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Promoting healthcare for refugees via information and communication technologies: a gamification approach

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Abstract

This dissertation explores mobile health (mHealth) solutions to strengthen vulnerable groups, such as refugee communities and creates a mobile application, HealthBridge, tailored to these populations' specific requirements and conditions.

To lay the theoretical groundwork and comprehend the current state of mHealth applications, the study starts by completing an exhaustive literature review.

The target audience's needs are then gathered using a user-centred design methodology, ensuring that their voices and preferences define the features and functionalities of the HealthBridge app. The development phase entails prototyping and refining the application through iterative design cycles. A prototype is created using high-fidelity renders, eventually evolving into a more advanced prototype. This iterative process allows continuous improvement and integration of user-friendly interfaces that enhance accessibility and usability.

To evaluate the effectiveness and usability of the prototype, usability testing is conducted. The methodology involves recruiting participants, creating test scenarios, and employing relevant metrics to measure usability. The findings and results from these testing sessions provide valuable insights into user experiences, identifying areas of success, challenges, and user struggles. The study's conclusion summarises the project's important learnings and contributions based on the research. Additionally, it analyses the shortcomings found and offers potential future developments for the HealthBridge app's expansion and improvement.

Ultimately, this work seeks to use mHealth solutions to close the healthcare access gap and strengthen exposed communities. HealthBridge strives to educate and empower refugees by creating a specific smartphone application, giving them a reliable and easily-accessible tool for managing their health and well-being in their new surroundings.

Keywords: Refugees, Mobile App, Mobile Game, Health, Well-being, Gamification.

Resumo

Esta dissertação explora soluções de saúde móvel (mHealth) para reforçar grupos vulneráveis, como as comunidades de refugiados, e cria uma aplicação móvel, HealthBridge, adaptada aos requisitos e condições específicos destas populações.

Para estabelecer as bases teóricas e compreender o estado atual das aplicações de saúde móvel, o estudo começa por realizar uma revisão exaustiva da literatura.

As necessidades do público-alvo são depois recolhidas utilizando uma metodologia de conceção centrada no utilizador, garantindo que as suas vozes e preferências definem as características e funcionalidades da aplicação HealthBridge. A fase de desenvolvimento implica a criação de protótipos e o aperfeiçoamento da aplicação através de ciclos de conceção iterativos. É criado um protótipo utilizando renderizações de alta fidelidade, evoluindo eventualmente para um protótipo mais avançado. Este processo iterativo permite a melhoria contínua e a integração de interfaces de fácil utilização que melhoram a acessibilidade e a usabilidade.

Para avaliar a eficácia e a usabilidade do protótipo, são efectuados testes de usabilidade. A metodologia envolve o recrutamento de participantes, a criação de cenários de teste e a utilização de métricas relevantes para medir a usabilidade. As conclusões e os resultados destas sessões de teste fornecem informações valiosas sobre as experiências dos utilizadores, identificando áreas de sucesso, desafios e dificuldades dos utilizadores. A conclusão do estudo resume as aprendizagens e contribuições importantes do projeto com base na investigação. Além disso, analisa as deficiências encontradas e oferece potenciais desenvolvimentos futuros para a expansão e melhoria da aplicação HealthBridge.

Em última análise, este trabalho procura utilizar soluções de saúde móvel para colmatar as lacunas no acesso aos cuidados de saúde e reforçar as comunidades expostas. A HealthBridge esforça-se por educar e capacitar os refugiados através da criação de uma aplicação específica para smartphone, dando-lhes uma ferramenta fiável e de fácil acesso para gerir a sua saúde e bem-estar no seu novo ambiente.

Palavras-chave: Refugiados, Aplicação móvel, Jogo móvel, Saúde, Bem-estar, Gamificação.

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Abbreviations and Symbols

ACeS	*Agrupamento de Centros de Saúde* - Grouping of Health Centres
ACSS	*Administração Central do Sistema de Saúde* - Central Administration of the Health System
APP	Application
FAQ	Frequently Asked Questions
ICT	Information and Communication Technologies
ISO	International Standards Organization
mHealth	Mobile Health
SNS	*Serviço Nacional de Saúde* - Portuguese National Health Service
UCD	User-Centred Design
UN	United Nations
UX	User Experience
WWW	*World Wide Web*

Chapter 1

Introduction

This dissertation focuses on promoting healthcare and delivering first aid services to refugees and other newcomers to a host country. By taking advantage of the wide availability of ubiquitous mobile technologies in the daily life of almost everyone in today's society, mHealth could be a solution for delivering these services safely and making medically correct information widely available.

This first chapter details the context of the dissertation, its motivations, the definition of initial and final objectives to be achieved during the development of this work, and the structure applied to this document.

1.1 Contextualisation

In recent times, the number of displaced people has drastically increased globally. The main reason for that may be easily identified as the emergence of new conflicts, such as the war in Ukraine [1], in addition to the continuation of older and as important ones like the wars in Syria, the Taliban conflict in Afghanistan and the social-economic instability in Venezuela [2]. With all those tragic events, the number of refugees coming to Europe seeking shelter and a better life is at its highest [3], as referenced by Ociepa-Kicinska and Gorzalczynska-Koczkodaj [1, p.1], *"Within the first six days of the war in Ukraine, the number of Ukrainian refugees exceeded 4 million, which is more than twice the total number of incomers who arrived in Europe during the Syrian migration throughout 2015"*. Also, Figure 1.1 allows an understanding of the big picture of the drastic increase in European migration rates when comparing the 2022 flux originating in Ukraine and the 2015 Syrian flux.

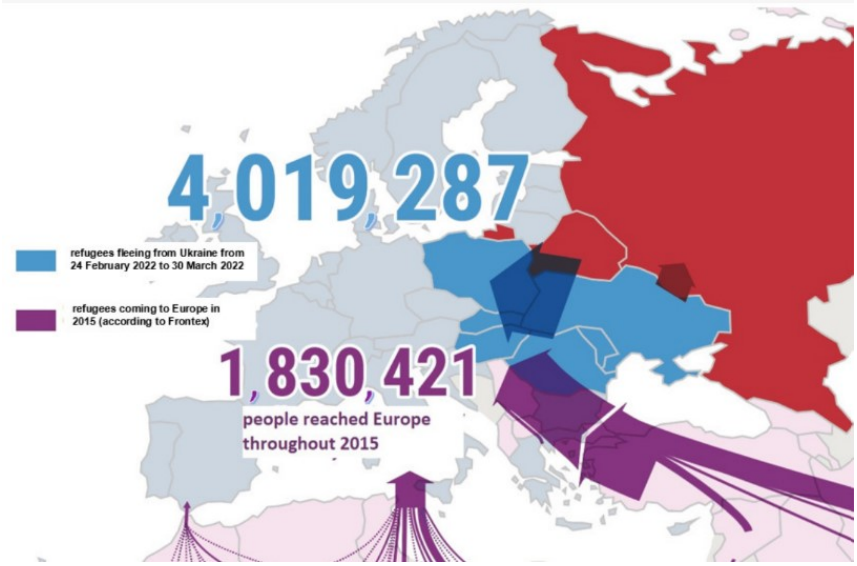


Figure 1.1: Comparison between migration rates 2015 and the start of 2022. Adapted from [1]

Refugees are ordinary people, but they have lost or had to leave everything they have behind. They seek a new home where they can work, contribute to society, and their children can go to school [3]. Like us, they want to live with dignity, freedom and security. They have been exposed to traumatic and violent events which can effortlessly scar their mental well-being [4]. In addition, the already difficult task of adapting to a new and unknown country can bring loneliness and social exclusion, pressuring these individuals' already precarious mental health. So, there is an urge to find the correct response to refugees' needs. When looking at coping mechanisms for this social problem, it is evident that European healthcare professionals are correctly trained and ethically obligated by law to prepare a response to public health problems related to the refugee flux [5]. Despite that, a window of opportunity exists to help a refugee reach the correct aid.

1.2 Motivation

We should look for ways to ensure that a person coming to an unfamiliar country has a vast range of means to access appropriate healthcare. Hence, the easiest and most obvious method of reaching the highest volume of people simultaneously is using their phones and the internet [6]. The development of Information and Communication Technologies (ICT), which represents a wide range of technological tools used to transmit, process and store data, presents one of the most effective ways to allow refugees access to the help they need to cope with the drastic changes in their lives [7, 8].

In a way, ICTs are already used by refugees, mainly for keeping in touch with family and friends, but when applying these technologies to the healthcare sector, eHealth or mHealth solutions (when regarding their mobile component) [7, 8] surface as powerful methods used to open the door for easy and safe access to healthcare and medical information services. Their usefulness comes in many ways, more significantly by supporting and improving the overall access to

healthcare and promoting public health within a refugee population in a new country [7]. Incorporating a gaming aspect to these approaches allows users to engage more with the process, improving their experience and the app's effectiveness [9]. Serious games are a great example of this incorporation. When comparing serious games to entertainment games, serious games inherit gameplay characteristics (gamification) from entertainment games. However, the main focus of this approach is the lessons that can be learnt and applied in real-life environments, thanks to these types of apps [9].

The United Nations' Sustainable Development Goals [10], established by the UN General Assembly in 2015, are a set of seventeen objectives that aim to eradicate poverty, preserve the environment, and ensure the prosperity of all people by 2030. Each one of the goals is further divided into precise targets and indicators that offer a framework for gauging its development. In particular, when looking at the problem at hand, this agenda makes it easier to understand the importance, value and benefits of mHealth solutions for refugees, as they are associated with three of the seventeen goals (Figure 1.2):

- **Goal 3**: Good health and well-being; "Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and safe, effective, quality and affordable essential medicines and vaccines for all" [10].
- **Goal 10**: Reduce Inequality; "Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies" [10].
- **Goal 17**: Partnership for the goals; "Strengthen the means of implementation and revitalise the global partnership for sustainable development" [10].



Figure 1.2: UN's Sustainable Development Goals associated with this approach, adapted from [10]

1.3 Objectives

To effectively address these challenges, it is important to establish a clear set of objectives that will provide a comprehensive understanding of the research questions and specific goals for the study. Therefore, initial work should focus on exploring the perceptions and attitudes of refugees towards technologies in general, their access to mobile devices, and their view and knowledge of mHealth, including factors that may influence their uptake and use of these solutions. Then, the work should focus on collecting data regarding the current state of mHealth utilisation among refugees and identifying any barriers or challenges to its adoption.

Then, with all that information, identifying the best practices and critical considerations for successfully implementing mHealth interventions with refugees will be achieved, including data privacy, security, cultural sensitivity and user engagement solutions. Consequently, the final goal is to apply all the knowledge and data collected on the design and development of a prototype mobile application, with hints of gamification, that groups of refugees can use and, ultimately, can provide the first-degree aid they need to feel included, by engaging them in the new community, helping them manage change and maintain their well-being. The final objective focuses on evaluating this prototype among potential users, obtaining feedback on the prototype and allowing the correction of negative features within the prototype's concept.

In accordance, the challenge presented by this dissertation can be broken down into the following objectives:

(i) **Investigate and Understand the Current Context of mHealth**: This objective aims to thoroughly examine the existing landscape of mHealth solutions and their significance for fragile communities.

(ii) **Establish a Methodology**: This objective involves establishing a systematic approach to guide and develop the mobile app. It also includes defining the project scope and outlining key tasks and procedures, ensuring a structured and organised approach to the project.

(iii) **Gather Requirements from the Target Population**: This objective focuses on gathering requirements from the target population. Through interviews, surveys, or user feedback sessions, the objective is to understand the unique needs, preferences and challenges the target population faces in accessing and managing healthcare services. Additionally, the gathered requirements will set ground rules for the design and development of the mobile app, ensuring its relevance and effectiveness.

(iv) **Develop an Initial Mock-up Prototype**: Following the work plan, this objective focuses on the creation of an initial mockup prototype for the HealthBridge app. Using user-centred design principles, the requirements gathered from the target population will be translated into a visual representation of the app's interface and basic functionalities. This prototype will serve as a starting point for further refinement and development.

(v) **Develop an Operating Prototype**: Building upon the initial mockup prototype, this objective involves the development of an operational prototype. The goal is to create a fully functional version of the mobile app with enhanced features, supported by the literature review findings and data gathered.

(vi) **Conduct Usability Testing**: This objective evaluates the mobile app's operative prototype through usability testing. The objective is to gather feedback, identify areas of improvement, and measure the app's usability and user satisfaction. Usability testing will be conducted in multiple phases to ensure comprehensive insights and maximum data extraction.

1.4 Structure

As said before, the present chapter, "Introduction", introduced the project's contextualisation and motivation and defined its final objectives. In the rest of the document, seven complementary chapters are presented.

Chapter 2, "Background", aims to provide a comprehensive understanding of the key concepts that form the foundation of the research. It will delve into topics related to mHealth and explore the user-app interaction concept, establishing a theoretical framework that guides this paper.

Chapter 3, "State of the Art," is related to objective (i), and it sets the theoretical foundation for the developed mHealth system by examining the existing literature about the project's core principles. Ultimately, this chapter establishes the theoretical framework that informs the subsequent development and evaluation of the mHealth application by critically examining the relevant literature.

Chapter 4, "Methodological Approach", is connected to objective (ii), outlining the approach and steps to develop the mobile app after extensive research and data collection on existing mHealth applications. Besides, this chapter traces the strategies used to maintain a user-centred design philosophy that will support the development process.

Chapter 5, "Requirements Definition", is linked with objective (iii), delving into the crucial process of gathering requirements for developing the mobile app. The chapter begins by outlining the methodology for gathering requirements. Furthermore, the chapter overviews the identified requirements by analysing the gathered data and underlining the key themes and patterns that emerged during the process.

Chapter 6, "HealthBridge App", provides an in-depth description of the development process, highlighting the crucial steps and design decisions made throughout the prototyping stage, attaching itself to objectives (iv) and (v). In other words, it provides a thorough overview of the system's development from the first ideas to the finished prototype, beginning with an overview of the general development strategy used. The chapter may include visual representations or screenshots of the different prototypes and interface iterations to provide readers with a comprehensive understanding of the app's design journey.

Chapter 7, "Usability Testing", coupled with objective (vi), comprehensively describes the methodology and procedures employed during the testing phase of the mobile app. It highlights the steps taken to ensure the effectiveness of the testing process, delves into the created testing scenarios, and emphasises the importance of aligning the test scenarios with the app's core functionalities and user goals, ensuring that the testing process captures essential aspects of the user experience. Finally, the chapter discusses the results gathered from the testing phase, highlighting key observations, user struggles, and areas of success, providing valuable insights into the strengths and weaknesses of the app's user interface and overall usability.

Chapter 8, "Conclusions and Future Work", is the last one, and it encapsulates the culmination of the research journey undertaken in previous chapters, consolidating the theoretical foundations, literature review, user-centred design approach, and the development and testing phases of the mobile app. On top of that, it acknowledges the need for continued collaboration, evaluation, and refinement to ensure the app's effectiveness and adaptability in addressing the unique healthcare needs of vulnerable populations.

Chapter 2

Background

In the last chapter, an introduction to the basic concepts of this project was made. This second Chapter will highlight the main aspects of those essential concepts, supporting this dissertation's theoretical framework. It will also explore User-App Interaction concepts considered vital for developing a mobile app.

2.1 Basic Concepts

Technology has integrated itself into every aspect of our everyday lives in today's quickly changing world. Information and Communication Technology (ICT) transformed how we interact, work and learn [11]. We can now access healthcare services remotely thanks to Mobile Health (mHealth), and Gamification has increased the enjoyment and engagement of learning and skill development [9]. These fundamental ideas have revolutionised how we use technology and created new possibilities for us to lead better lives. This part will examine these ideas and their uses and advantages in many fields.

2.1.1 ICT

Information and Communication Technologies refer to a wide range of technological tools that facilitate communication and access to information. ICT includes hardware, software, networking technologies, and applications and services that transmit, process, and store data [11]. Some examples of ICT include computers, smartphones, tablets, the internet and various communication systems.

ICT is now crucial in many economic and educational fields, and it may make it easier for vulnerable groups, like refugees, to receive vital services and assistance [12]. ICT can also offer refugees precious support in healthcare [13]. Language problems, cultural differences, and restricted access to healthcare facilities are a few of the considerable obstacles many refugees confront while trying to access healthcare services [12]. By offering information and remote healthcare services, ICT can aid in overcoming these obstacles. For instance, telemedicine enables refugees remote access to medical care and consultations. With this technology, refugees

can communicate with medical professionals who are fluent in their language and aware of their cultural traditions and needs [13]. Additionally, it gives individuals a more practical and easy means to get medical treatment, particularly for people who reside in isolated or disadvantaged locations. Information and Communication Technologies can also make it easier to share resources for education and healthcare [13]. For instance, mobile health apps or websites that provide information on precautions, health concerns, and treatment alternatives are available to refugees [13]. It is possible to modify this information to suit their unique linguistic and cultural requirements better, making it more straightforward for them to comprehend and use [14].

