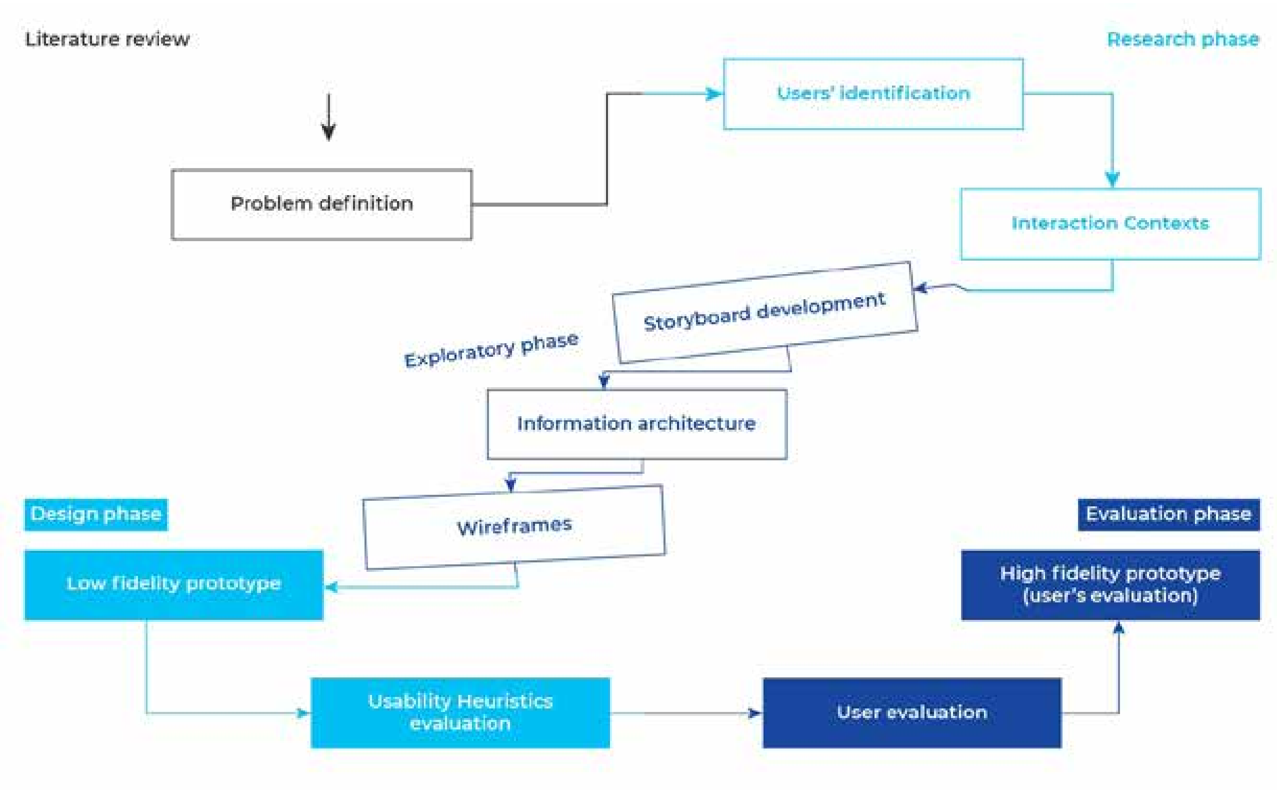

Figure 1. Development process of a digital application for the patient's medical history using an RtD approach.

about identifying groups of potential users by interviewing real participants. The exploratory phase focuses on the development of storyboards, information architecture, and wireframes. The design phase is a conceptualization of the wireframes into a low-fidelity prototype and its evaluation through usability heuristics. Lastly, the evaluation phase is an iterative process of evaluation with end users through performance testing and a SUS (system usability scale) survey.

In sum, this paper presents the development of a mobile application for sharing patient medical history using an RtD methodology, and discusses implications of this technology for the healthcare context.

2. Literature Review

"A patient-accessible medical record can potentially improve medical care in a variety of areas, particularly by enhancing doctor-patient communication" (Ross & Lin, 2003, p.1).

2.1. Patient-Centered Care

Patient-Centered Care (PCC) is an approach that encourages a relationship between the doctor, the patient, and their family to solve a certain problem (Delaney, 2018). By understanding and corresponding to the patients' needs, these can make their own choices concerning a medical treatment that fits them (Levinson, 2011). Linked to PCC, there is patient-centered communication, which intends to improve the patient's experience by actively trying to understand their perspective (Levinson, 2011). The application of PCC appears to positively influence patients' recovery (Olsson et al., 2009; Rathert, 2013), and patient-centered communication plays a big role in it. If the patient has specific needs and PCC seeks to actively listen to them, then accessing the individual's past clinical experiences facilitates a PCC approach. "By facilitating online access to medical information (...) personal health records are envisaged as having a key role in patient-centered care" (Reti et al., 2010, p. 1). For example, chat functionalities between doctors and patients and mechanisms to facilitate the search for second medical opinions could be considered in the strategy of our research problem, since both are patient-centered.

2.2. Free Access to Healthcare Data: Privacy and Security Implications

Healthcare data accessibility brings numerous problems associated with privacy and security. According to Cushman et al. (2010), the unauthorized access and leaks of sensitive data by external applications might result in discriminating situations in job opportunities or worse, because, although most institutions with access to these data are traditionally clinics or hospitals, there are unregulated organizations with commercial purposes above the associated privacy concerns benefiting from free access to healthcare data. Haas et al. (2011) claimed that existent EHRs (electronic health records) providers share patients' personal data with doctors, healthcare services, and drug stores. According to Perera et al. (2011), most patients and physicians do not agree with medical records being shared with insurance companies, external researchers, and pharmaceutical industries, and do not want the government to have that information. Systems involving sensitive data such as patient medical records must be carefully designed to maintain and preserve anonymity.

Security is also a big challenge in the technical development of such an application. Accordingly, the use of a Blockchain technology could be a good strategy for such concerns (Chen et al., 2020). Blockchain functions through validation mechanisms in a linked computer network that facilitates transactions without the need of authorities or intermediaries to maintain and supervise the system's functionality (Rennock et al., 2018). If a new transaction occurs, then a new block is added to the computer chain with the supervision of clever code and mass collaboration between the network blocks (Rennock et al., 2018). Peer-to-peer transactions are a fundamental idea in blockchain, which means that two identities can make a transaction directly, maintaining their anonymity and that of the permanent records of the transaction (Hassani et al., 2018). The extent of blockchain applicability has already opened opportunities in healthcare, smart cities, energy industries, supply chains and logistics, and Internet of Things (Bodkhe et al., 2020).

2.3. RtD Approach

RtD aims for knowledge production through the development of a solution to a research problem, while evaluating it with end users. It is considered a legitimate research methodology in the investigation of wicked problems (Zimmerman et al., 2010)—that is, those with "innumerable causes, (…) tough to describe, and [without] a right answer" (Camillus, 2008, p. 2). According to Hamilton (2008), research involving healthcare often addresses good examples of wicked problems. The context of this research involves politics, public health, healthcare, health insurance, among other areas, which converge towards a complex problematic. The strategy for our research problem uses interaction design as a tool to develop insights. We did "design as a part of doing research" (Stappers & Giaccardi, 2002) into our problem, gaining preliminary insights into the problematic.
Besides the RtD approach, we also used UCD principles in the design process. According to Abras et al. (2004), UCD is described as the methods or processes that utilize end users' needs to influence the design of a product or system. In our case, while the users were not involved in all the development phases, they were consulted in two phases (research and evaluation) and influenced the options made throughout the design development process.

3. Research Phase

The research phase aimed to define and characterize groups of potential users through interviews with patients in the research context.