Overall, ICT has the potential to completely transform how refugees are supported in terms of their healthcare, giving them access to better, more inexpensive, and more effective medical treatment [15]. Healthcare professionals may enhance the standard of care given to refugees and ensure they get the assistance they need to maintain their health and well-being by utilising technology [15].

2.1.2 mHealth

Mobile Health (mHealth) refers to the practice of medicine, supporting public health, with mobile devices, such as smartphones, tablets, and wearable technology, helping healthcare services [7, 8].

Nowadays, the presence of mobile technologies is visible all over the globe, including in developing countries. Therefore, using mHealth can revolutionise healthcare delivery, particularly in resource-limited settings of vulnerable populations, such as refugees, for whom specialised help may not be readily available [16]. By enabling remote access to medical care, enhancing health education and awareness, and facilitating the collection and analysing of health data, mHealth has grown in popularity in the healthcare industry. mHealth can increase refugees' access to medical treatment, particularly in emergencies where conventional medical facilities are unavailable [17]. Getting healthcare services remotely is one of mHealth's main advantages, especially in emergencies or when residing in isolated places, refugees might need access to conventional healthcare facilities [17]. Refugees can now contact healthcare professionals and get treatment and advice from any location, anytime, thanks to mHealth technologies. Plus, for refugees, mHealth can enhance health literacy and awareness, information on precautions, and health concerns to be aware of [8]. These resources can be modified to meet their unique linguistic and cultural requirements, making them simpler to comprehend and use [8]. Additionally, mHealth can make it easier to gather and analyse health data. Using mobile devices, healthcare professionals can collect health information on refugees, such as vital signs, symptoms, and medication adherence [7, 8]. This information can be used to uncover patterns and trends in health and guide decisions about healthcare and policy.

In summary, mHealth offers the chance to help refugees receive better healthcare and support, especially in emergencies where conventional healthcare facilities might not be accessible. Using mobile devices and applications, healthcare professionals can engage with refugees and offer them necessary healthcare treatments, education, and support [17]. Additionally, mHealth can facilitate

the gathering and analysis of health data, which can help with policy formulation and healthcare decision-making to better serve populations of refugees [17].

2.1.3 Linking ICT and mHealth

Information and Communication Technologies and mHealth are related but distinct concepts. On the one hand, ICTs refer to a wide range of technologies and tools that facilitate communication [13]. On the other hand, mHealth refers specifically to mobile technologies, such as smartphones, used to deliver healthcare services and information. mHealth technologies can support a wide range of healthcare activities, including disease prevention and management, telemedicine and public health surveillance [7]. For example, thanks to telemedicine, refugees can receive medical attention and consultations whenever they want [18]. Healthcare professionals can interact with refugees, offer them medical advice, and, if necessary, prescribe medication by utilising mobile devices and software [18]. This can be especially beneficial for refugees who reside in isolated or underdeveloped locations without access to traditional healthcare services [18]. Another example is that health data gathering and analysis can be made possible through ICT and mHealth [19]. Using mobile devices and applications, healthcare professionals can gather patient health information from refugees, such as vital signs, symptoms, and medication adherence. Analysing this data can reveal health trends and patterns, which can help with policy and decision-making in the healthcare industry [19]. For instance, health information gathered from immigrants can be used to track the spread of infectious diseases, identify disease outbreaks, and create focused treatments to meet particular health needs [20]. A third and final example is that ICT and mHealth can give refugees access to health education and awareness resources [21]. Information on precautions to take, health concerns to be aware of, and available treatments can be found on websites and mobile applications for refugees [22]. These resources can be modified to meet their cultural and linguistic requirements, making them more straightforward to comprehend and use [23].

In short, ICTs are a broad category of technologies supporting communication and information access. At the same time, mHealth refers specifically to the use of mobile technologies for healthcare purposes and can be categorised as a specific ICT category (as it is visible in Figure 2.1) for securing healthcare access to people in need, for example, refugees.

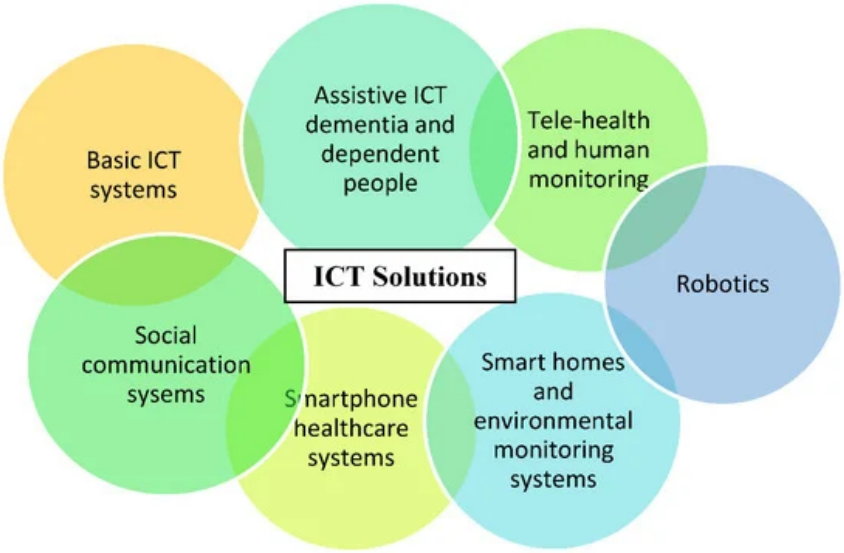


Figure 2.1: Different categories of ICT solutions from the simplest technologies. Adapted from [24]

2.1.4 Gamification

Besides the concept of mHealth, Chapter 1 also briefly introduced the concept of Gamification. This concept refers to the technique that leverages game elements and mechanics to engage users, enhance their motivation, and facilitate learning. It has gained significant attention in various fields, including education, marketing, and healthcare [9].

On the one hand, games built with a primary goal rather than sheer entertainment are known as serious games [25]. To provide memorable experiences and promote learning, they include educational content, engaging challenges, and task-based activities [26]. Healthcare organisations have utilised serious games to train staff members and encourage patients to adopt healthier habits. They offer an immersive and dynamic setting that makes it easier to learn new things and hone existing skills. On the other hand, a method called game-based learning uses video games as a teaching aid [27]. It entails creating games with educational objectives and using instructional content and game mechanics to promote learning and skill development. It has been demonstrated that game-based learning improves motivation, engagement, and memory. It makes learning more engaging and successful by enabling learners to actively engage in the process, explore various scenarios, and get rapid feedback. Therefore, even though serious games and game-based learning are separate ideas, "gamification" is frequently used to refer to both strategies for simplicity [28]. Gamification integrates game components, such as points, badges, leaderboards, and challenges, into contexts that are not games, such as healthcare and education [29]. It seeks to improve the experience's engagement, inspiration, and enjoyment to improve learning results.

This dissertation will use gamification as the overarching concept to integrate game elements and mechanics to enhance engagement and learning [25, 26]. By incorporating gamification techniques, organisations and applications can create interactive and immersive experiences that capti-

vate users' attention, promote active participation, and facilitate the acquisition of knowledge and skills [27].

2.1.5 Gamification and its Role in mHealth

Gamification can be used in healthcare to increase patient engagement and encourage healthy habits [29]. For instance, game features can be incorporated into mobile applications to enable users to engage in healthy behaviours like working out, eating healthily, and taking their medications as prescribed [30]. Gamification can inspire people to adopt better habits and manage their health more successfully by making these activities more enjoyable and rewarding [29]. On top of that, Gamification can be used to teach people about medical-related subjects [25]. Healthcare professionals, for example, can create games that instruct people about disease prevention, symptom management, and treatment alternatives [26]. Since these games may be customised for various age groups and cultural backgrounds, they are more appealing and valuable for particular target audiences [26]. Gamification can also help refugees receive better healthcare outcomes [27]. For instance, smartphone apps might be created to inform refugees about the availability of resources and emergency procedures in their new community [27]. To encourage refugees to interact with the material and learn more successfully, these applications can be created to include gaming dynamics like challenges and quizzes [27].

In a nutshell, gamification is an effective strategy that can be applied in the healthcare industry to increase patient engagement, encourage healthy lifestyles, and inform people about various health-related issues [29, 30]. Gamification can be particularly useful in the context of refugees in improving health education, making access to healthcare facilities more accessible, and enabling people to take charge of their health and well-being [9]. Healthcare practitioners can offer more entertaining and practical support to refugees and vulnerable populations by adding game design principles and mechanics into healthcare services [25, 26].

2.2 User-App Interaction

User interaction with a software program or application is known as User-App interaction. This can be done in various ways, such as typing, clicking, scrolling, swiping, and more [31]. The user-app interaction generally refers to how the user interacts with the application and how the application reacts to that interaction [31]. From the developer's point of view, the aim is to make this interaction as simple and user-friendly as possible so that the user can complete duties and reach their objectives within the application [32]. Hence, the developer should apply techniques, methods, and best practices to designing, evaluating, and implementing computer systems to improve overall User Experience, engagement and credibility [33].

2.2.1 User Experience

The User Experience (UX) is a critical aspect of user-app interaction because it refers to a user's general experience while using an application. Numerous elements, including the application's usability, functionality, accessibility and style, all fall under the umbrella of the User Experience [34]. An enjoyable User Experience can lead to greater user satisfaction, high engagement, better retention rates, positive user testimonials and user-generated recommendations [35]. However, a poor User Experience can result in irritated users, poor engagement and unfavourable evaluations and feedback [35]. Therefore, it is impossible to overstate the significance of the User Experience in user-app contact, and the following reasons validate its importance:

- **Increases user engagement and satisfaction**: Users are likelier to use and engage with an application with a good UX. A good UX provides users with an enjoyable and fulfilling experience, making them more likely to return to the application.
- **Reduces user frustration**: An application's user may become frustrated and depart if the UX is subpar. This could lead to low retention rates and unfavourable feedback, harming the application's image.
- **Improves conversion rates**: Users are likelier to carry out a desired action, such as making a purchase or filling out a form, when the User Experience is positive.
- **Enhances reputation**: An application's image and the brand it represents can both be improved by a strong UX. If users have a good application experience, they are likelier to tell others about it.

Applications must be developed and designed to meet the target audience's requirements and expectations while being intuitive, simple to use, and visually appealing [34]. Software developers can build applications more likely to be adopted, used, and recommended by users by prioritising the User Experience during development [34, 35].

2.2.2 Engagement

Engagement is a crucial aspect of User-App interaction that dramatically affects an application's success. It is a term used to describe how involved, interested, and satisfied a user is while using the software [36, 37]. User Experience (UX) and engagement are closely linked because high levels of engagement require excellent UX. A strong User Experience increases the likelihood that an application will be engaging because it gives users a satisfying and enjoyable experience [37]. As a result, users may interact with the application more frequently and take the desired actions, which can increase user engagement. As a result, it is essential to prioritise user-app interaction involvement and to create applications that are interesting to use. This can be accomplished by concentrating on crucial elements for a good UX, such as usability, functionality, accessibility, and style [34].

Adopting this aspect in mHealth solutions is significant, as sustained engagement is critical for achieving long-term behaviour change and improving health outcomes [38].

2.2.3 Credibility

Credibility, another crucial component of user-app interaction, is vital for software applications. A credible, trustworthy, and accurate app will probably acquire user engagement, trust, positive feedback, enhancing usage, satisfaction, and loyalty [39]. On the other hand, a less dedicated app may cause user annoyance, low engagement, and unfavourable reviews, which could be detrimental to the app's reputation and brand. Credibility must be prioritised in app design and development to ensure a favourable User Experience and the app's success [34].

Since mHealth apps aim to encourage health and well-being, their credibility is essential to their success [40]. Users are more likely to believe in a mHealth app if it has credibility, which is the perception that it is dependable, trustworthy, and honest. Users are more likely to use and suggest an app they trust, which can increase user's happiness and adherence to health goals [41].

Chapter 3

State Of The Art

A systematic review of the existing literature was conducted to produce a solid bibliographic analysis, locating and organising essential data for future steps. The following sections will carefully and meticulously display the procedures followed in this stage.

Also, this information was gathered and organised, resulting in an article titled "Promoting healthcare for refugees via information and communication technologies: a systematic review", submitted to the Journal of Immigrant and Minority Health (JOIH), from the academic publisher Springer, with ID: JOIH-D-23-00195.

3.1 Methods

A systematic review is a method that enables the collection, evaluation, and synthesis of all available evidence on a particular topic. This systematic review followed the PRISMA statement guidelines and checklist [42]. It started with the planning and execution of a Research Strategy 3.1.1 followed by a Material Selection 3.1.3 from the research's results.

3.1.1 Research Strategy

The first step taken within the systematic review was the generation of research questions:

1. Do refugees have access to mobile phones, and if so, what mobile applications do they use?
2. Which mHealth applications or games have been developed in recent years?
3. How are mHealth applications or games applied?
4. What are these technologies' main characteristics?

These questions were drawn up with the support of the initial objectives, present in 1.3, and traced the path to valuable information as they were answered after analysing the research results.

To obtain an exhaustive summary of the literature, the search was conducted in three different databases: PubMed, SCOPUS and CINAHL. The research queries used in each database

were defined after several preliminary tests using different combinations of topic-related terms and Boolean operators (AND, OR and NOT). Hence, the following queries were assembled and used in the respective database:

- **PubMed** and **CINAHL**: ((Refugee) AND (Video Game OR Game OR Experimental Game OR Gamification OR Serious game OR Simulation Game OR Mobile game OR Mobile App OR Mobile Application OR Electronic game OR Website OR Gamified OR App OR Mobile) AND (Health OR Well-being))
- **Scopus**: (TITLE-ABS-KEY(("Refugee")) AND TITLE-ABS-KEY(("Game") OR ("Video Games") OR ("Virtual game") OR ("Games Recreational") OR ("Gamification") OR ("Mobile game") OR ("Mobile App") OR ("Mobile Application") OR ("Website") OR ("gamified") OR ("App") OR ("Mobile")) AND TITLE-ABS-KEY ("health") OR ("well-being"))

Extra studies were added to the reference list due to Backward Citation Searching, consulting the references of the included studies.

3.1.2 Results Obtained

The query inserted in each database on October 2022 produced the number of different results illustrated by Table 3.1.

Table 3.1: Results obtained in each database search

Database	Number of results
PubMed	147
CINAHL	70
SCOPUS	231

The research totalled 448 articles published between 2017 and 2022.

3.1.3 Material Selection

These articles were then exported from the databases and imported to Rayyan QCRI®(Systematic Reviews web app), allowing easier data access and initial screening. Papers were reviewed and selected according to the criteria included in Table 3.2.

Table 3.2: Eligibility criteria used for the selection of the articles

Inclusion criteria	**Exclusion criteria**
• Articles that address a population of refugees with healthcare problems assisted by Mobile Applications or Games.	• Articles that do not target a population of refugees. • Articles that do not include Mobile Applications, Games or Websites. • Articles that address Mobile Applications, Games or Websites for scholarly education purposes rather than health education

The 448 results were evaluated according to their relevance for inclusion in the following four stages:

- In the first stage, the duplicates were eliminated, leaving 279 different articles and the articles were checked by its title. After this first stage, all titles were reviewed, and 92 records were excluded.
- In stage two, the remaining 187 articles were examined by reading their abstracts, resulting in 148 articles being excluded at this stage.
- In the third stage, 39 articles were screened by reading the complete text, and 20 were excluded.
- In the fourth and final stage, a cross-referencing of the selected 19 articles was conducted, adding four new articles to the review.

So, after the selection process, a total of 23 articles were selected for review in a detailed analysis that will be presented in the next Chapter. Figure 3.1 summarises this process.