3.1. Participants

To achieve an approximate definition of the potential user groups, we conducted structured interviews with participants that fitted the research context: patients or people accompanying patients, registered in the Portuguese national healthcare system, seeking second medical opinions or better healthcare in private and public institutions. The sample consisted of 10 participants, aged between 21 and 58 years old, three male and seven female (Table1).

Table 1. Participant demographic data.

Participant	Age	Nationality	Residence	Occupation	Gender
P001	32	BR	Lisbon	Student	F
P002	22	PT	Lisbon	Working student	F
P003	21	PT	Lisbon	Student	F
P004	25	PT	Lisbon	Dentist	F
P005	23	PT	Lisbon	Working student	F
P006	58	PT	Lisbon	Professional Insurance Technician	F
P007	28	PT	Lisbon	Product designer	M
P008	21	PT	Lisbon	Student	M
P009	42	PT	Lisbon	Restaurant owner	F
P010	21	BR	Lisbon	Working student	F

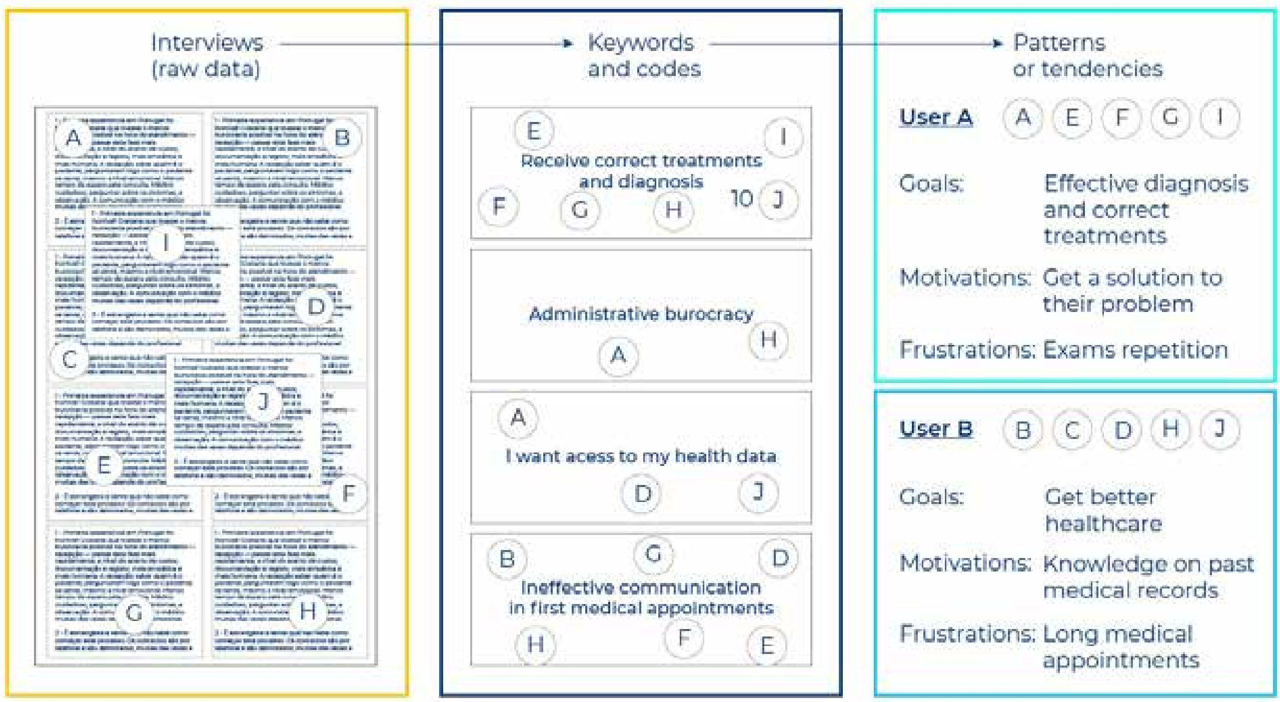

Figure 2. An example of the coding process in the analysis of the data collected (adapted from Adler, 2005).

3.2. Procedure

We conducted interviews focusing on the patients' objectives, motivations, and frustrations. The interviews were conducted during a period of seven days, through the Zoom platform, and included a record consent request. The interviews followed the script below:

How would the perfect experience in a first medical appointment be?

In reality, what are the major problems that you find in the process of medical appointments?

Have you ever needed a second medical opinion? Why?

What do you know about personal data privacy?

Would you consider your health data as personal data?

Would you be able to name the institutions that have access to your health data?

Would you consider yourself a person that easily trusts in others?

Guide me through your routine in a day with a medical appointment.

How would you characterize the communication between doctor and patient?

According to Saldaña (2016), during the interviews, we were finding 'key moments' for pre-coding, highlighting words and phrases that needed further attention in the analysis process. The interviews were recorded for later consultation.

3.3. Analysis

We coded the transcribed interviews and generated keywords from the answers, identifying and groupping approximate profiles of user groups. The search for patterns or tendencies during the coding process, considering the small sample, was done for all the interviews at once, in one coding cycle (Figure 2).

The circles with letters correspond to interview fragments and each column refers to the data analysis phases: the first represents the raw data, the second represents the coded data, and the third represents the potential user characterization.

3.4. Results

The interviews took on average 10 to 20 minutes. Participants expressed disappointment with the overall healthcare service, and some referred to their motivation of accessing their medical records in order to facilitate the communication with doctors when seeking second medical opinions. They also showed concerns about their medical data privacy and referred to the lack of empathy of some doctors, which made them ask for second medical opinions. Most of the codes obtained (Table 2) were linked to ineffective communication between patients and doctors.

3.4.1. User profiles

As a result of the research phase, we characterized two different users. User A's motivations are medical appointments in short time periods, obtaining effective diagnosis, and finding a thoughtful doctor to follow their case. Their objectives are getting their health problems solved and be attended to as soon as possible. The major frustrations are lack of confidence in previous diagnosis, exam repetition, and administrative bureaucracy.

User B accompanies a family member, seeking better healthcare for them. Their motivations are waiting less time for medical appointments, the wellbeing of their family member in medical treatments, and doctor knowledge of their situation. The objectives identified are the pursuit for better healthcare and effective diagnosis in future medical appointments. The frustrations are the lengthy medical appointments in the public sector, excessive administrative bureaucracy, and exam repetition.

4. Exploratory Phase

The exploratory phase aimed to discover possibilities in interaction storyboards, information architecture, and wireframes with the user profiles.

4.1. Procedure

While focusing on the identified user goals, motivations, and frustrations we developed storyboards. The possibilities of interaction were explored in this context and led to the development of the information architecture and wireframes.

Table 2. Codes obtained in the analysis of the interviews.

Codes obtained	Interview data (examples)
“Know the patient”, “Correct treatments and diagnosis”, “Careful	“The medical staff should know the patient and ask how they feel physically and emotionally” – P001
“Exams lost”, “Lack of empathy”, Administrative bureaucracy”, “Ineffective diagnosis”, “Booking medical appointments”	“Due to the lack of public services organisation, the patient should take the exams with him although it might get lost.” – P002 “I’m not from Portugal and I do not know how the process is. The contacts are long, unstable and made by telephone.” – P001 “In the emergency area of the public service, there is no time with the patient to get an effective and proper diagnosis.” – P007
“There is data sharing without a conscious consent”, “There is no data privacy”, “medical confidentiality”,	“I think that our country shares some data with other countries and even the national health system does it without my consent.” – P002 “I am aware of privacy concerns in my professional area (dentist), the medical
“I need control on my health data”, “not sure if I am the owner of my data”	“it is my health data but nowadays it belongs to healthcare facilities and in my case, if I had access to my medical records, the communication with the second doctor would be much easier.” – P001 “I do consider it my personal data and I have the right to access it. However, considering emergencies and extreme cases, health data should be accessible
“Ineffective communication”, “ineffective diagnosis”, “Access to medical records is helpful”	“The overall communication between patients and doctors is bad, because the patient might not be able to express his health problems or the doctor might misunderstand that information. (...) doctors might even ignore some signals due to their lack of time and miscommunication.” – P005 “It’s difficult in the first medical appointments. The patient has to

Figure 3. User A's interaction storyboard in a new medical appointment.