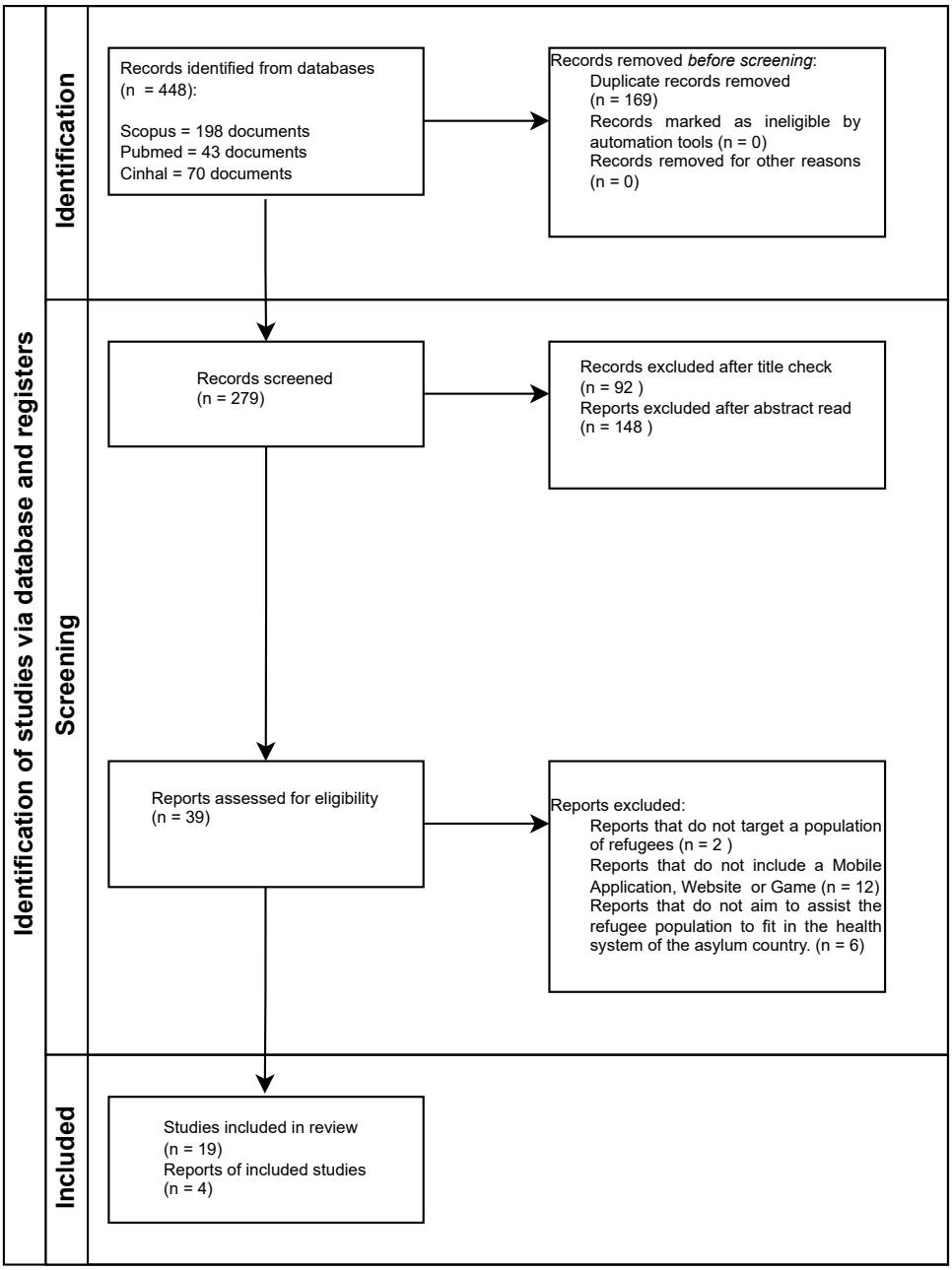


Figure 3.1: Selection process of the articles reviewed in the current study – PRISMA Diagram flow

This methodology made possible the identification of relevant articles on the usage of smartphone applications, games, websites and other digital solutions by refugees. They are eHealth applications that aim to positively impact integrating refugees into a host country, helping them manage change or easing overall access to healthcare.

3.2 Results

After the phases described in Figure 3.1, the remaining 23 articles answered positively to the inclusion criteria and were eligible for review. Of these articles, 4 were published in 2017, 3 were published in 2018, 6 were published in 2019, 4 were published in 2020, 4 were published in 2021, and 2 were published in 2022, as illustrated in Figure 3.2.

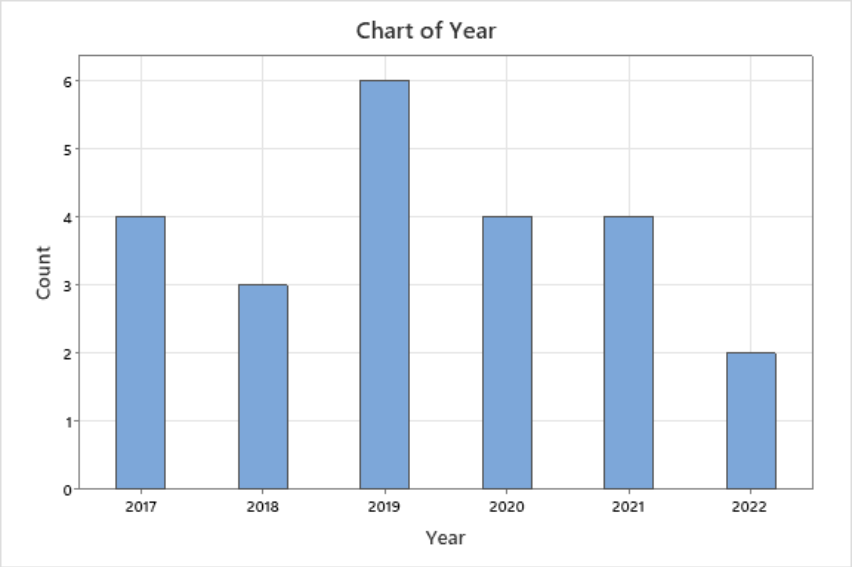


Figure 3.2: Selected articles publishing year

Regarding the setting of the studies, most of them took place in Germany (21.7%), the United States (13%), Jordan (13%), and Lebanon (13%). Figure 3.3 displays this distribution.

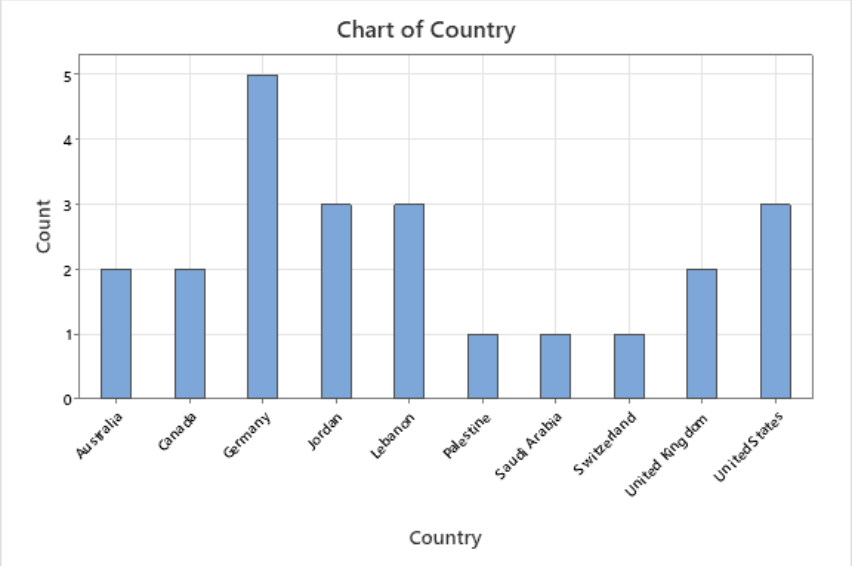


Figure 3.3: Study setting of the articles selected

The following Table 3.3 was built to facilitate the visualisation of the included articles, summarising them by Authors, Year, Country, Study Design, Study Aim, Participants, App Type and App Aim.

Table 3.3: Detailed information about the studies included in the review

ID	Authors; Year; Country	Study Design	Study Aim	Participants	App Type	App Aim
E1 [43]	Müller et al.; 2020; Germany.	Field testing of the DCTA app.	Explain the main features of the app and the reception by users.	36 refugees in primary health care in Friedland, Germany.	Digital multilingual communication assistance tool.	Improve the quality of care experienced by foreign-language speakers.
E2 [44]	Röhr et al.; 2021; Germany.	Data exposition and analysis from tests using the Sanadak App.	Assess the cost-effectiveness of the Sanadak App.	Syrian refugees in Germany, aged 18 to 65 years, have experienced traumatic events.	Self-help intervention in the Arabic language.	Reduce post-traumatic stress symptoms in its users.
E3 [45]	Pinto et al.; 2022; Australia.	A randomised controlled trial.	Check if the eResilience app is a valid alternative in diagnosing and treating trauma by neural examination of 18 to 65-year adults.	100 participants exposed to war.	A neuroscience-informed mobile mental health app that analyses changes in cognitive performance and brain activity.	Help to increase the efficacy of treatment of people exposed to severe trauma in emergency settings.

Continues on the next page

ID	Authors; Year; Country	Study Design	Study Aim	Participants	App Type	App Aim
E4 [46]	Bartlett et al.; 2021; Australia;	A randomised control trial.	Evaluate how well an app for health information to its non-English speaking users could perform.	13 participants were involved in the evaluation process: 4 were refugees, 3 UX/ Programmers, and 7 were from SMEs.	Shifra, a health app that delivers local, safe and culturally relevant information to its users, mainly refugee and migrant women.	Provide high-quality rights-based information on sexual health, family planning, mental health, family violence and adolescent health.
E5 [47]	Fondacaro et al.; 2021; United States.	A randomised control trial.	Apply Chronic Traumatic Stress-Treatment by using the NESTT Mobile Application.	Refugee participants that have suffered from traumatic experiences.	The NESTT is a language-free app for Chronic Traumatic Stress-Treatment that mental health experts and cultural consultants developed.	The user begins by creating an avatar representing themselves and engaging in various activities and exercises provided for CTS-Treatment.
E6 [48]	Liem et al.; 2020; Canada	A rapid review.	Summarize the current status of digital health applications in Medical Health Care for refugees.	Participants from various countries (India, Afghanistan, Somalia, etc.).	7 software applications, 5 websites and 4 video conferencing technologies	The range of digital health solutions is useful in MHC. Patients can use them independently as a self-help tool.

Continues on the next page

ID	Authors; Year; Country	Study Design	Study Aim	Participants	App Type	App Aim
E7 [49]	Nasir et al.; 2020; Jordan	A randomised controlled trial.	Highlight factors associated with downloading and using the e-MCH Handbook app.	1047 Participants, refugee pregnant women or mothers of children aged 0–5 years.	Mobile health application (mHealth) that gives online and offline access to educational information and personal health records of the user and their children.	Give pregnant women and mothers access to scholarly information and health records on their smartphones.
E8 [50]	Aldridge et al.; 2020; United Kingdom.	Data acquisition (surveys) via a smartphone application.	Determine the viability of an app, optimise its engagement and gather preliminary profile health status data to analyse health risk factors among refugees.	275 refugees in the UK.	The Health On the MovE (HOME) is a quantitative data collection app designed for data collection among refugees in the UK.	The HOME app enabled the creation of a data collection platform aiming to examine the health and well-being of migrants in the UK.
E9 [51]	Saleh et al.; 2019; Lebanon.	Article about the characteristics and development of the Sijilli app.	Identification of the purposes behind creating a mobile electronic health records system for refugees.	No participants.	Sijilli is a data secure, universal access and interoperability application of health record data for refugees.	Facilitate access to medical records ideally in refugees' home countries but if not possible in the first host country.

Continues on the next page

ID	Authors; Year; Country	Study Design	Study Aim	Participants	App Type	App Aim
E10 [52]	Golchert et al.; 2019; Germany.	A randomised controlled trial.	Develop and evaluate the benefits of a low threshold supportive self-help app.	1200 Syrian refugees living in Leipzig, Germany.	A Self-help app in Arabic, usable online and offline, developed in cooperation with a German e-mental health program provider.	The app aims to assist with low PTSD symptom severity and associated secondary outcomes in favour of improvement in quality of life.
E11 [53]	Neag; 2019; United Kingdom.	Cross-national interviews.	Present a unique approach to interviewing refugee children, which successfully gained in-depth data.	56 children participated, 11 were girls, and 45 were boys.	The first board game had the face of a clock, and participants They were asked to talk about or write about the social media technology they used during the day. The second one had the participants connect apps they use to specific activities.	The first board game aims to explore the media experiences of refugee children around the face of a clock. The second board game allowed children to give their opinions on the most used apps.

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ID	Authors; Year; Country	Study Design	Study Aim	Participants	App Type	App Aim
E12 [54]	Burchert et al.; 2019; Germany.	Rapid qualitative assessment (surveys)	Describe the initial stages and reception of an e-mental health intervention developed by the WHO called Step-by-Step (SbS).	128 adult Syrian refugees.	SbS is a self-help e-mental health intervention app.	Increase access to an intervention resource that could reduce psychological distress and improve functioning in fragile communities like refugees.
E13 [55]	Sabri et al.; 2019; United States.	Describe the design of web-based safety aid/safety planning interventions.	Test the efficiency of the intervention in reducing abused women's risk for future IPV/IPH, poor mental health and increasing empowerment.	1250 foreign IMR women in the US aged 18 to 64 years had experienced intimate partner violence within the past year and had access to a safe device with internet access.	Two culturally adapted versions of the safety planning (myPlan) intervention, weWomen and ourCircle.	weWomen is designed for refugee women, and ourCircle is designed for indigenous women. Both technologies are designed to able easy access to services avoiding stigma.

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ID	Authors; Year; Country	Study Design	Study Aim	Participants	App Type	App Aim
E14 [56]	Ballout et al.; 2018; Jordan.	An article about the design of a mHealth program.	Report on the rationale for developing UNRWA's eHealth system, including the project phases.	Patients in 121 Healthcare Centers.	An electronic Maternal and Child Health (e-MCH) mobile application released in Jordan.	With an Arabic-language interface that enables mothers to read their and their children's medical files. Includes a notification system to alert them of their appointments. It also provides health education content.
E15 [57]	Ben-Zeev et al.; 2017; Palestine.	Data analyses (surveys).	Analyse if mHealth approaches for remote mental health treatment can be a viable alternative.	272 Palestinian adults in urban, rural, and refugee camp settings.	A possible future development of a mHealth intervention focused on the content, structure, functionality, design, and usability.	Mental health resource intended for potential users adapted to their culture, history, and geopolitical.

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ID	Authors; Year; Country	Study Design	Study Aim	Participants	App Type	App Aim
E16 [58]	El-Khatib et al.; 2020; Jordan.	Article with the Children Immunization App (CImA) design description.	Emphasize the need for vaccination of children among refugees.	Refugees in the Zaatari refugee camp in Jordan.	Mobile phone app called The Children Immunization App (CImA).	Provide access to vaccine information and record vaccination history for children following the Jordanian national vaccination guidelines.
E17 [59]	Schuler and Raknes; 2021; Lebanon.	A randomised controlled trial.	Highlight the potential of the HH game when implemented in different settings that varied regarding group size and face-to-face approach versus digital contact.	125 Syrian adolescents forced to displace and live in Central Beqaa, Lebanon.	A free-to-download Game where the player helps a friend to master emotional challenges.	Improve access to mental health tools for adolescents.
E18 [60]	Saleh et al.; Lebanon.	Qualitative and quantitative assessment of a mHealth.	Evaluate the effectiveness of SMSs on self-reported perceptions of lifestyle modifications.	1390 participants were contacted, and 1000 responded to the survey.	A mHealth intervention called ‘eSahha’.	The SMS-based intervention is useful for individuals with hypertension and diabetes.

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ID	Authors; Year; Country	Study Design	Study Aim	Participants	App Type	App Aim
E19 [61]	Ashfaq et al.; 2020; United States.	Systematic Review.	Check the current state of mHealth and the type of mHealth used in recent years. The review enabled the inclusion of other studies in this review.	Mainly Arab culture refugees.	TeleHealth, mobile Health or electronic health platforms.	Mental health provision.
E20 [62]	Neuenhaus and Aly; 2017; Germany.	Field testing and prototype development of a mobile game.	Develop a mobile application in gaming format to level German youths and Syrian refugees.	Eight people participated in the test.	A mobile game called Empathy-Up (EMP-UP).	Eliminate stereotyping assumptions of German youth on Syrian refugees and create an emotional bond between these two communities.
E21 [63]	Atallah et al.; 2018; Saudi Arabia.	Qualitative study, Cross-Sectional resorting to surveys.	Explore the prevalence of the use of mHealth applications for mental health.	376 Adult mental health patients in Saudi Arabia.	mHealth applications.	Engagement with patients to help patients manage their mental health condition.