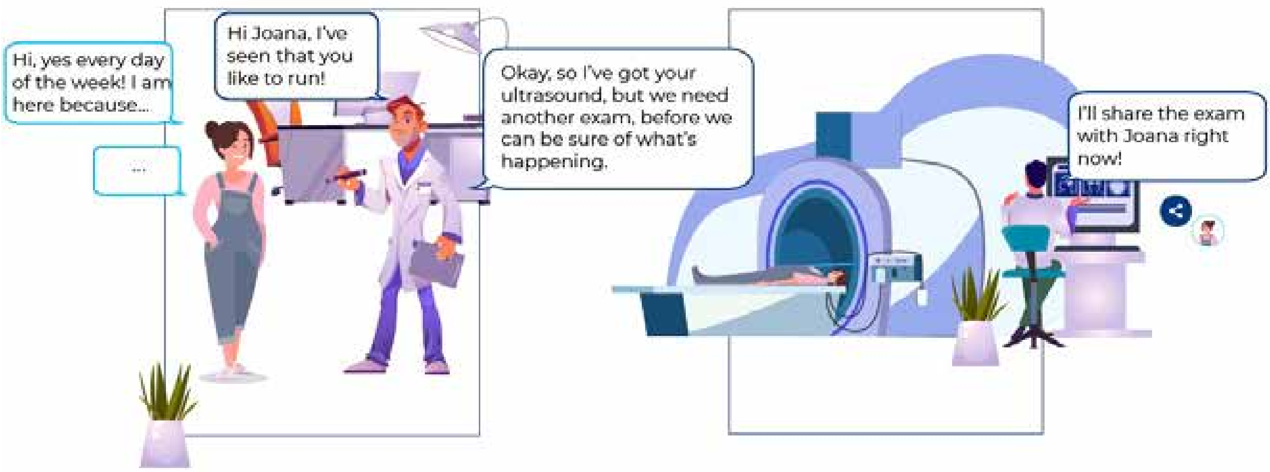

Figure 4. Constant data sharing between the user and the doctor.

For the information architecture, we focused on the user profiles to explore the main interest areas within the mobile application. After that, we segmented the secondary areas such as vaccination records or medication records, which were inside the main topic: medical records. Subsequently, we developed the wireframes—by visually detailing each one of the screens thought in the information architecture, we realized opportunities to improve the original set up, opting for clearer submenus.

4.2. Results and Outcomes

4.2.1. Storyboards

As an evolution of the interaction contexts, we present the example of the storyboard of user A, exploring the interaction between user, doctor, the environment, and the mobile application Olhar Clínico [Clinical Viewpoint] (Figures 3, 4, and 5).

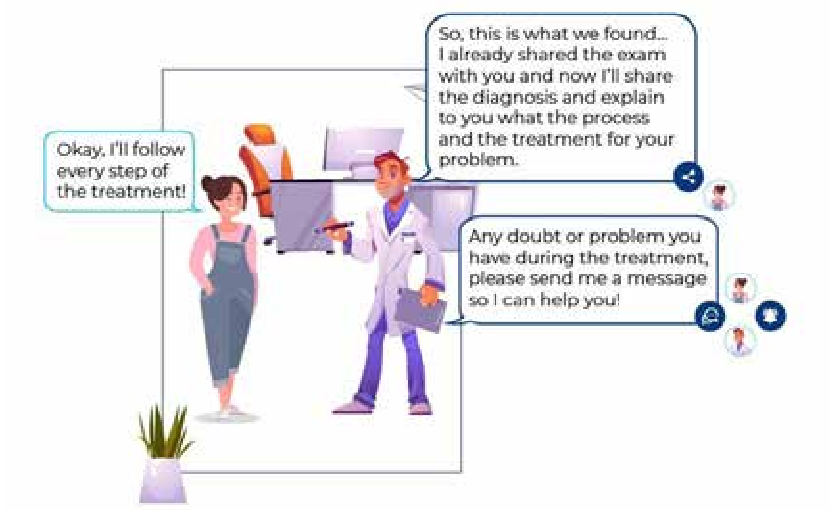

Figure 5. The doctor tells user A that they can message them through the mobile application.

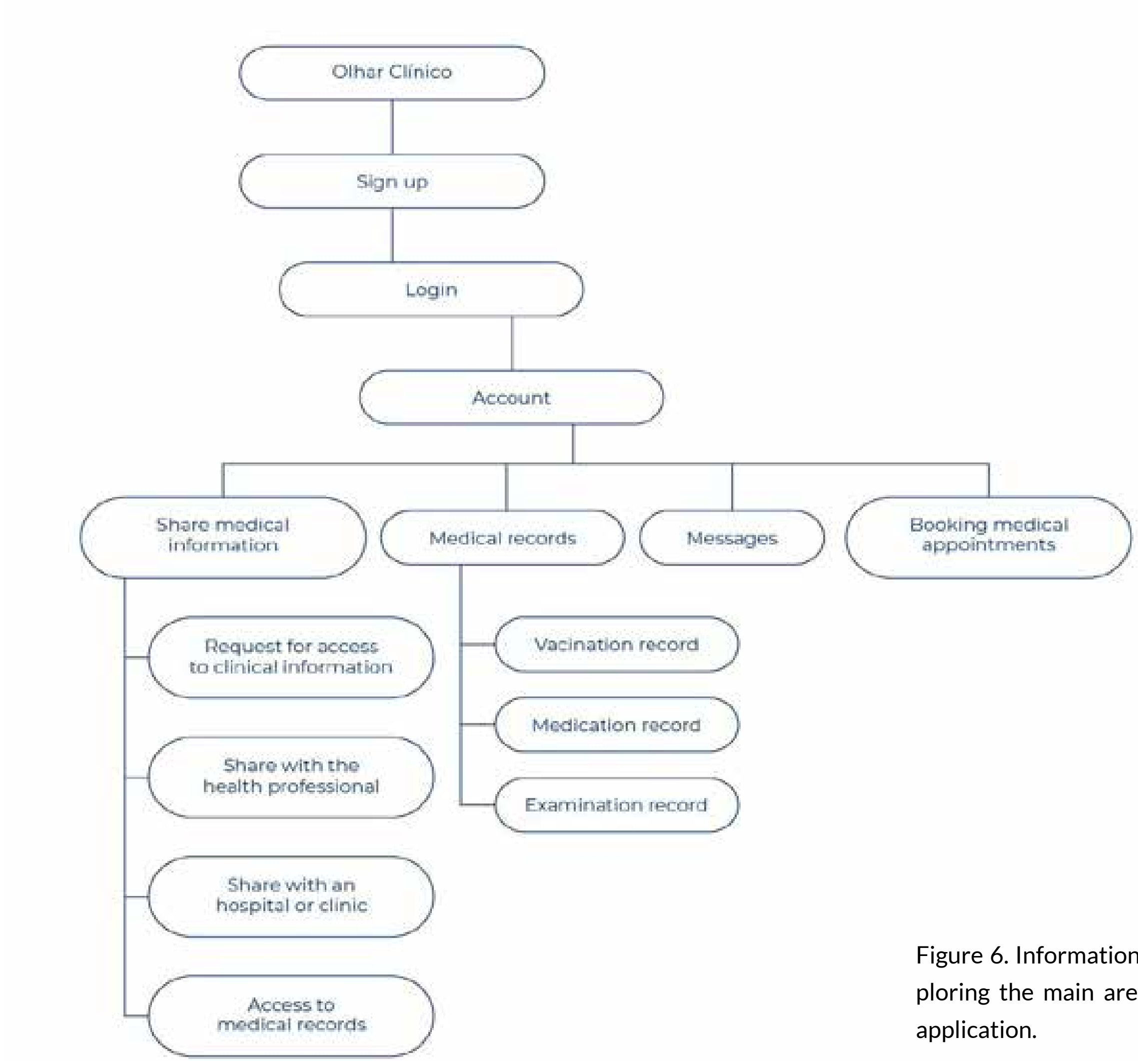

Figure 6. Information architecture exploring the main areas of the mobile application.