Continues on the next page

ID	Authors; Year; Country	Study Design	Study Aim	Participants	App Type	App Aim
E22 [64]	Morina et al.; 2017; Switzerland.	A randomised crossover trial.	Investigate the efficiency of psychological screening software for touch-screen devices.	30 Adult refugees from Afghanistan, Iraq, Turkey, Sri Lanka, and Sudan, currently living in Zurich, Switzerland.	Audio Computer-Assisted Self-Interview Software (ACASI) for touchscreen devices.	Screening purposes in a clinical setting.
E23 [65]	Ahmad et al.; 2017; Canada.	A randomised controlled trial.	Assessment and comparison between interactive computer-assisted client assessment survey (iCCAS) and usual immigrant care groups.	147 refugees from different communities.	A iCCAS software in English and Spanish for mental healthcare.	Facilitate the detection of common mental disorders among refugees and fragile communities.

3.2.1 Outcomes

Besides the synthesis of the 23 studies included, it is important to highlight the main outcomes of each one.

- **E1** [43]: The DCAT App was widely accepted and effective among the refugee population that participated in the trial. Based on the feedback, the DCAT app could complement a clinical visit.
- **E2** [44]: The Sanadak App was ineffective in reducing Post-traumatic Stress (PTS) in Syrian refugees. In addition to that, it was not a cost-efficient alternative. However, reports from participants pointed to good usability and a reduction of the stigma related to mental health problems among the refugee population.
- **E3** [45]: The eResilience App trial had low dropout rates compared to other PTSD clinical trials, with only 3% of the PTSD participants dropping out before treatment initiation and none dropping out during or after treatment. This statistic indicates a successful approach due to the vital interest of the refugee community participating in this study.

- **E4** [46]: All survey respondents reported positively when asked if they felt comfortable sharing their opinions. All participants felt valued, safe, appreciated, and respected during the co-design sessions. Overall, the Shifra App had a good design approach. However, this evaluation also provided several recommendations for improvements to Shifra's human-centred design approach.
- **E5** [47]: The participants in the NESTT App trials were involved in ten different modules. They were presented with many other coping skills associated with the app's varying components, including gamification approaches aiming to manage chronic traumatic stress. Because of that, participants reported being more challenged and engaged in the process.
- **E6** [48]: Sixteen studies were included in this rapid review, and after their review, various challenges of digital health applications in MHC could be highlighted, such as:
  - The stigma related to mental disorders;
  - The cultural diversities and cultural barriers among refugees;
  - Participants who lacked technology literacy;
  - Participants' physical barriers;
  - Technological and network issues;
  - Unsecured software.
- **E7** [49]: The study had a response rate of 42%, enrolling 1047 participants in total. From these, 95.5% had a mobile phone, and the results were only extracted from android users since data from iPhone users were lost. The 235 participants (23.8%) who downloaded the application perceived technology as a useful source of information, had internet at home and knew the application.
- **E8** [50]: The HOME app will be tested in the participant's population and is expected to have a baseline completion of 20%. In general, this study will position the research team in a better position to understand the context and the users. The team also identified some possible limitations in the study. For example, a proportion of the population will not be fluent in English, and the development team will not be able to include data from individuals who have not yet arrived in the UK.
- **E9** [51]: This article does not present any trial or test. Although this article was useful for gathering essential functionalities and features for this type of technology.
- **E10** [52]: The trial results regarding the HOME App have not been published yet but are expected to expand the current knowledge regarding the efficiency of mHealth interventions. Besides that, the HOME App aims to add routine care options.
- **E11** [53]: The author emphasised the fact that there is a need to think outside the box, as it is crucial to create a research tool that speaks a universal language. In addition, board games excelled in creating a safe environment for participants.
- **E12** [54]: The Syrian population participating in this trial had good knowledge of digital technologies. The SbS App provoked a positive reaction in this population, with 78% stressing the potential health impact of the intervention. Besides that, 58% highlighted the flexibility in customisation of the app, and 33% referred to the app as easy to learn. The main criticism was the

length and pace of the sessions (25% of the participants reported that), and the main barriers were acceptability and assuring credibility to the user.

- **E13** [55]: The trial results regarding the weWomen and the circle App are expected to provide evidence that will support a culturally tailored intervention like these. In advance, the developing team identified reliability linked to the fact that they will rely on women's self-reports while subject to reporting bias. Although, it is expected to be minimal due to the use of a web-based format.
- **E14** [56]: The UNRWA's eHealth system proved to be cost-effective, secure and supportive of general healthcare services in the 121 Healthcare Centers where it was implemented. With that information, the UNRWA can classify it as essential to ensure better healthcare quality.
- **E15** [57]: This study obtained valuable information regarding smartphone usage among a population of refugees. From these, 79.9% of the participants reported having a smartphone and over 61% of them reported that more than half of their communities struggled with Mental Health. Acceptance of mHealth was significant, with over 60% revealing interest in various solutions.
- **E16** [58]: The trials completed with the CImA App showed that it successfully supported parents in keeping track of their children's vaccination records.
- **E17** [59]: Only 28% of the participants in the study before the HH program reported average well-being, while after the completion of the program, that percentage raised to 99%.
- **E18** [60]: Almost 94% of the participants rated the SMSs as valuable and easy to understand. Almost 77% of them reported compliance with the SMSs, reflecting behavioural modifications throughout the day.
- **E19** [61]: This article is a systematic review of mHealth solutions that concluded that the main barriers lie in the lack of a harmonious base with the Arab socio-cultural norms and the lack of a realistic conceptual framing.
- **E20** [62]: There was a significant shift in German youth concerning the refugee population, including active volunteering to meet and help refugees.
- **E21** [63]: The results from this study pointed to 64% usage of mobile phones to access health data among the participants. Besides that, 64% expressed interest in using mobile phones to track the progress of their mental health and almost 50% reported using one or two healthcare applications on their mobile phones.
- **E22** [64]: This study listed no significant differences between conventional and mobile application screening. Because of that, it was concluded that ACASI is a feasible and efficient alternative. Besides, using mobile applications also proved to be time efficient.
- **E23** [65]: The main results that came from the comparison between the iCCAS group and the control group were:
    - iCCAS group had more mental health discussions than the control groups (58.7% and 40.3% respectively);
    - iCCAS group had higher clinical detection of mental health symptoms than the control group (38.7% and 27.8% respectively).

3.3 Discussion

This systematic review aimed to explore the current state of eHealth solutions for refugees and their successes and failures. This review is critical to inform the development of future solutions that advance first-degree care in fragile communities such as refugees. Consequently, this work allowed us to successfully answer the research questions listed in subsection 3.1.1.

3.3.1 Access and Interest

Firstly, it was essential to understand if mHealth was a plausible alternative for vulnerable communities where access to mobile devices and technology, in general, might be more complex than others. Although thanks to the results obtained in the research, especially for the analysis of the studies E15 and E21, it was clear that access to electricity, Wi-Fi and smartphones was not a barrier to mHealth. For example, in the West Bank, almost 100% of the participants have access to electricity, and 80% have a smartphone [57]. Besides, of those with a mobile phone, 96% use it for calls, 75% for SMSs and almost 65% regularly use apps [57]. The more relevant apps for this population are social media for keeping in contact with relatives and friends [57]. The next step should be to check for interest, from these types of communities, in mHealth solutions. In E21, there was quite a positive outcome regarding that matter. A percentage of 64% reported 'yes' and 20% reported 'perhaps' when asked if they were willing to use a mobile application to monitor their health [63].

3.3.2 Recent Developments

Another central question that triggered this research was related to which digital solutions have been developed and tested for integrating refugees. Therefore, the goal was to find examples of applications developed and, ideally, tested among these communities between 2017 and 2022. The 23 studies extracted from the research contained 18 different Apps that are mobile/smartphone (N=13; DCAT [43], Sanadak [44], eResilliance [45], NESTT [47], e-MCH [49, 56], HOME [50], Sijilli [51], HELP [52], CImA [58], HH [59], eSahha [60], EMP-UP [62]) or web/computer based (N=5; Shifra [46], Sbs [54], weWomen [55], ourCircle [55], ACASI [64], iCCAS [65]) as well as 2 board games [53].

3.3.3 Their Applications

Moreover, another question that was raised preliminary to the beginning of the research was how these approaches could be applied. When it comes to that, there are cases like the DCAT App, the Hikma EHR, the NESTT App, the ACASI and the iCCAS software, which it is used to complement a clinic visit, either before or after a medical check-up or therapy session. In other cases, it can function as self-help for diagnosis and prevention or a distance intervention that aims to reach the maximum number of people and keep them in contact with specialised help, such as the Sanadak App, the eResilliance App, the Shifra App, the e-MCH Handbook, the HOME App, the

Sijilli App, the HELP App, the Sbs App, the weWomen and the ourCircle programs, the CImA App, the HH App, the eSahha App and the EMP-UP game do. In some cases, the presented self-app solutions can also be used in groups or as part of social and emotional learning at schools or other facilities, and the board games referenced in E11 are great examples of scholarly applications of these techniques for children's mental health prevention and education [53]. In addition, it is possible to look in more detail at the target of these applications; for example, the weWomen program was developed for refugee women that have been exposed to partner violence [55], and the e-MCH Handbook is directed to pregnant women and mothers with the need to updated educational information and personal health records of themselves and their children [49, 56].

3.3.4 Main Characteristics

The fourth and final question was related to the main characteristics embodied in digital solutions applied for healthcare assistance in fragile communities. After careful analyses of the articles obtained from the review, it is clear that features connected to usability are a priority. So, when it comes to contact with refugees, it is crucial to remember that most are non-English speakers, and some can also be illiterate [66]. Because of that, examples like the DCTA app, which supports 19 different languages and dialects [43], and the HELP App, which is aimed at Syrian refugees and because of that is available in Arabic [52], are excellent guidelines. Besides, the HELP app is also complemented by video and audio sequences that come in handy for possible illiterate users [52].

Also, availability and acceptability are pivotal in well-founded digital healthcare solutions. One solution to increase availability is offering offline support like the CImA App, where users can add child information and vaccines without an internet connection [58]. Acceptability is attained with culturally adapted and science-informed approaches, which was done in developing the eResilliance App [45]. Otherwise, as seen in the study of the SbS App, when appropriate actions are not taken, it can result in a loss of credibility [54].

Another essential characteristic is the capability of keeping the user engaged, which is achievable by avoiding lengthy and slow-paced procedures. This is a mistake reported in the article of the SbS App, where 25% of the participants said that the length of the interventions hurt their experience [54]. Contrary to SbS, the HOME App has two types of surveys, enabling the user to choose between a shorter survey and a longer one [50]. In other cases, such as those of Sanadak, HH and EMP-UP, the user is dynamically attached to the process, thanks to gameplay features applied in those applications. For example, Gamification is present in Sanadak through interactive material such as animated videos and audio, as well as games and exercises that maximise user interest [44]. In HH, the game sends the user on the mission of helping virtual friends master emotional challenges and face fears, such as dealing with criticism, suicidal thoughts and bad memories [59]. The EMP-UP game also excels in this criteria, keeping the user (Syrian or German) on the move by using a geolocation system that encourages the user to seek direct contact with the Syrian culture [62].

Chapter 4

Methodological Approach

After the conduction of extensive research and collection of crucial data regarding already existing mHealth applications, highlighted in the previous chapter, the dissertation will focus on developing our mobile app.

This development will follow a User-Centred Design (UCD) approach to perfect the user-mobile app experience. UCD is an iterative design process that prioritises the design and development of a product with the needs, goals and overall satisfaction of its users [67]. We will be following a standard in product development proposed by the International Standards Organization, named ISO 9241-210 [68], that offers a design structure centred on the user, presenting the following six principles:

- The design is based upon an explicit understanding of users, tasks and environments;
- Users are involved throughout the design and development;
- The design is driven and refined by user-centred evaluation;
- The process is iterative;
- The design addresses the whole user experience;
- The design team includes multidisciplinary skills and perspectives.

Figure 4.1, adapted from International Standards Organization, named ISO 9241-210 [68], represents the different steps our UCD approach will have during the design process. The four different stages can be defined as follows:

- **Specifying the Context of Use**: Identify the intended users of the product, the purposes for which they will use it, and the environments in which they will use it.
  In our case, the potential users are already identified as refugees.
- **Specify Requirements**: Identify user goals that must be met for the final product to be successful.

These requirements can be viewed as necessities of the population and difficulties they face daily to get appropriate healthcare. These answers will be obtainable via surveys in questionnaire format, focus group sessions and interviews.

- **Produce Solution**: This part of the process may be done in different phases, interspersed with evaluations of the design from actual users.
  At the start, the mockup design of the application's graphical interface can be pivotal for the beginning of the code implementation as there will be visual support of what is expected to achieve. Tools like *Figma* and the *Moqups* are handy software for this stage.
  The goal is to build from a rough concept to a complete design, with feedback from the target population. Because of that, the aim is to achieve a prototype concept, using *Android Studio* with Java as the programming language, that will be presented and tested by potential users.

- **Evaluate Design**: A evaluation of the solution is tested, ideally through usability testing with actual users.
  The purpose of these tests will be to examine how simple it is for users to navigate and interact with the software and whether its functionalities meet their requirements and needs.
  In our case, contacts were already established with the people responsible for welcoming Ukrainian refugees and identifying their health needs, and they showed interest in helping with the app's testing.

If needed, this set of steps can be repeated until the expected performance for the product is achieved. They are creating a viable alternative for refugees to access healthcare through a mobile app.

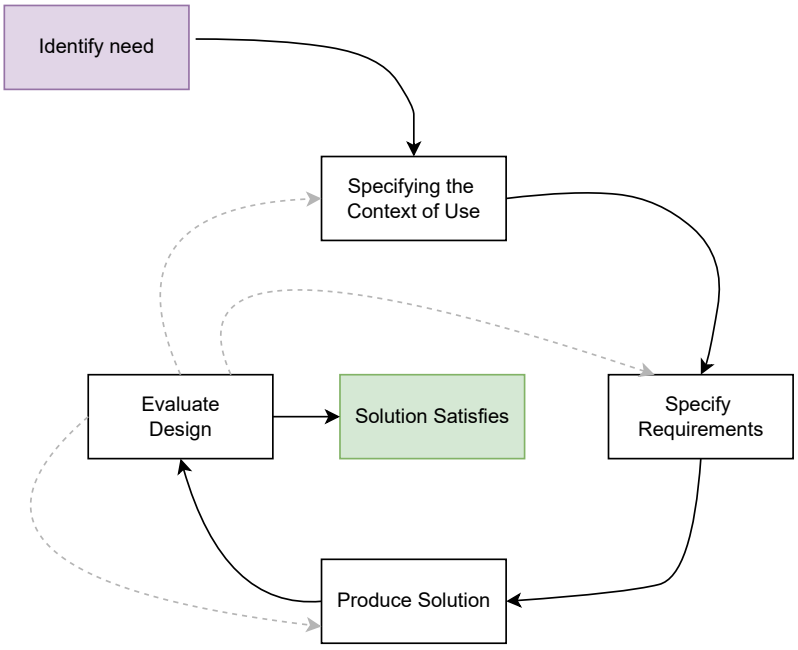


Figure 4.1: Interdependence of User-Centred Design stages. Adapted from [68]

Therefore, this methodology resulting from the adaptation of ISO 9241-210 [68] comprises a cycle of three iterations:

(i) **Requirements gathering**: With the help of the information collected from interviews and surveys;

(ii) **Prototyping**: From low fidelity basis to a potential final product;

(iii) **Evaluation**: Usability testing is crucial to the prototype's improvement.

Figure 4.2 describes the methodological process adopted, which will be thoroughly described throughout this chapter.

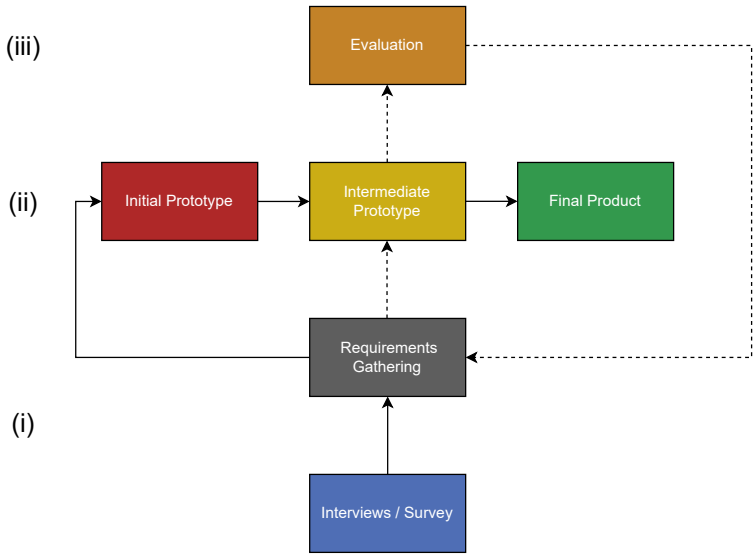


Figure 4.2: Methodological procedure adopted

4.1 Requirements Gathering

A critical factor in the development of this work is identifying and understanding the main parameters and features that make a successful mHealth approach for refugees. A survey was created to supplement the theoretical foundations gathered and reviewed before.