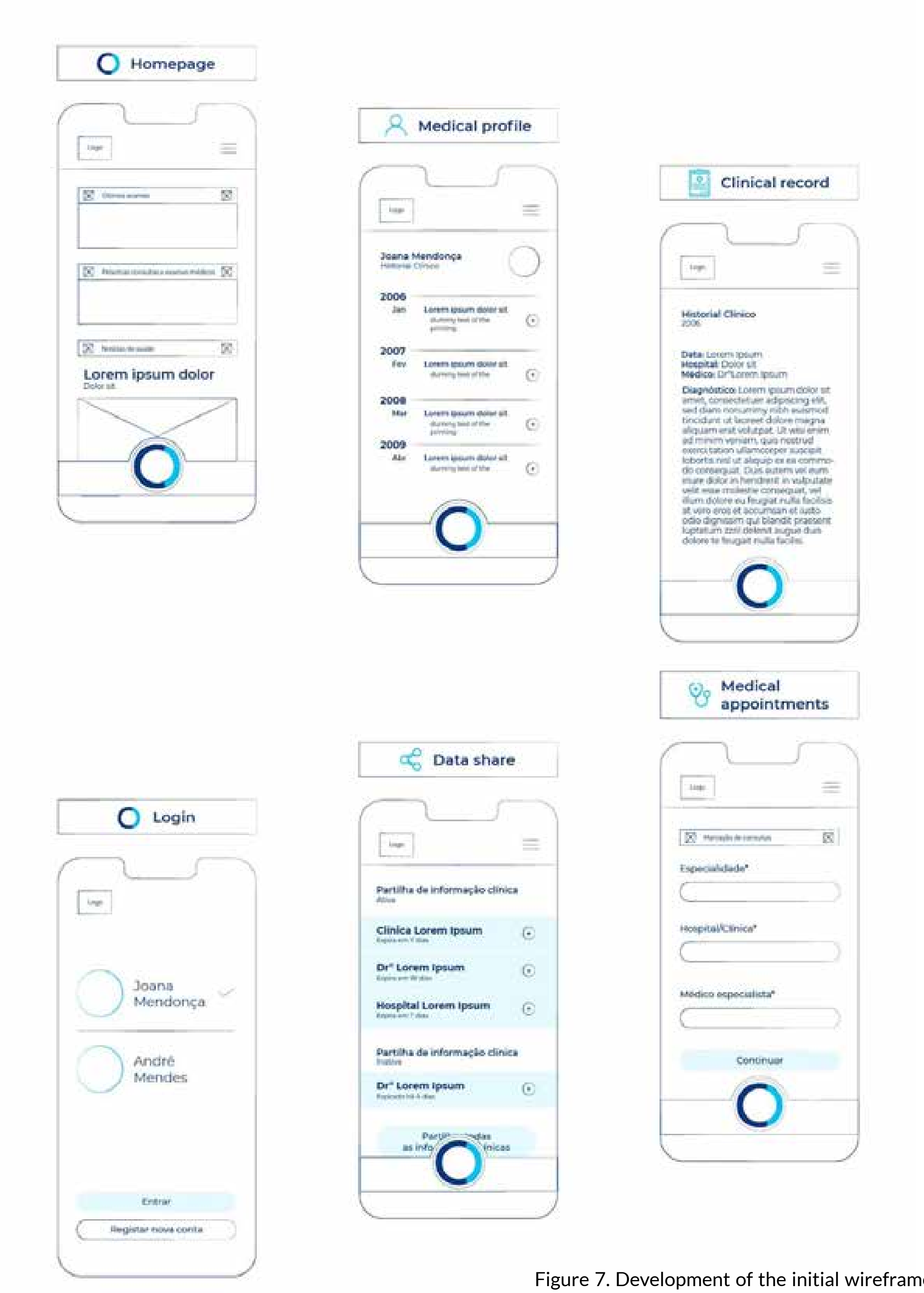

Figure 7. Development of the initial wireframes with attention to the main areas of the information architecture.

4.2.2. Information Architecture

We structured the functionality of the mobile application by setting up the main areas and submenus into a visual scheme (Figure 6).

4.2.3. Initial Wireframes

Due to the early phase of the mobile application development and conceptualization, we were exploring information positioning, menus, shortcuts, and interaction possibilities without focusing on details such as font types (Figure 7).

5. Design phase

The main objective of the design phase was the creation of a medium-fidelity prototype to be evaluated by end users. Beginning with the initial wireframe development we wanted to accomplish a solution to our research problem as a low-fidelity prototype. Furthermore, we carried out a usability heuristics evaluation of the low-fi prototype in order to reach this phase's goal, a medium-fidelity prototype.

5.1. Procedure

We had a special attention here because we were developing the first screens from the initial wireframes. Having in mind the users' goals, motivations, and frustrations in every step of prototyping helped us avoid later problems with the product. The creation of screens, interactions, and animations from the initial wireframes resulted in a low-fi prototype that went through a usability heuristics evaluation. The usability heuristics were consistency, efficiency, feedback, and easy recovery from errors (adapted from ISO/DIS 9241-11; ISO/DIS 9241-110; ISO/DIS 9241-112; ISO/DIS 20282-1; ISO/FDIS 9241-306; Schlatter & Levinson, 2013).

5.2. Analysis

In order to apply a careful evaluation, we used checklists for each usability heuristic, which are included in the tables below (Tables 3, 4, 5 and 6).

Table 3. Usability heuristics evaluation through the usage of checklists: Consistency.

Usability heuristics	Visual	Functional	Internal	External
Consistency	Screen balance Screen symmetry Graphic elements regularity Graphic elements predictability Graphic elements sequentially Space economy Graphic elements unity Color harmony in screens	Functions associated by colors Functions associated by animations The images and graphic elements used are consistent with the page subjects Names consistent with actions Menus hierarchy Navigation options identification	Functional areas localization through screens Types, fonts, colors and interactions Terminologies	Common social conventions: symbols, vocabulary User stability and confidence Real world analogies User expectations

Table 4. Usability heuristics evaluation through the usage of checklists: Efficiency.

Usability heuristics	User navigation	User dialogs with the product / system	Reduce the user short-term memory	Design for minimization	Design to capture the user attention	Readability
Efficiency	Navigation options identification Specific information search identification Mouse and keyboard interactions with the menu Tasks minimization Grouped functionality commands	Quick access keys Data entry	Avoid user	Graphic elements purpose User needs: screens	Assign colors to important tasks Animations to important tasks	Avoid serif letters in digital devices Avoid abuse of capital letters

Table 5. Usability heuristics evaluation through the usage of checklists: Feedback.

Usability heuristics	Error messages	Dialogues
Feedback	Positive error messages The user is not the cause of an error Clear language Avoid unknown codes	Long and short tasks information to the user Avoid negative sentences Help steps are settled chronologically Clear utility information before asking for registration Differentiate “sign in” from “sign up”

Table 6. Usability heuristics evaluation through the usage of checklists: Easy recovery from errors.

Usability heuristics	Avoid using the keyboard to enter text	Inform at the right time and place about mistakes
Easy recovery from errors	Data entry shortcuts	Mistakes and successes dialogues

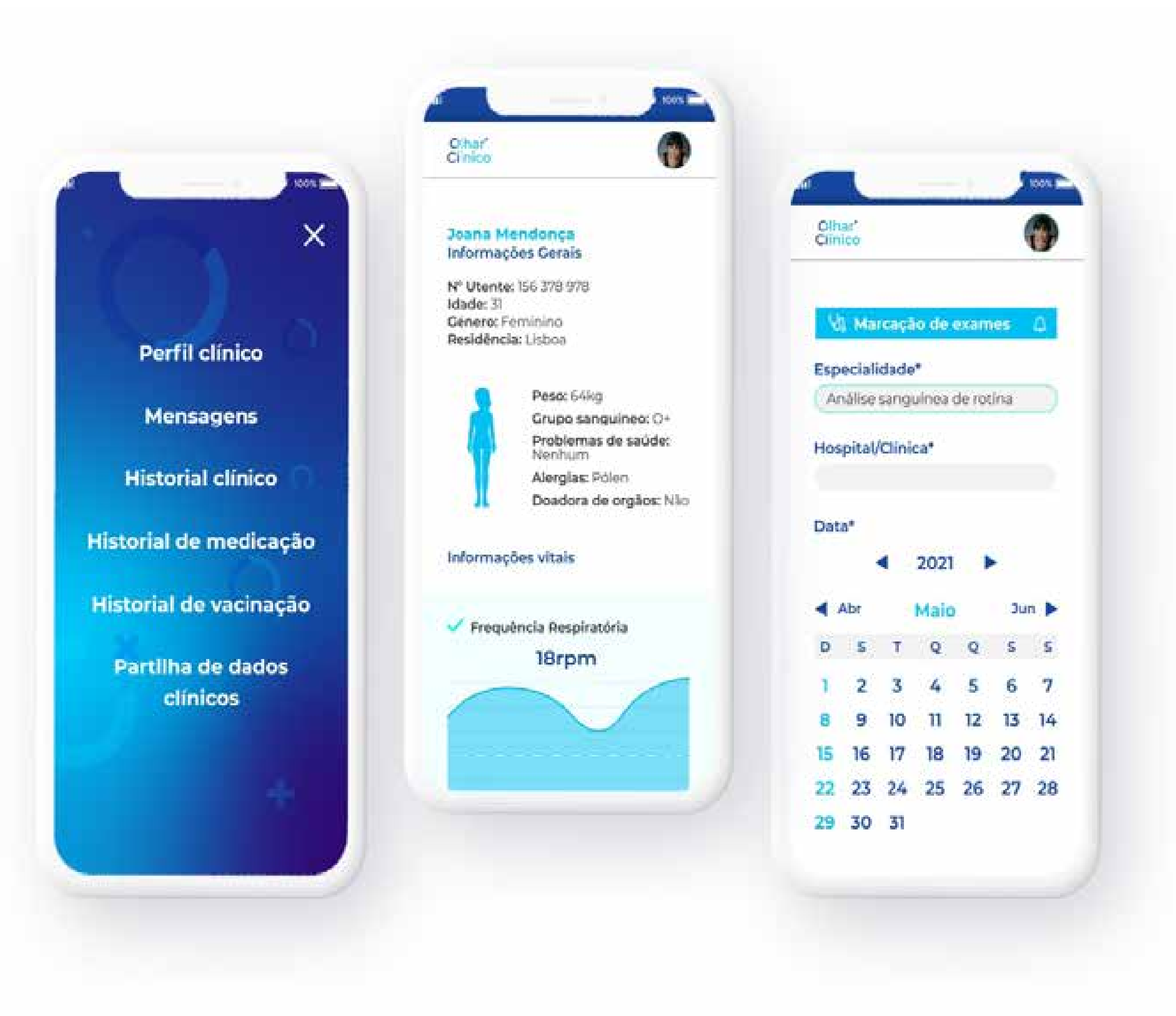

Figure 8. Representation of the low-fidelity prototype.

5.3. Results

The design phase was composed of two different parts: the creation of a low-fidelity prototype based on the initial wireframes and user profiles (Figure 8) and the evaluation with usability heuristics, which resulted in a medium-fidelity prototype (Figures 9 and 10).

5.3.1. Low-fidelity Prototype

5.3.2. Usability Heuristics Evaluation and Medium-Fidelity Prototype

Figure 9. An example of the external consistency evaluation using checklists in the usability heuristics evaluation.

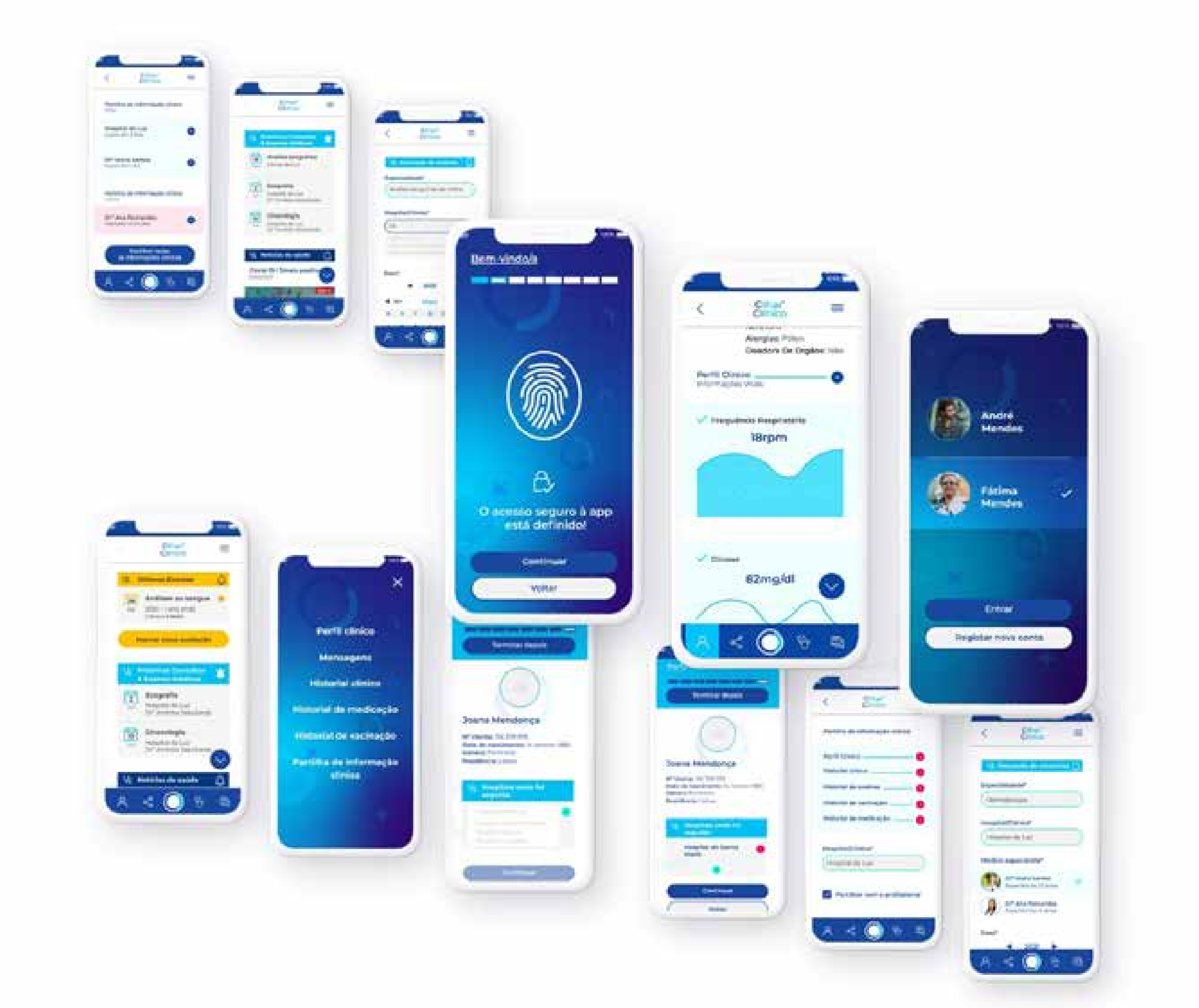

Figure 10. An overview of the medium-fidelity prototype.