Surveys are an interactive way of collecting information from individuals or groups of a specific population over the internet. It is an effective tool because it provides a convenient and functional way of gathering data via a time and resource-saving technique that assures data accuracy and security. Thus, for this work, it is vital that the software chosen can collect quantitative and qualitative data because, while qualitative research focuses on gathering insights and comprehending people's experiences, opinions, and attitudes, quantitative research involves gathering numerical data and analysing it using statistical methods and, combining this due types of data allows for more informed decision-making and improved outcomes.

4.1.1 Survey Software

The software used will be *Google Forms*, ideal for conducting quantitative and qualitative research. Both data types can be collected through surveys created and distributed using the platform. *Google Forms* can collect numerical data on a broad scale for quantitative research, making it simple to analyse and draw conclusions. The poll results can be exported to programs like *Google Sheets* or statistical analysis applications for additional examination. Open-ended comments from participants can be gathered using *Google Forms* for qualitative research, providing a more profound knowledge of their experiences and viewpoints. Several qualitative research techniques can be used to analyse the responses, including content analysis, thematic analysis, and grounded theory.

4.1.2 Establishing Contact

The connection with the correct population is a fulcrum aspect of this work, enabling the recolonisation and comprehension of particular demographic difficulties while analysing refugees' demands and crucial components for mHealth apps. Refugees are diverse, with distinctive histories, life experiences, and health issues. Because of that, the study must seek to include different background stories, keep diversity and explore different points of view. To achieve the goal, contacts were established with various individuals and associations that interact directly with refugee populations in Portugal.

Another factor that was kept in mind was that refugees could experience difficulties with communication, restricted access to healthcare, and cultural differences that impair their adaptation to another country. Therefore, two versions of the online form were created to facilitate engagement with the population in question, one in English and one in Portuguese. Those were the two versions shared with different identities and from which valuable information was gathered.

4.2 Prototyping

The second part of the project's design involves the iterative development of a prototype tailored to meet the mHealth needs of refugees in a new country, building upon the initial requirements identified in the previous stage. A low-fidelity prototype was created using *Moqups* [69] to initiate the prototyping process, which visually represents the app's structure and functionalities. As the project progressed, the prototype evolved into a higher-fidelity version developed using *Android Studio* with Java. This complex prototype will simulate a realistic user experience and incorporate the desired features and interactions identified during the requirements-gathering phase.

4.3 Evaluation

The evaluation phase of the project involves evaluating the developed prototype to assess its effectiveness, usability, and overall performance. This phase will outline the appraisal procedures, including selecting participants, defining evaluation criteria, and executing the sessions. During this stage, a diverse group of participants representative of the target user population will engage and interact with the prototype. Their feedback and observations will be carefully collected and analysed to identify strengths, weaknesses, and areas for improvement.

Thus, this phase is crucial in gauging the prototype's efficacy and validating its potential impact on the intended users. The evaluation outcomes will inform further refinements and guide the future development of the mHealth application, contributing to its overall success and usability in assisting refugees in their healthcare journey.

Chapter 5

Requirements Elicitation

The extensive literature review resulted in the gathering of critical scientific pieces of information and data, the comprehension of the development scenario of this dissertation and the shortcomings and challenges recognised by refugees. However, now the importance turns from the theoretical foundation to a thorough study of the needs and difficulties in healthcare access of a particular refugee population.

As already said, this dissertation is committed to developing a technological solution for promoting healthcare to refugees in a new setting. The target audience's experiences will become crucial to the design and development planning strategy.

5.1 Survey Objectives

So, to identify and understand the population's needs and preferences, a series of data collection was conducted via *Google Forms*. The survey's structure was assembled to extract the maximum amount of important information in the fastest way possible without crossing any boundaries or pressuring the interviewee. Hence, the general objectives of the survey were established:

(i) Legitimize the survey, make the objectives clear to the interviewees, motivate them to participate and ask for their consent;

(ii) Extract their basic information and their familiar and individual context of arrival in Portugal with some initial questions while maintaining their anonymity;

(iii) Explore their knowledge, experience and point of view of mHealth solutions;

(iv) Explore their current access to healthcare, needs and difficulties in doing so;

(v) Check the participant's interest in using a mHealth app to help access healthcare, extract the most important characteristics that the app should have;

(vi) Thank them for their participation and ask for contact information for a possible future interview.

Consequently, the survey's structure is based on its six general objectives, namely:

- **Objective (i)** is fulfilled by the "Consent" section, where an introductory text is presented to the participants. They are informed that the survey was conducted for a dissertation project by a student at the Faculdade de Engenharia da Universidade do Porto. They are also informed that the project aims to develop a mobile application that can help screen refugee populations and refer them to appropriate care, that their participation of the message's recipient in the survey is highly valued and essential for the project's success and that the research team assures the confidentiality and anonymity of the information gathered. After that introductory text, a consent option is presented, where if answering "yes", the participant declares that they have read and understood the information provided. If the answer is "no", the survey ends.

- **Objective (ii)** is secured by a series of quick socio-demographic questions such as sex, age, home country, region of residence, education, etc.

- For **Objective (iii)**, the concept of mHealth services is introduced at the beginning. The participant is asked if they are familiar with that concept before and have used such a service. If the answer is positive, they are also asked about the mHealth service they have used and their overall satisfaction with it.

- **Objective (iv)** is achieved by asking the participant about the types of healthcare services they currently have access to, what type of information they consider necessary when trying to access those healthcare services, and if they currently have any healthcare services need but do not have access to. If the participant answers "yes" to the last question, they are asked to specify that healthcare service need. After that, they are asked about their experience with language barriers and how they currently access healthcare information.

- **Objective (v)** focuses on the importance of specific characteristics of mHealth apps for the participants. Therefore, they are asked to grade the importance (on a 6 points scale, where 1 is "Not important" and 6 is "Very important") of specific characteristics withdrawn from the literature review.

- **Objective (vi)** is completed by giving the researcher's contact information and asking the participants if they can be contacted for a possible future interview.

The full survey template can be viewed in Appendix A.1.

5.2 Survey Results

The following section presents the results from the survey conducted with refugees, providing valuable insights into their experiences, perspectives, and preferences regarding the mHealth application.

5.2.1 Sample Characterisation

To ensure a diverse spectrum of opinions, perspectives and stories, a diverse sample of participants with different age groups, backgrounds, and nationalities was sought after for completing this study. As a result, there were 17 valid submissions collected between 21/04/2023 and 05/05/2023, to which every participant consented to participate. Tables 5.1 and 5.2 present a detailed overview of the socio-demographic characteristics of the sample.

Table 5.1: Table with respondents' socio-demographic data (Part 1)

#	Sex	Age	Country	Residence	Months in Portugal
1	Female	33	Ukraine	Porto	7
2	Female	34	Ukraine	Porto	12
3	Male	18	Ukraine	Porto	13
4	Male	35	Ukraine	Porto	14
5	Female	23	Ukraine	Porto	13
6	Male	22	Syria	Guarda	60
7	Female	34	Tunisia	Braga	60
8	Female	38	-	Porto	145
9	Female	25	Ukraine	Porto	13
10	Male	37	Russia	Setúbal	7
11	Female	36	Russia	Lisboa	7
12	Female	27	Russia	Lisboa	32
13	Female	36	Russia	Lisboa	60
14	Female	33	Ukraine	Porto	13
15	Female	65	Ukraine	Porto	8
16	Female	36	Ukraine	Porto	12
17	Female	47	Ukraine	Aveiro	12

Table 5.2: Table with respondents' socio-demographic data (Part 2)

#	Educational level	Profession	# of family members	Smartphone
1	Bachelor's degree	Unemployed	1	Yes
2	Licensed degree	Intellectual and scientific experts	4	Yes
3	Secondary School (10 -12 years)	Student	2	Yes
4	Licensed degree	Intellectual and scientific experts	4	Yes
5	Secondary School (10 -12 years)	Student	3	Yes
6	Without educational levels	Unqualified workers	6 or more	Yes
7	PhD	Intellectual and scientific experts	0	Yes
8	Licensed degree	Unemployed	3	Yes
9	Master's degree	Workers skilled in farming and agricultural trades	2	Yes
10	Licensed degree	Technicians and intermediary-level occupations	3	Yes

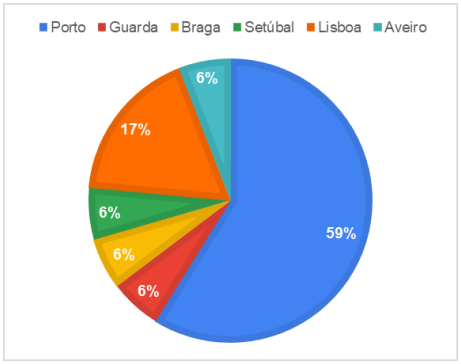
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Table 5.2 – *Continues from previous page*

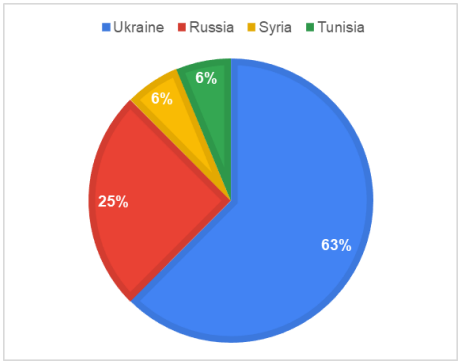
#	Educational level	Profession	# of family members	Smartphone
11	Licensed degree	Unemployed	1	Yes
12	Master's degree	Intellectual and scientific experts	0	Yes
13	Master's degree	Intellectual and scientific experts	0	Yes
14	Master's degree	Unemployed	3	Yes
15	Secondary School (10 -12 years)	Workers of personal, protection and safety services and salespeople	1	Yes
16	Licensed degree	Intellectual and scientific experts	4	Yes
17	Licensed degree	Intellectual and scientific experts	3	Yes

Thus, from this valuable initial information, it is safe to say that the survey results are pretty diverse due to the participants' ages, residences, educational levels and professions:

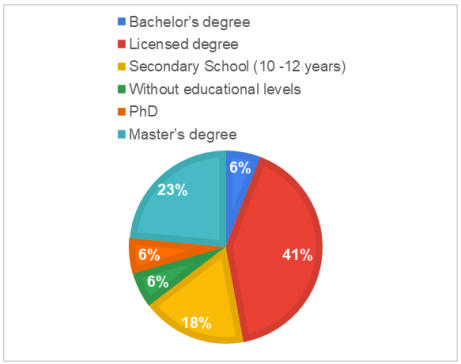
- Their age is between 18 and 63, and the mean and median of the ages are around 34, indicating that the number of respondents above and below this age is roughly equal.
- The participants' residence is distributed between the north (Porto, Braga, Guarda and Aveiro), centre (Lisboa) and south (Setúbal) of Portugal, with the north and particularly Porto being the more represented. Figure 5.1a displays that information.
- The participants' nationalities are primarily Ukrainian and Russian due to recent events in these countries. However, efforts were made to ensure representatives of other backgrounds. Figure 5.1b showcases that distribution.
- Regarding participants' educational level and line of work, there are various qualifications and occupations, as seen in Figure 5.1c and 5.1d, respectively.



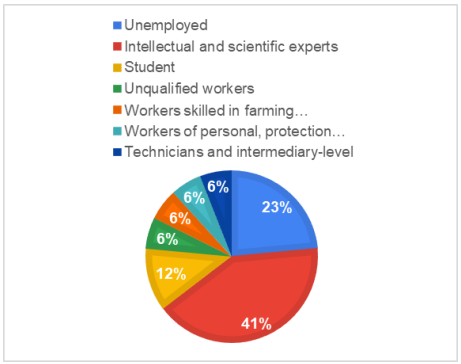
(a) Participants' region of residence



(b) Participants' home country



(c) Participants' educational level



(d) Participants' line of work

Figure 5.1: Results from participants' socio-demographic questions

The only exception, in terms of diversity in the sample, would be the sex of the participants, as only 4 of the 17 (23.5%) responses came from men. This can be explained by the characteristics of the population in question, as there is a significant representation of Ukrainian and Russian individuals, and there may be a higher proportion of women refugees than men due to the

current situation of those two countries. Furthermore, there may be systematic differences in the willingness of individuals of different genders and backgrounds to provide personal information. This may be influenced by cultural, social or contextual factors affecting people's willingness to participate in these surveys [70].

However, from this initial information, the most important for the affirmation and validation of this work is that 100% of the participants currently have a smartphone, which confirms the possibility of making mHealth a valid alternative for healthcare, thanks to its wide range of availability.

In addition, in these initial questions, the participants were also asked to describe difficulties accessing healthcare services since leaving their home country. Various valuable answers were given, and they will help identify barriers, tailor our innovation to respond to their needs and promote equality to access healthcare. Depending on the associated problem, those answers can be organised into different groups, such as:

- **Lack of Family Doctor**: Participants #10, #14 and #16 highlighted jointly difficulties in accessing a family doctor. Participant #14, for example, said: *"I have small children that, in my country, had access to doctors, as they presented health problems from birth. When we arrived here, we communicated this to our family doctor, and so far, we have not been called for more than one appointment. It is impossible to wait 3 months for a baby to go to the doctor, who must be monitored regularly."*;

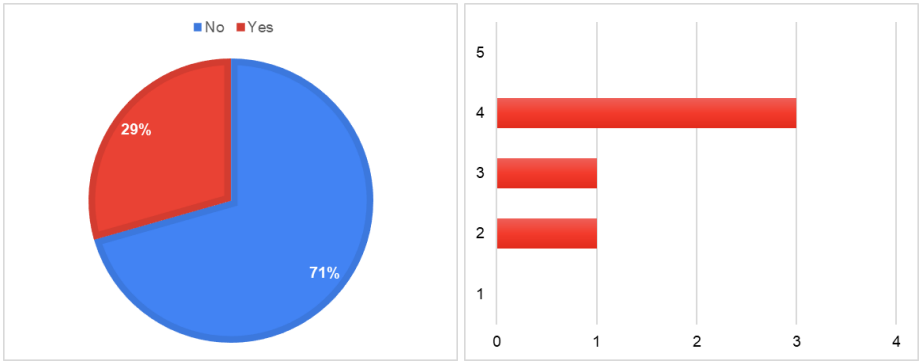
- **Difficulties in accessing simple information**: Answers like the one of participant #1 underline the need for these people to have access to simple and specific information: *"I was in a 'urgência' twice after I arrived. At that time, I was renting a short-term apartment; I did not have a permanent address. The hospital registered my temporary address. Later I found out that the hospital could send me a bill for services to that temporary address. I no longer live there and have no access to it."*;

- **Language Barriers and Communication Issues**: The answer given by participant #11 points out difficulties in communication: *"Although many doctors speak English, most of the employees at administration desks don't. So as a patient, I hardly knew where to go (where to find the medical specialist I needed), what are the procedures for getting medical help, and the most frustrating was that the people at the reception didn't understand what I wanted from them."*;

- **Financial Constraints and Private Insurance**: Participants #2 and #12 underlined financial difficulties. Participant #2 said: *"In our country, we make an appointment with a doctor on time at a state clinic and get on the exact time. It's a nightmare for you; you can expect a doctor for 4 hours or more. For this reason, I had to take out insurance for the family and pay for it and appointments in private hospitals, not a small amount, but at least without a queue."*.

5.2.2 Sample Knowledge of mHealth

To understand if the concept of mHealth is present in the participants' knowledge, they were asked if they were familiar with it and if they have ever used it. Figure 5.2a shows the results of those questions, where 12 participants (71%) expressed that they did not know what mHealth was before the survey and had never used it. From the 5 participants that answered "Yes", the mHealth solutions they used were for health information, education and remote consultations with Healthcare providers. Their overall satisfaction with those services was reasonable, as the average of all answers is 3.4 out of 5, as seen in Figure 5.2b, indicating significant room for improvement in offering better user-centred mHealth solutions.