Table 7. Tasks performed by end users.

Tasks	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
	Successful registry	Change account	Make a medical appointment	Share medical data	Find a specific	Find a specific information
Task context	You downloaded the mobile application Olhar Clínico, from the App Store or Play Store. Sign up in the platform	You signed up successfully! Imagine that you also manage someone's health data in your family. Enter in their account to check their medical appointments	Make a medical appointment in Hospital da Luz with a dermatologist this week	Since you have your medical appointment scheduled, share your medical information with your new doctor	Find your health data, like your heart rate	Find clinical information from a past medical
	120s	20s	40s	40s	20s	20s

6. Evaluation Phase

The evaluation phase intended to improve the medium-fidelity prototype through an evaluation with end users. It was conducted in the form of performance tests and a SUS survey, using sample from the interviews (Table 1).

6.1. Procedure

For the performance testing, we conducted two rounds: the first round with three users where we found improvement opportunities and a second round with four users that evaluated the improved prototype. For both rounds, we defined a set of six tasks (Table 7) to evaluate due to their importance for the application's functionality. The testing was conducted through the Zoom platform in individual sessions, which took around 20 minutes. We presented a short session guide for the tests and applied a SUS survey at the end of each performance test.

6.2. Analysis

For the analysis, we used the DataLogger V5.0—an excel tool developed to help record qualitative and quantitative data during usability evaluations (Zazelenchuk, 2009). During each individual session we had to select the best option for the users' performance as 'easy,' 'medium,' 'hard,' and 'assist'—if the user needed assistance to complete the task—, or 'fail'—if the user stopped in the middle of the task. In the beginning of each task, we would start the excel tool clock to keep track of the time spent and write any explicit difficulties during the navigation through observation. In addition, we selected the best option for the user's confidence level while completing the task from level one to seven based on observation. At the end of each performance test we applied a SUS survey.

6.3. Results

The tool automatically generated the charts displaying the measured effectiveness and efficiency of the product evaluated. In this section we present the performance tests charts that helped us improve the mobile application with data about the time spent and observations about user difficulties.

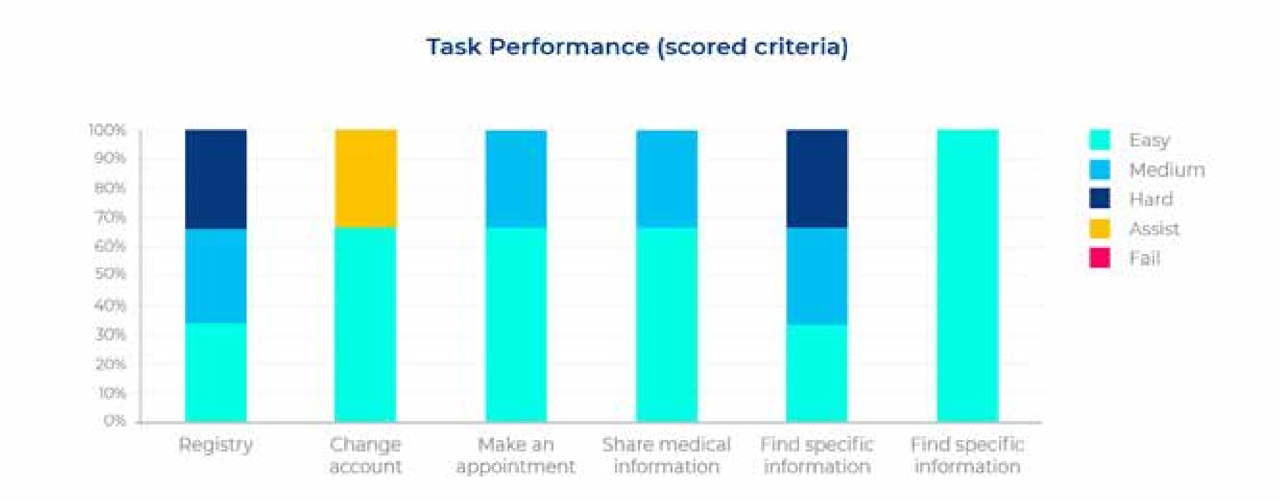

Chart 1. Task performance for the first round of tests

Chart 2. Task completion and confidence for the first round of tests.

6.3.1. First Round (Three Performance Tests)

Chart 1 shows that every task was performed by users without 'fails,' however, there was an 'assist' in the "change account" task and two 'medium' scoring tasks where users faced difficulties performing them. Overall, the users performed the tasks easily, but there was enough space for improvement in the "registry," "change account," and "find specific information" tasks.

Chart 2 shows that, overall, users were confident performing the tasks, which indicates that despite not finding what they needed, they were navigating through the mobile application without concerns or expressed doubts. We can identify the "share medical information" and "find specific information" tasks as the ones with higher confidence levels.

Chart 3 shows task completion time, where we verify that the "registry" task took more time than we expected, which indicates the need for adjustments, as in the "find specific information" and "change account" tasks, of which we already had data from past charts indicating improvement opportunities.

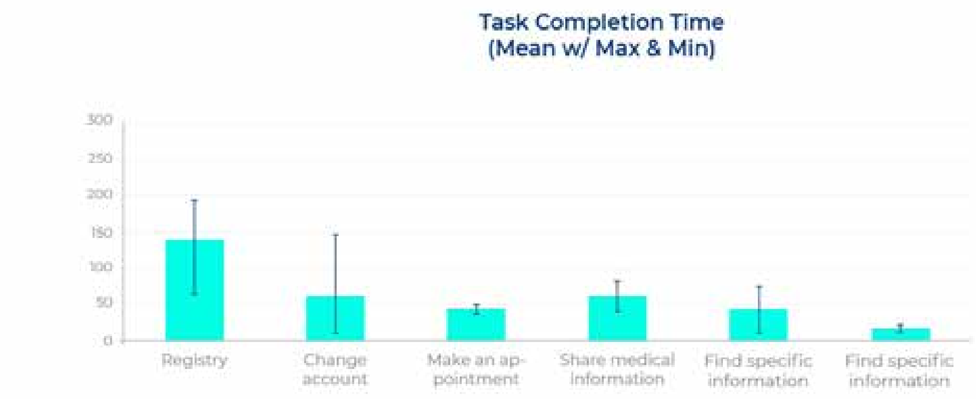

Chart 3. Task completion time for the first round of tests.

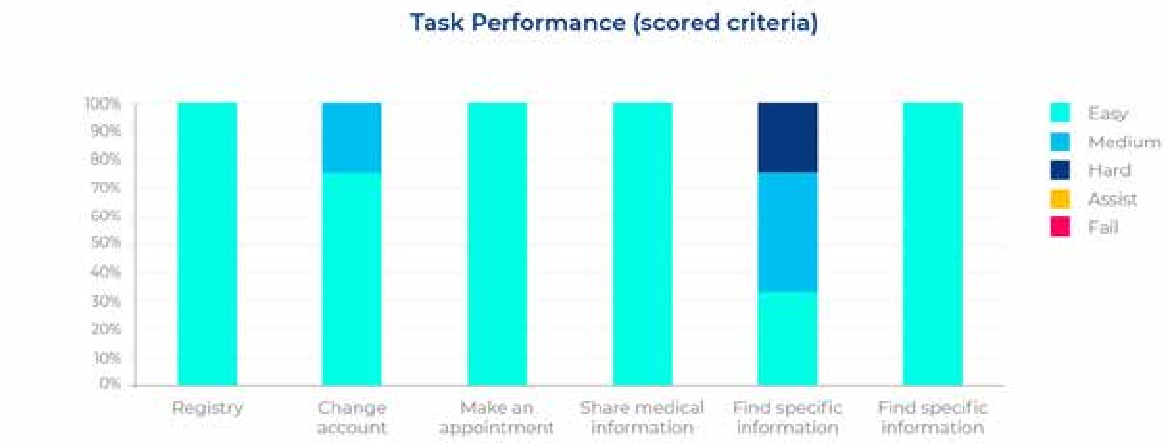

Chart 4. Task performance for the second round of tests.

Despite the identified improvement opportunities, a 78,3% SUS score indicated that the usability of the mobile application was good, according to Bangor et al.'s (2009) adjective rating scale. Before conducting the second round of tests, the prototype was improved accordingly. Most improvements were made due to technical errors in the prototype such as small clickable areas or locked screens where scroll was crucial. To solve the "change account" task difficulty, we added an alternative option to swap accounts in the patient's profile and reorganized the main menu options by grouping all the options related to medical history such as vaccination or medication records in sub-groups. In the "registry" task, we identified some technical errors with the prototype that were interfering with the task completion flow.

6.3.2. Second Round (Four Performance Tests)

Chart 4 shows that after the improvements, the same tasks had better results without assistance needed.

Chart 5 shows how the improvements on task completion rates influenced the confidence rates.

After the improvements, we verified that the users are spending the expected time performing the tasks (Chart 6). However, users faced difficulties in the "find specific information" task, which is visible in the data analysis. Due to the lack of logical reasons and improvement opportunities, future tests are needed to solve this issue.

Chart 5. Task completion and confidence for the second round of tests.

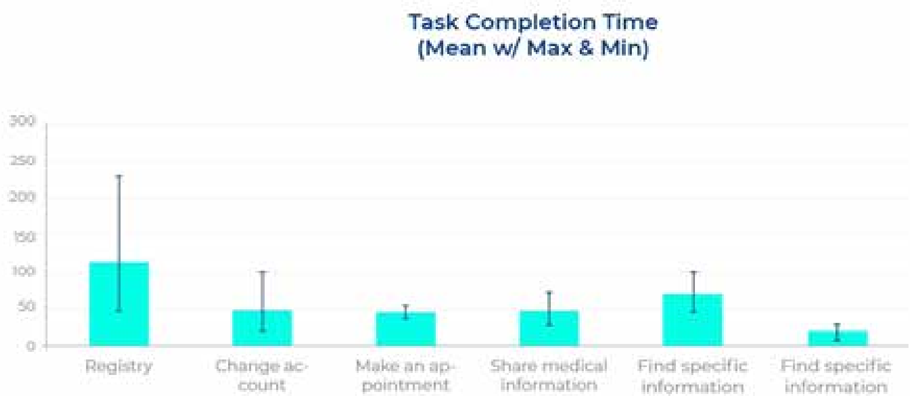

Chart 6. Task completion time for the second round of tests.

The last prototype had a 88,1% SUS score, making the mobile application an excellent usability product example, according to Bangor et al.'s (2009) adjective rating scale.

6.3.3. Final Prototype

Through the evaluation phase, improvements were made in an iterative process considering users' feedback and performance testing, resulting in the final prototype.

7. Discussion

Some studies point to the expensive cost of implementation and maintenance, and the time consumption of healthcare providers' adaptation to EHR systems (Ray, n.d.). However, we believe that our strategy might bypass this for a few reasons. The mobile application is not invasive—it works outside the system and with the patients' consent. The patients are the owners of their clinical data and they have the power to share it with new doctors, clinics, and hospitals. Doctors and other medical staff would not need adaptation, because their workflows would be the same; however, the healthcare facilities administration sectors would have more work. To solve this crescent volume of work, we encourage further research in a system across all healthcare facilities.

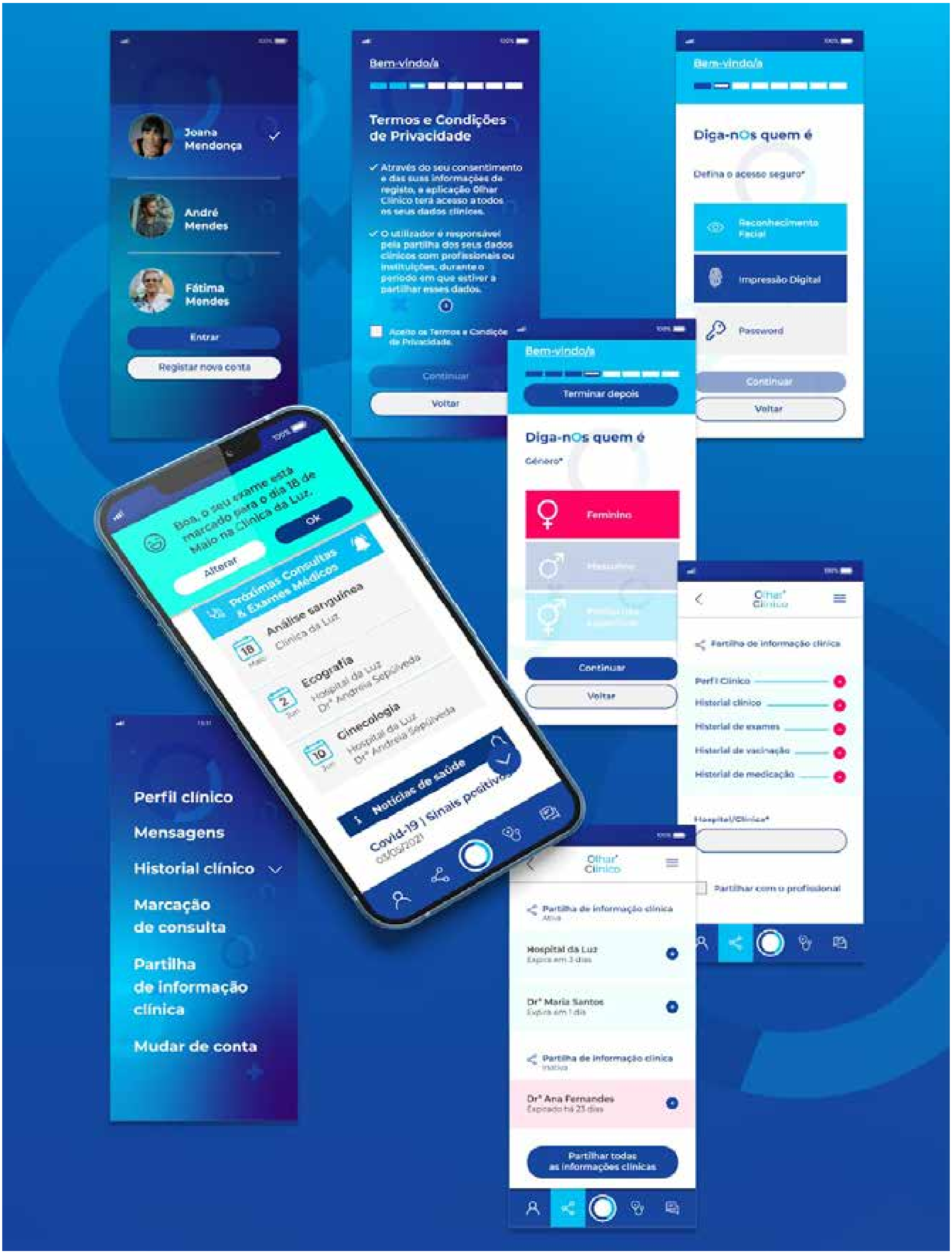

Figure 11. Final prototype of Olhar Clínico.

The fact that patients are the owners of their data is desirable but not perfect. We believe in the possibility of patient control over his/her data to some extent. Healthcare facilities must be informed of patients' clinical history to some point, for instance emergency entries where patients are not conscious or are carriers of communicable diseases that might harm public health. Without considering these situations, healthcare facilities could not provide their services effectively.