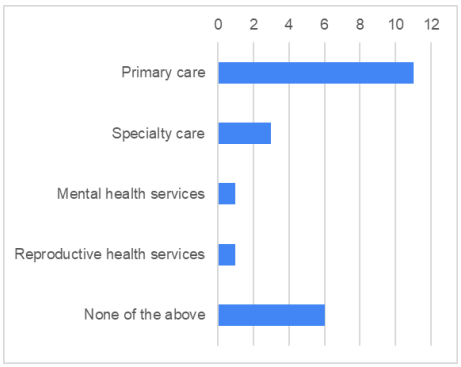


(a) Participants' knowledge of mHealth (b) Satisfaction with mHealth solutions

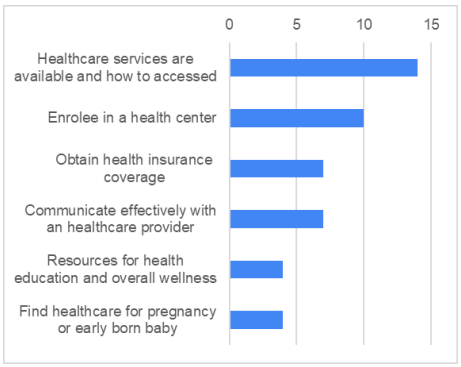
Figure 5.2: Results from the participants' familiarity with mHealth questions

5.2.3 Sample Needs and Requirements

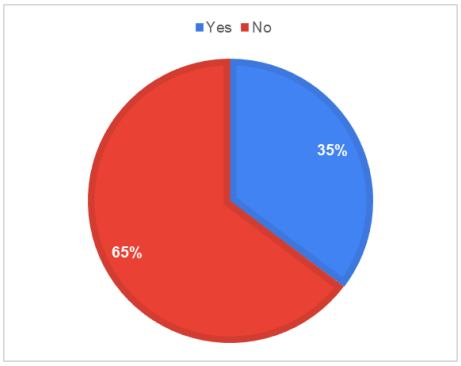
To understand the current needs of the participants, the data collected from the following series of questions need to be analysed with extreme detail. Firstly, it is crucial to know which participants in question have access to healthcare services and, in case they do not, if they need to. Thus, from figures 5.3a and 5.3c, it is evident that 11 of the interviewees have access to healthcare services (65%), and 6 of them do not have access to any care but do need it (35%). On top of that, by examining the results presented in 5.3b, it became evident that information regarding available healthcare services and ways of accessing them was considered the most important by the sample (82% of the participants selected it), along with information concerning registration at a health centre, information about health insurance and others. Figures 5.3d and 5.3e show that from all the participants, a big percentage has faced language barriers when accessing healthcare and would prefer, if possible, to access healthcare services in their native language. From this set of questions, it was also possible to understand that the primary healthcare information source was identified as the Internet (65% of the participants selected it) instead of specialised healthcare support from professionals (24% of the participants selected it). This can be seen in Figure 5.3f.



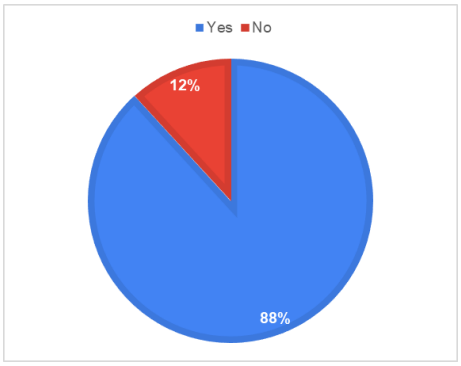
(a) Participants' current access to healthcare



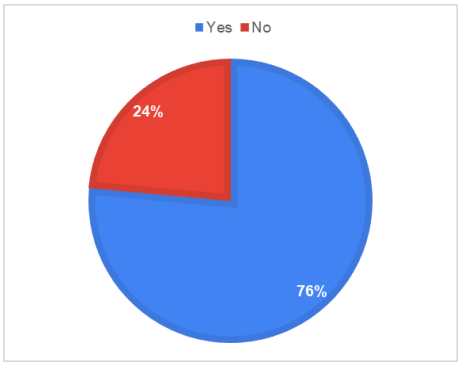
(b) Important healthcare information for the participants



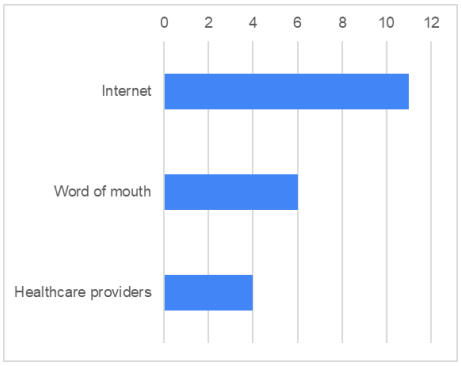
(c) Participants' need for healthcare services



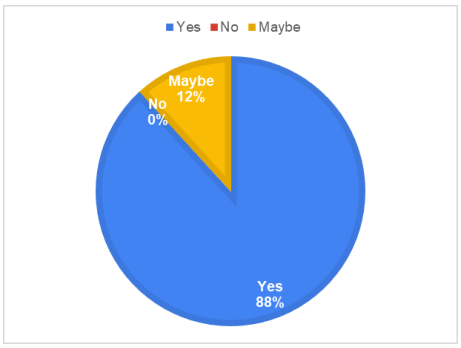
(d) Participants' experience with language barriers when accessing healthcare



(e) Participants' preference in accessing healthcare in their native language



(f) Participants' ways of accessing healthcare information



(g) Participants' interest in using a mobile app that could help them access healthcare

Figure 5.3: Results from participants' needs and requirements questions

Finally, the participants were asked if they would be interested in using a mobile app that could help them access healthcare. The results were highly positive, as shown in Figure 5.3g and because of that, all 17 participants were presented with a final question. This question was intended to extract the importance of the following possible characteristics of the mobile app:

1. Multilingual support
2. Ease of use
3. Address barriers to healthcare access
4. Remote consultations
5. Privacy and confidentiality
6. Compatibility with a variety of devices
7. Maintain user engagement
8. Evaluation and improvement of the support

Figure 5.4 shows the results of each characteristic on a five-point Likert scale where 1 corresponds to "not important" and 5 to "very important". From the bar chart, we can sort the characteristics according to the grades given by the interviewees. Thus, that order is: (3.) Address barriers to healthcare access (average of 3.94); (1.) Multilingual support (average of 3.88); (2.) Ease of use (average of 3.71); (4.) Remote consultations (average of 3.30); (6.) Compatibility with various devices (average of 3.24); (8.) Evaluation and improvement of the support (average of 3.11); (7.) Maintain user engagement (average of 2.82); (5.) Privacy and confidentiality (average of 2.76).

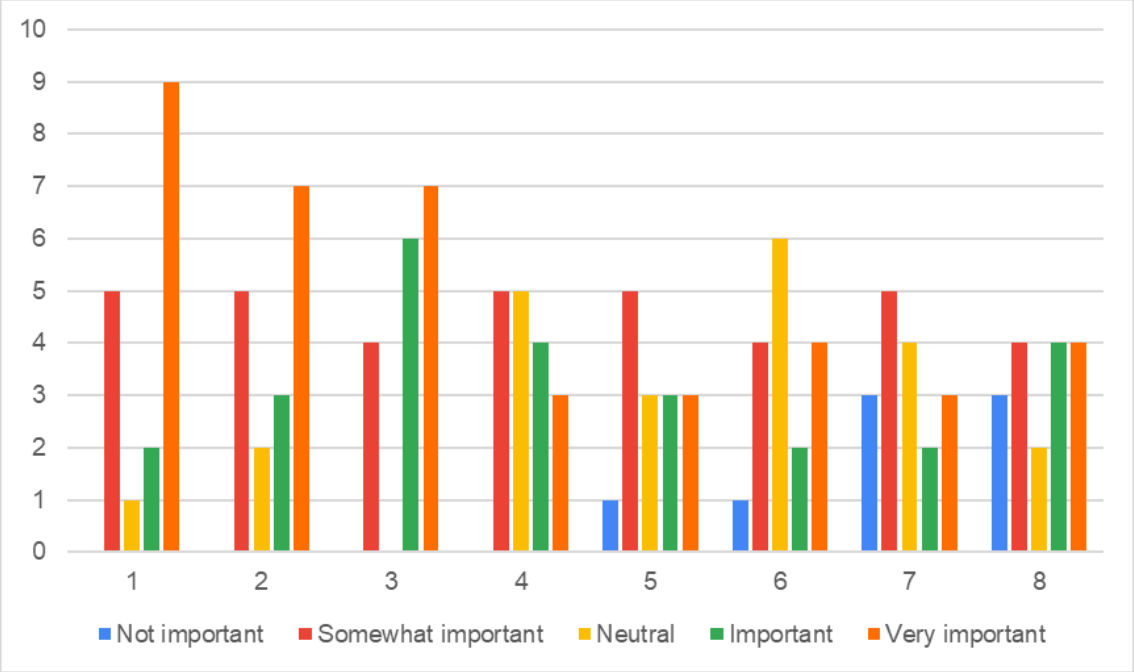


Figure 5.4: Importance of mobile app characteristics, for the participants

5.3 Discussion

The adoption of a user-centred design methodological approach implies the study of the needs and behaviour of potential users for the development of a technological solution. Therefore, by taking a closer look at the results displayed in section 5.2 and by combining it with previous theoretical foundations already described before, a study of the refugee population's needs and preferences regarding healthcare access and the factors that would contribute positively for their integration in the Portuguese healthcare system was done.

Even though the survey does not represent a vast range of opinions, it still illustrates empirical evidence of refugee populations' poor knowledge of mHealth solutions, and, for those who were familiar with the concept, the experience with such technological services could have been more impressive. Plus, when looking at the results related to their needs for healthcare access and by applying quantitative analyses, it becomes pretty concerning that more than a third of the participants do not have access to any healthcare service despite needing such services. By gathering these two results and adding them to the fact that every single one of the participants had a smartphone, it becomes evident that the initial proposal of building a mobile app to assist refugees in accessing good healthcare services, and information related to them, is something valid and that could be of great value to this population.

For this reason, and complementary to all the participants who showed interest in using that mobile app, the qualitative and quantitative analyses of the participants' experiences and points of view become significant for priority setting in the app's development. From the survey results, it is clear that characteristics related to addressing the challenges in seeking healthcare, providing solutions and ensuring ease of use for the users are considered pivotal aspects that should be embedded in the app. Other than that, enabling the user to access healthcare information remotely is an aspect to be considered when implementing the application, without forgetting the importance of keeping users actively involved and interested in the support system, ensuring that their data is protected, which fosters trust in the support system. However, although it was considered necessary for the interviewees, multilingual support and compatibility with various devices will be aspects that will have little importance at an initial stage since the primary focus will lay on developing a reliable prototype.

In conclusion, the study of healthcare access needs and preferences among refugee populations, along with empirical data from the survey, strongly encourages the creation of a user-centred mobile app. The findings demonstrate how little refugees know about mHealth options and how critical it is for them to access healthcare. Key concerns included addressing issues with accessing healthcare, offering user-friendly solutions, enabling remote consultations, retaining user engagement, and guaranteeing privacy and data protection. The app's development has the potential to significantly increase healthcare access and aid in integrating refugees into the Portuguese healthcare system, thereby boosting the well-being and quality of life of those who use it.

Chapter 6

HealthBridge App

The smartphone application HealthBridge, a method for accessing healthcare support and information, looks to solve the issue raised in this research. This chapter thoroughly describes the development progression and lists the design choices made throughout the various prototyping phases of the system. The final prototype can be viewed at: https://youtu.be/HrHhZNwp3OQ

6.1 Concept

Benefiting from the proliferation of mobile and ubiquitous computing in everyday life population, this dissertation proposes HealthBridge, a mHealth application that meets the needs of refugees regarding their personal well-being, safety, and comfort in terms of health, establishing a connection between the user and the Portuguese healthcare system as its primary goal. The platform, which took the form of a mobile application, provides user-centred services. The platform's functionalities and resources were defined using the theoretical information previously gathered from the literature, which was then supported by the findings of a study on the needs and priorities of people for whom the use of this application would be indicated. As a result, the system has three main components: simple diagnosis, information to frequent questions and a game section. These components of the app contribute to achieving the following:

- **Simple Diagnosis**: The software provides a straightforward diagnosis tool that enables users to evaluate common health conditions and get preliminary advice. By giving refugees self-assessment tools and fundamental medical knowledge, they may seek the correct medical care.
- **Frequently Asked Questions**: HealthBridge includes a comprehensive section that addresses frequently asked questions regarding healthcare access, local healthcare services, rights and entitlements, and other relevant information. This resource aims to empower refugees with knowledge and facilitate their integration into the healthcare system.

- **Game Section**: The application has mini-games to increase user engagement and support health education. Refugees can learn about preventive measures, healthy lives, and understanding healthcare procedures through these interactive games created with an emphasis on health-related issues.

Besides, the HealthBridge app relies on a sign-up/login feature that meets critical requirements for secure access and customised user experiences. This tool allows refugees to set up personal accounts and securely control their health data, preferences, and game progress. The software can establish user identities and safeguard sensitive information by establishing a robust authentication mechanism with e-mail verification, promoting trust and confidentiality when creating an account.

Overall, user input gathered through surveys and usability testing will be crucial for the application's development and enhancement. HealthBridge strives to empower and assist refugees' access to trustworthy healthcare information, self-assessment tools, and educational materials while seeking medical care in Portugal. The ultimate goal of the software is to encourage effective integration, enhance general well-being, and improve health outcomes for populations of refugees.

6.2 Design

Design is pivotal in developing a user-friendly and visually appealing mobile application like HealthBridge. Using the intuitive design platform *Moqups* [69], a series of mock-ups were meticulously created. Making mock-ups, which visually depict the app's user interface and serve as a guide for its development, is an essential step in the design process, expressing design concepts, assessing user flow, and guaranteeing a positive user experience.

Note that the name "Johanna Doe" used in some of the mock-ups is fictitious.

6.2.1 App Logo

The logo operates the app's visual representation and identity, the key to user perception and brand recognition. A well-designed logo communicates the essence and purpose of the app concisely and memorably.

Clarity and identification are guaranteed with a simple logo design. The logo is made readily recognisable and memorable for users using a simple design, clean lines, and minimalistic features. It enables simple identification, even in small sizes or contexts, such as app icons, website headers, or advertising materials. As a result, the logo in Figure 6.1 was designed.



Figure 6.1: HealthBridge app logo

6.2.2 Log-in and Sign-up

The first mock-up set, displayed in Figure 6.2, focuses on the log-in and sign-up screens, which are crucial for establishing user accounts and securing access to personalised features. Users can access their accounts by entering their email address and password on the log-in screen, which has an easy-to-use layout. This screen is the initial gateway, which ensures secure authentication and safeguards users' private information. On the other hand, the sign-up procedure consists of two screens, each with a distinct function. The initial screen records crucial information such as the user's email address, password, and confirmation password, verifying the validity of their login credentials. In this phase, the significance of data security is emphasised, and users are urged to develop secure passwords. The second sign-up screen reinforces the verification process by asking users to confirm their email and submit other details like a username and complete name. These specifics allow for a more individualised experience within the app and make it easier for users to communicate with the system.

Each screen in the sign-up and log-in process is crucial to building confidence, ensuring data security, and personalising the app to each user's needs. The first entry point is the log-in screen, which verifies user credentials and ensures authorised access. In addition to gathering data required for account creation, the two sign-up screens also help users prove their identities and improve app personalisation. The app may provide a seamless and user-centred experience, encouraging a sense of security, confidence, and engagement from the very beginning by carefully creating and improving these displays. As the design process progresses, the mock-ups for subsequent screens will further demonstrate the app's visual and functional aspects, providing a comprehensive overview of the user interface and the overall user journey. The app's interface will be fine-tuned through clever design iterations and user feedback, resulting in an intuitive and immersive experience for refugees accessing healthcare services through HealthBridge.

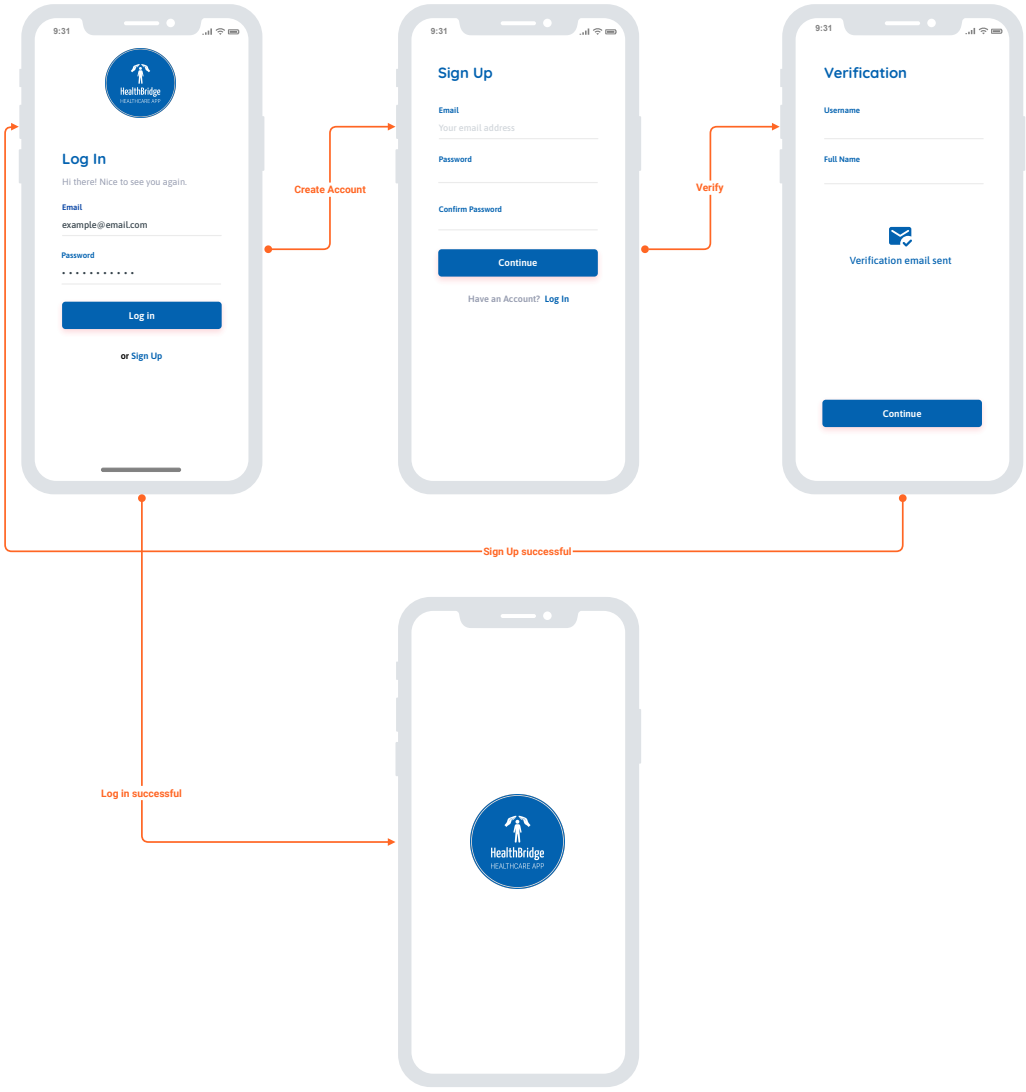


Figure 6.2: Log-in and Sign-up mock-up

6.2.3 Profile and Menu Screen

The profile screen is the primary centre for managing accounts and accessing significant features. The profile screen's design prioritises creating a user-friendly and customised experience, giving refugees the power to manage their information and interact with the app successfully. The screen has four options displayed using cards, each catering to a different account management area and user involvement.

Users have the option to change their profile photo with the first card. Users can upload a new photograph or select one already available by tapping this option to represent their identity within the app. Customising the profile image encourages a sense of ownership and familiarity while adding a personal touch. Editing profile data is done on the second card. The user's username, name, gender, and birthday can all be changed here. Giving users this personalisation guarantees they can appropriately represent themselves and update their profiles. The app improves personalisation and adjusts the experience to individual preferences by allowing users to modify these variables. The third card has a feedback option that lets users send the app creators their ideas, comments, or complaints. Users can provide insightful feedback, report errors, or make suggestions for enhancements by tapping on this item. The user-centred design methodology values user feedback, ensuring their opinions are heard and considered for ongoing development and improvements. The fourth and final card offers a logout option, enabling users to log out of their accounts safely. Thanks to this feature, users can manage their sessions and safeguard their personal information, which guarantees privacy and gives them control over account access.

A hamburger button is also placed on the profile screen in the upper-left corner. This button, when touched, causes a slide menu to appear, revealing a wide range of options for browsing the app. Thanks to the sliding menu, users may easily explore various functionalities, which provide access to the three critical elements of the app's healthcare access functionality already described in Section 6.1. The slide menu also has sections for "About Us" and "Settings," allowing users to get more information about the app and personalise their experience.

The design and mock-up of the profile screen and sliding menu, illustrated in Figure 6.3, were meticulously created with a focus on user-centred principles. By considering user feedback and incorporating essential account management features, the profile screen ensures a user-friendly, customisable, and engaging refugee experience using the HealthBridge app.

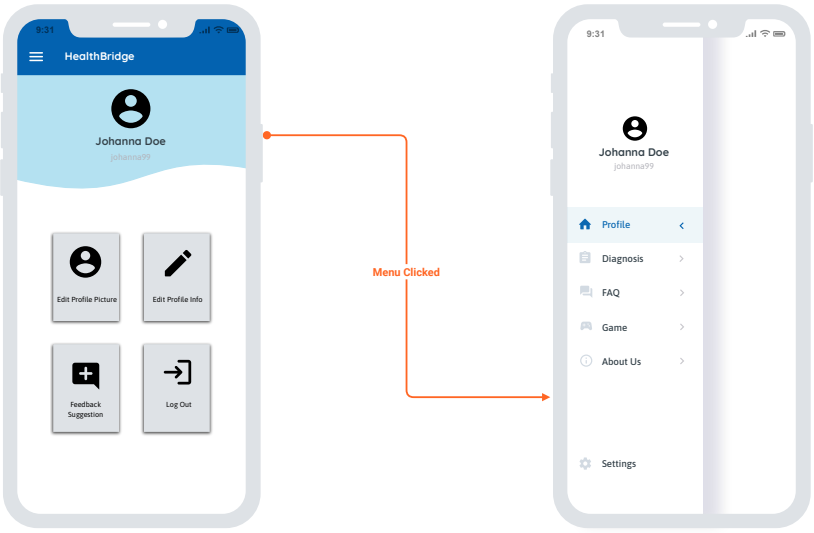


Figure 6.3: Profile and Menu mock-up

6.2.4 Diagnosis

Users can evaluate their health conditions using the app's diagnosis feature and get some initial advice. Users can self-evaluate common health conditions and learn the basics of medicine through a series of tailored questions. The diagnosis section's goal is to give refugees a user-friendly, accessible platform so they can decide on their healthcare needs with knowledge. The app seeks to assist users in finding the proper medical care and increasing their general well-being by providing self-assessment tools and crucial medical information.

The mock-up in Figure 6.4 presents the diagnosis section. The user's journey begins with the sliding menu, where the user clicks on the "Diagnosis" option. This action takes them to a screen that provides a clear explanation of what the diagnosis tool is and what it entails. This screen serves as an introduction, setting the user's expectations and creating awareness of the tool's purpose. The user is shown a screen with the diagnostic questions in the following phase. The format is user-friendly, and the questions are presented straightforwardly and concisely. Each question has two response alternatives, "Yes" and "No," these buttons make it simple for the user to go around the questionnaire. Upon asking all the questions needed, the app directs the user to the final screen, where their "diagnosis" is indicated. This screen provides a summary or recommendation based on the user's responses. The information presented is concise and easy to understand, ensuring

the user receives clear feedback about their potential health situation or a recommended course of action.

The app uses this mock-up design to give users a straightforward and helpful experience. The easy-to-use interface allows refugees to quickly access and use the diagnostic tool to assess common medical disorders and seek medical attention.

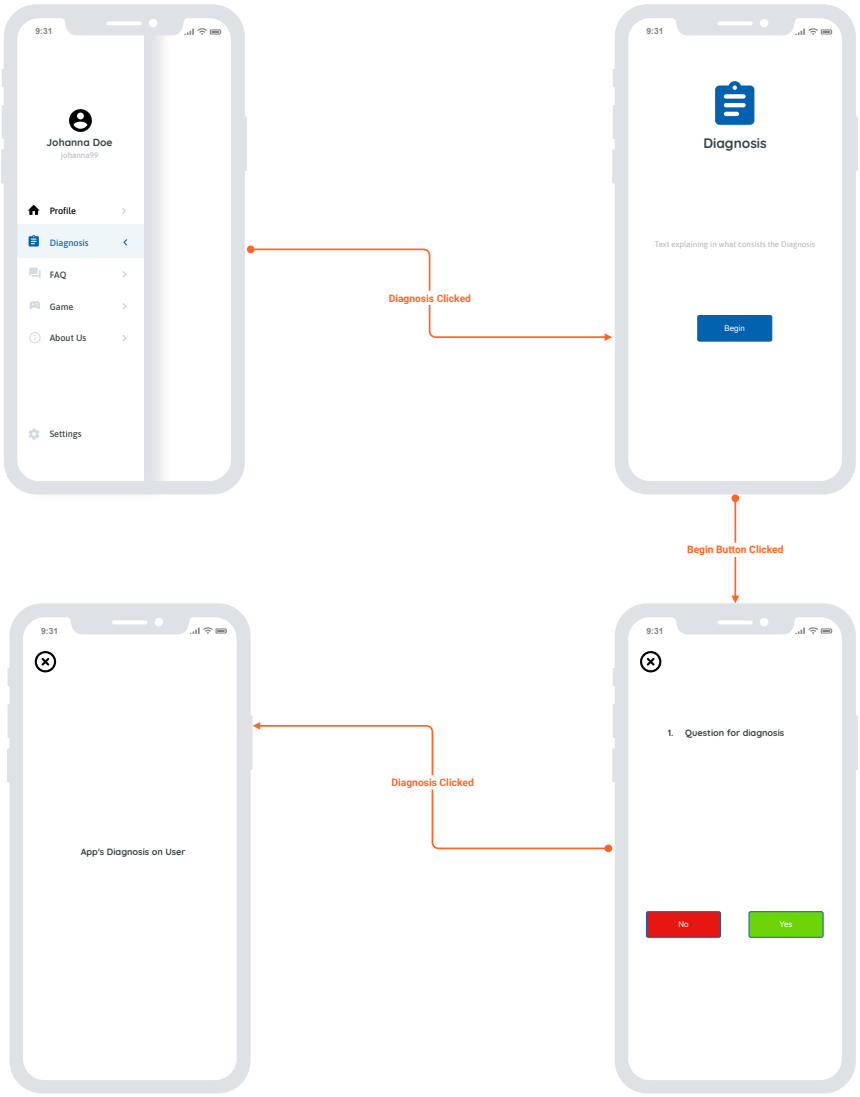


Figure 6.4: Diagnosis mock-up

6.2.5 FAQ

The app's FAQ section is designed to provide users with frequently asked questions and their corresponding answers. The objective is to provide readily available information and respond to typical questions refugees might have about services, healthcare, and other pertinent subjects. Two primary displays make up the mock-up of the FAQ area, Figure 6.5. The sliding menu's FAQ

option is shown in action on the first screen, and an explanation of what it includes and how this section of the app can help users is shown on the second screen.

Following these introductory screens, the mock-up showcases the main FAQ screen, which features a list of pull-down questions. Users may easily navigate this interactive style and quickly get the necessary information. The FAQ section seeks to supply refugees with helpful information and support their healthcare decision-making by offering a user-friendly layout and a complete set of pertinent questions and answers.

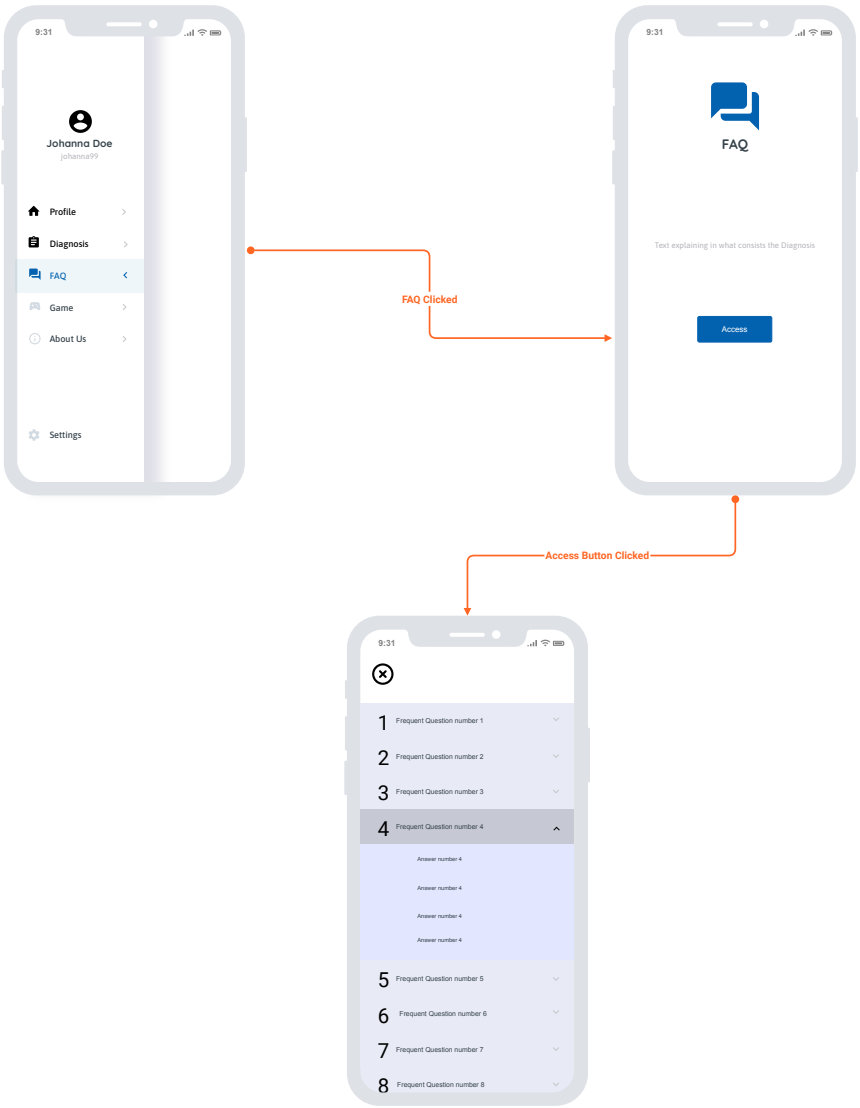


Figure 6.5: FAQ mock-up

6.2.6 Game Menu

The app's Game section offers users an interactive and engaging experience through two game options: the Association Game and the Quiz Game. The mock-up follows the philosophy of the previous sections, with the sliding men. However, this time, the game section, present in Figure 6.6, showcases a menu with two distinct options, each leading to a different game screen.

The first card represents the Association Game. Users who choose this option will be taken to a screen that describes the game and gives instructions on playing. The same thing applies to The Quiz Game, represented by the second card. Choosing this option will lead users to a screen that presents a fun and interactive quiz about healthcare access in Portugal.

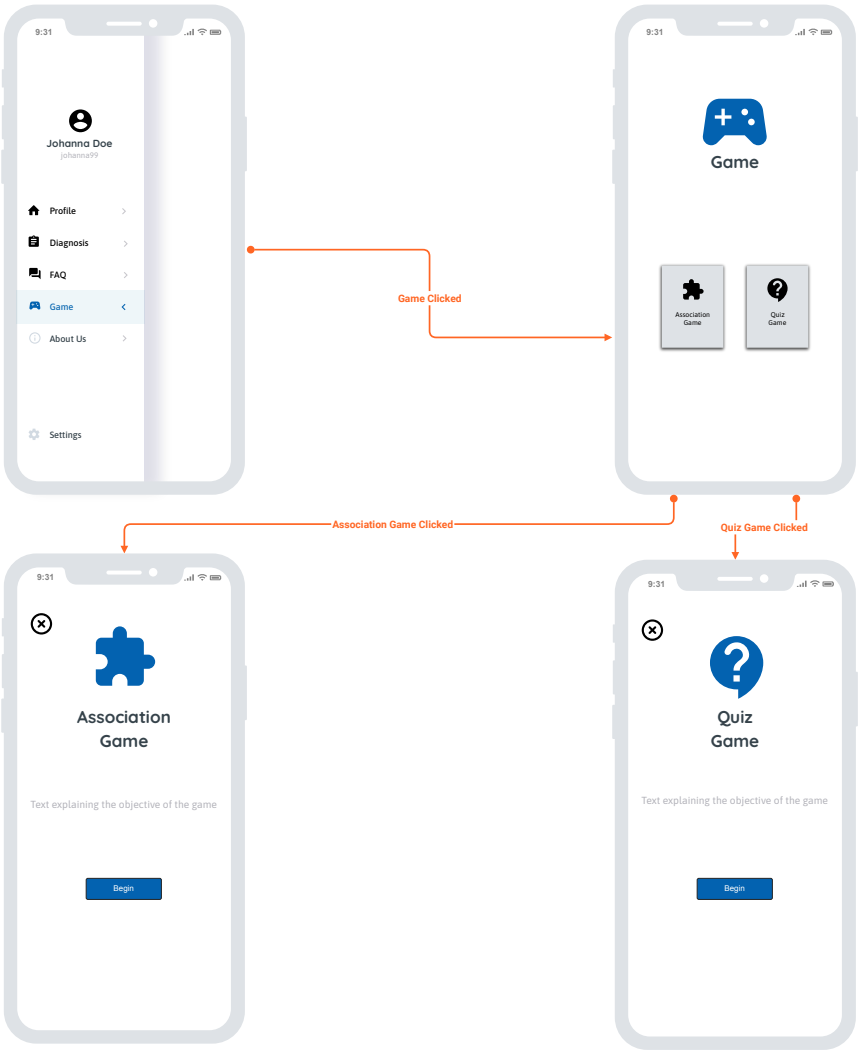


Figure 6.6: Game screen mock-up

6.2.6.1 Association Game

The Association Game looks to challenge users to match the name of medical specialities, presented in Portuguese and its translation to English, with an image related to that medical speciality. This will enhance their understanding of medical terminology in Portuguese. The screen displays four cards with different images, and users must pair them correctly based on their association.