8. Conclusions

The RtD approach helped us define a strategy to a wicked problem. The mobile application Olhar Clínico, after the user's informed consent, sends a request to the healthcare facilities asking for their medical records in order to gather past clinical data. Our strategy was to avoid political influence to solve this issue or a total transformation in the healthcare Portuguese system. In the evaluation phase, we observed users navigating through the application without concerns. The users were happy with this solution and the SUS scores validate this.

The blockchain technology usage is a possible approach to the privacy concerns and our participants agreed with it—avoiding sensitive data leaks by healthcare facilities or third parties. Users are informed in the registration process; however, that is not enough. For instance, according to a 2017 survey, 91% of American users accept legal terms and conditions blindly (Deloitte, 2017). Due to these concerns, we carefully designed the terms and conditions screen with a short summary with the most important aspects of the legal agreement and the option to read it all without leaving the screen.

Overviewing our product's intentions and the system's careful care towards the patient, the advantages overcome the disadvantages. By facilitating the communication between patients seeking second medical opinions and doctors in first appointment conversations, healthcare providers benefit from the quality of the services (Xiau et al., 2012). The mobile application Olhar Clínico, by providing patients with their medical records across private and public healthcare facilities, could soften the distinction between the two services, promoting a cohesive and united healthcare system.

5.1. Limitations and Opportunities for Future Research

Some limitations of this study are the reduced number of participants used in the data collection, which could be strengthened with future research with a quantitative perspective. Furthermore, the final prototype was not implemented (coded) and not used with real patients currently in the healthcare system (live and in loco)—which can be done in future research. Lastly, the study was limited to Lisbon, Portugal's capital city; however, Portugal has many regions with different scales and necessities, and further research with those users might bring about improvements to the design.

References

Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-centered design. In: Bainbridge, W. (Ed.), Encyclopedia of Human-Computer Interaction, (pp. 445–456). Thousand Oaks: Sage Publications.

Adler, P.J. (2005). Dealing with interviews when creating personas: A practical approach. In Proceedings of Student Interaction Design Research Conference SIDER05 (pp. 84-88). Sønderborg: University of Southern Denmark.

Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS scores mean: Adding an adjective rating scale. Journal of usability studies, 4(3), 114–123.

Bodkhe, U., Tanwar, S., Parekh, K., Khanpara, P., Tyagi, S., Kumar, N., & Alazab, M. (2020). Blockchain for industry 4.0: A comprehensive review. IEEE Access, 8, 79764-79800.

Camillus, J.C. (2008). Strategy as a wicked problem. Harvard Business Review, 86(5), 98-101.

Chen, C-L., Deng, Y-Y., Weng, W., Sun, H., & Zhou, M. (2020). A Blockchain-based secure inter-hospital EMR sharing system. Applied Sciences, 10(14), 4958.

Crisp, N. (2015). The future of the Portuguese health system. Acta Médica Portuguesa, 28(3), 277–280.

Cushman, R., Froomkin, A.M., Cava, A., Abril, P., & Goodman, K.W. (2010). Ethical, legal and social issues for personal health records and applications. Journal of Biomedical Informatics, 43(5 Suppl), S51–S55.

Delaney, L. (2018). Patient-centred care as an approach to improving health care in Australia. Collegian, 25(1), 119–123.

Deloitte (2017). 2017 Global Mobile Consumer Survey: US edition The dawn of the next era in mobile. Available online: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology-media-telecommunications/us-tmt-2017-global-mobile-consumer-survey-executive-summary.pdf

Groeneveld, B., Melles, M., Vehmeijer, S., Mathijssen, N., Dekkers, T., & Goossens, R. (2019). Developing digital applications for tailored communication in orthopaedics using a Research through Design approach. Digital Health, 5, 205520761882491

Groeneveld, B.S. (2020). Talking the walk: Applying data-driven patient profiles in the design of tailored services in orthopaedics (Doctoral dissertation, Delft University of Technology).

Haas, S., Wohlgemuth, S., Echizen, I., Sonehara, N., & Müller, G. (2011). Aspects of privacy for electronic health records. International journal of medical informatics, 80(2), e26–e31.

Hamilton, D.K. (2008). Wicked problems, black swans, and healthcare. HERD Health Environments Research & Design Journal, 2(1), 44–47

Hassani, H., Huang, X., & Silva, E. (2018). Big-Crypto: Big data, blockchain and cryptocurrency. Big Data and Cognitive Computing, 2(4), 34.

ISO/DIS 20282-1 – Ease of operation of everyday products – Part 1: Context of use and user characteristics.

ISO/DIS 9241-11 – Ergonomics of human-system interaction – Part 11: Usability: Definitions and concepts.

ISO/DIS 9241-110 – Ergonomics of human-system interaction – Part 110: Interaction principles.

ISO/DIS 9241-112 – Ergonomics of human-system interaction – Part 112: Principles for the presentation of information.

ISO/FDIS 9241-306 – Ergonomics of human-system interaction – Part 306: Field assessment methods for electronic visual displays.

Levinson, W. (2011). Patient-centred communication: a sophisticated procedure. BMJ Quality & Safety, 20(10), 823–825.

McCracken, E.C., Stewart, M.A., Brown, J.B., & McWhinney, I.R. (1983). Patient-centred care: The family practice model. Canadian Family Physician, 29, 2313–2316.

names, dates, reference to a source publication, etc.), should also be given.

Olsson, L. E., Hansson, E., Ekman, I., & Karlsson, J. (2009). A cost□effectiveness study of a patient□centred integrated care pathway. Journal of advanced nursing, 65(8), 1626–1635.

Perera, G., Holbrook, A., Thabane, L., Foster, G., & Willison, D.J. (2011). Views on health information sharing and privacy from primary care practices using electronic medical records. International journal of medical informatics, 80(2), 94–101.

Rathert, C., Wyrwich, M.D., & Boren, S.A. (2013). Patient-Centered Care and Outcomes: A Systematic Review of the Literature. Medical Care Research and Review, 70(4), 351–379.

Ray, P. (n.d.). The Advantages and Disadvantages of Electronic Health Records (poster). Johns Hopkins University School of Nursing. Available online: https://nursing.jhu.edu/faculty_research/research/opportunities/fuld/documents/cohort-1/posters/prema-ray.pdf

Rennock, M.J., Cohn, A., & Butcher, J.R. (2018). Blockchain technology and regulatory investigations. Practical Law Litigation, 35–44.

Reti, S.R., Feldman, H.J., Ross, S.E., & Safran, C. (2010). Improving personal health records for patient-centered care. Journal of the American Medical Informatics Association, 17(2), 192–195.

Ross, S.E., & Lin, C.T. (2003). The effects of promoting patient access to medical records: a review. Journal of the American Medical Informatics Association: JAMIA, 10(2), 129–138.

Saldaña, J. (2021). The Coding Manual for Qualitative Researchers. Thousand Oaks: Sage Publications.

Schlatter, T, & Levinson, D. (2013). Visual usability: Principles and Practices for Designing Digital Applications. Burlington: Morgan Kaufmann.

Stappers, P.J. & Giaccardi, E. (2002). Research through Design. In: The Encyclopedia of Human-Computer Interaction, 2nd. Ed. Chapter 43. Interaction Design Foundation.

Xiao, N., Sharman, R., Singh, R., Singh, G., Danzo, A., & Rao, H. R. (2012). "Meaningful Use" of ambulatory EMR: Does it improve the quality and efficiency of health care?. Health Policy and Technology, 1(1), 28–34.

Zazelenchuk, T. (2009). DataLogger V5.0 [Computer software].

Zimmerman, J., Stolterman, E., & Forlizzi, J. (2010). An analysis and critique of Research through Design: towards a formalization of a research approach. In DIS '10: Proceedings of the 8th ACM Conference on Designing Interactive Systems (pp. 310-319). New York: ACM.