The game consists of 10 association questions, and at the end, the player will be given a score out of 10 according to the number of questions answered correctly. With that score, a particular medal will be given to the player and displayed on the app. Figure 6.7 showcases the mock-up for this game.

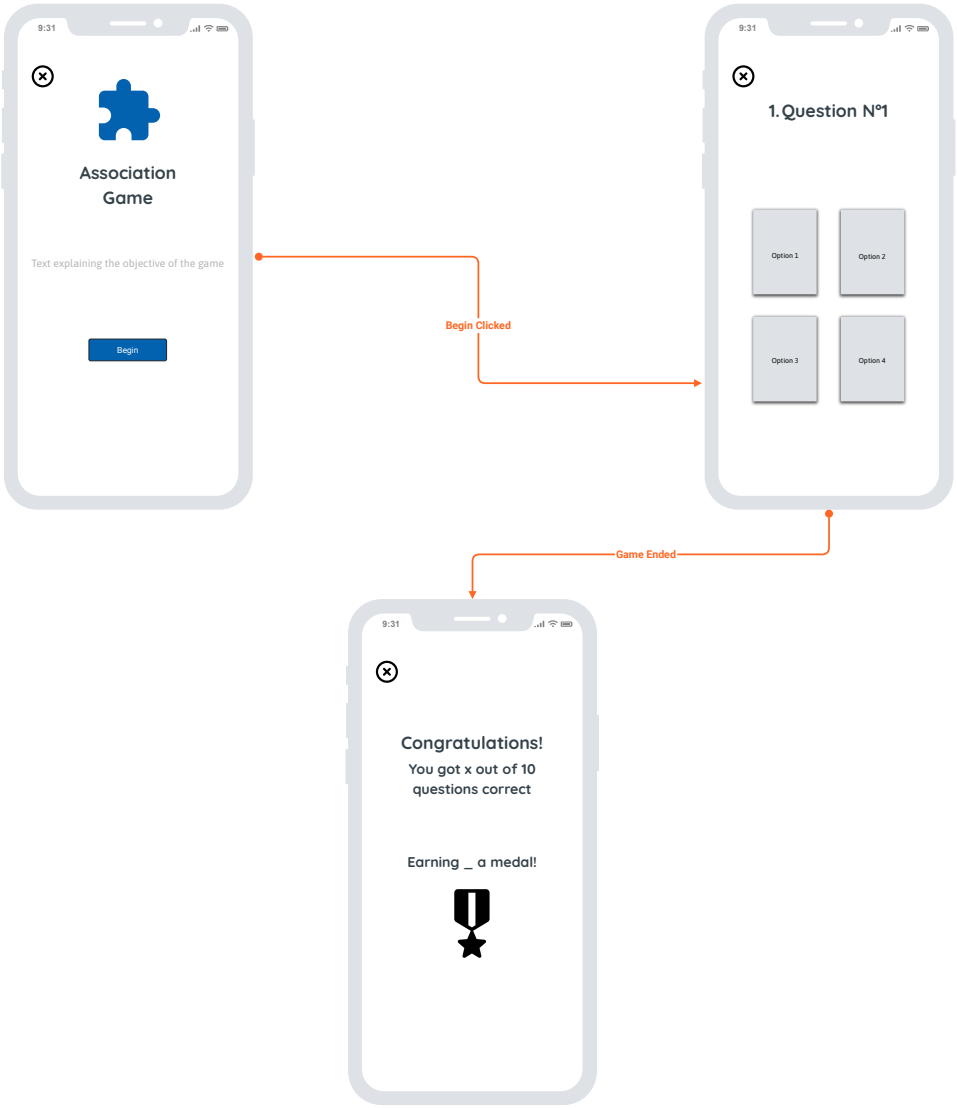


Figure 6.7: Association game mock-up

6.2.6.2 Quiz Game

The Quiz Game tests users' knowledge of various healthcare topics through multiple-choice questions. Users can select their preferred answer from the provided options, and upon submission, the app will provide instant feedback on the correctness of their response. The quiz game educates and entertains users while reinforcing their understanding of critical healthcare information related to the Portuguese healthcare system.

This game also has a scoring system identical to the one in the association game, with a score rated from 0 to 10 and a medal linked to that score. Figure 6.8 displays the mock-up designed for the quiz game.

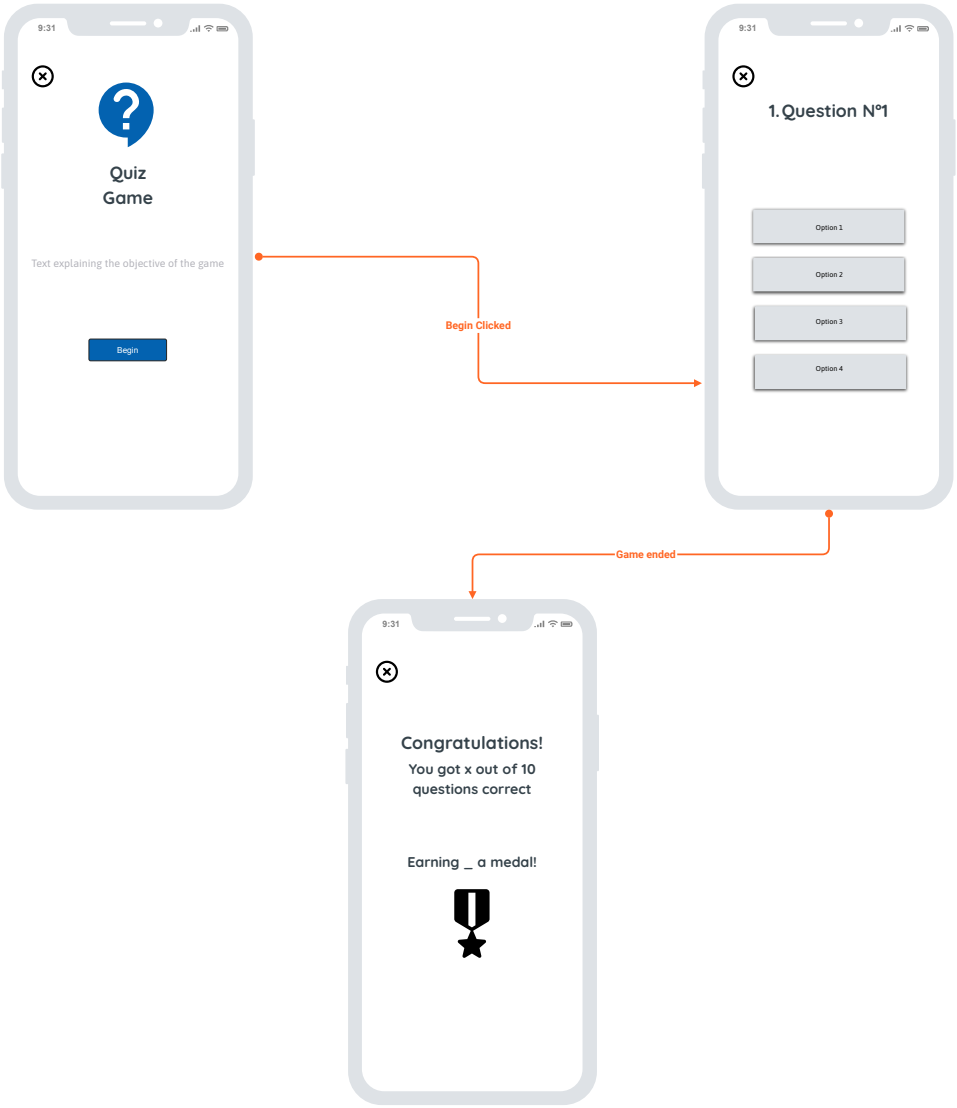


Figure 6.8: Quiz game mock-up

6.3 System Architecture

The system architecture of the HealthBridge app, developed in *Android Studio*, comprises two main components: its Android interface and Firebase database (Authentication and Realtime Storage). The latter follows a robust and scalable architecture to ensure efficient data management and user authentication. Here is a detailed overview of the system architecture represented in Figure 6.9:

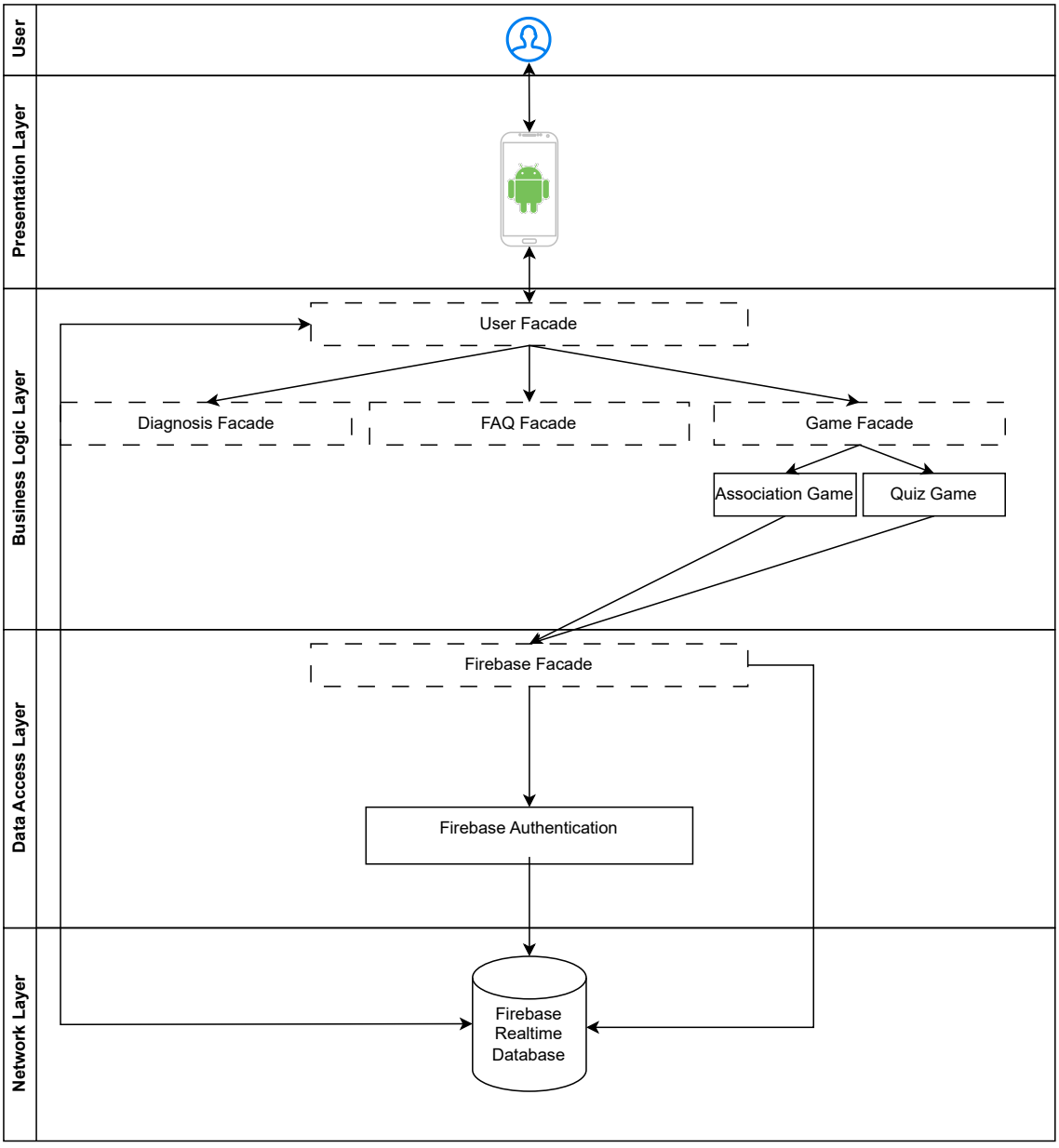


Figure 6.9: System Architecture Diagram

- **Presentation Layer**: The user interface elements, such as activities, fragments, and views, display data and record user interactions. It manages the app's graphical user interface and user interaction.

- **Business Logic Layer**: Contains essential processing and functionalities. It comprises the execution of several elements, including the game functionalities, FAQ area, and diagnosing tool. Through a User Facade, this layer interfaces with the presentation layer to retrieve and alter data. The User Facade is an abstraction layer for handling user-related operations and interactions. It encapsulates the logic for user authentication, registration, and profile management. This includes functionalities such as user login, logout, account creation, updating user information, and managing user preferences. It then divides itself into three more facades:

    1. **Diagnosis Facade**: This facade would include the diagnostic features. It would include strategies for starting the diagnostic procedure, dealing with user responses to inquiries, assessing the responses, and diagnosing based on the provided responses.
    2. **FAQ Facade**: The processes of the FAQ feature would be abstracted by this facade. It would offer ways to get the list of frequently asked questions and present the respective answers when requested.
    3. **Game Facade**: All interactions related to the game functionality would be handled by this facade. It would include the logic for beginning the quiz and association games, keeping track of game stats and user inputs, and getting game-specific information from the database, such as the score obtained by each user.

- **Data Access Layer**: It controls how the app communicates with Firebase services, including Realtime Storage and Authentication, with the Firebase Facade. The Firebase Facade and Firebase Authentication are two essential elements inside this layer:

    1. **Firebase Facade**: It is an abstraction or interface layer that hides the specifics of using the Firebase services. It offers a condensed and unified set of techniques and features for synchronising, storing, and retrieving data. The business logic layer may interface with Firebase services more efficiently since the Firebase Facade encapsulates the Firebase SDK integration, API calls, and data mapping.
    2. **Firebase Authentication**: It handles the authentication and authorisation processes within the app. It allows users to sign up, log in, and manage their authentication state securely with email and password authentication. Firebase Authentication ensures that only authorised users can access and manipulate their data within the app.

- **Network Layer**: The communication management between the app and the Firebase services falls under its purview. Its primary responsibilities are handling network requests, ensuring safe data transmission, and facilitating communication with Firebase services. The

Firebase Realtime Database is a vital component of this layer, and it enables the synchronisation and storing of data in real-time. It allows the app to store and retrieve data in real time, offering a robust and scalable data management solution. The network layer uses the Firebase SDKs and APIs to establish a reliable connection with the Firebase Realtime Database. It controls the synchronisation of data changes between the app and the Firebase Realtime Database, handles network requests to read or write data, and ensures data integrity. Therefore, the app can efficiently synchronise real-time data by leveraging the Firebase Realtime Database within the network layer. Any changes made to the data in the Firebase Realtime Database are automatically propagated to all connected clients, enabling real-time updates and collaboration. The network layer ensures that network requests to the Firebase Realtime Database are securely transmitted and that data integrity is maintained throughout the communication.

6.4 Implementation

The next step for successfully developing the HealthBridge app is the implementation of its Concept, Design and System Architecture. As previously mentioned, the software chosen for this task was *Android Studio*. This choice was made mainly because it is recognised as an integrated development environment (IDE) for developing Android applications, and it provides a rich set of features tailored specifically for Android app development, offering a robust code editor with features like code completion, refactoring, and debugging tools. The database and authentication service was **Firebase** [71], owing to its easy integration with **Android Studio** with SDKs and ready-to-use libraries that simplify the integration of authentication and database features. Besides, by being a cloud-based platform provided by Google, it leverages Google's infrastructure for scalability and reliability. It is also worth mentioning that all the figures and drawables used in implementing the HealthBridge app were either personally designed or taken from the "icons8" website [72].

6.4.1 Database Structure

The first implementation for the project's structure was setting up user authentication and a real-time database inside the Firebase.

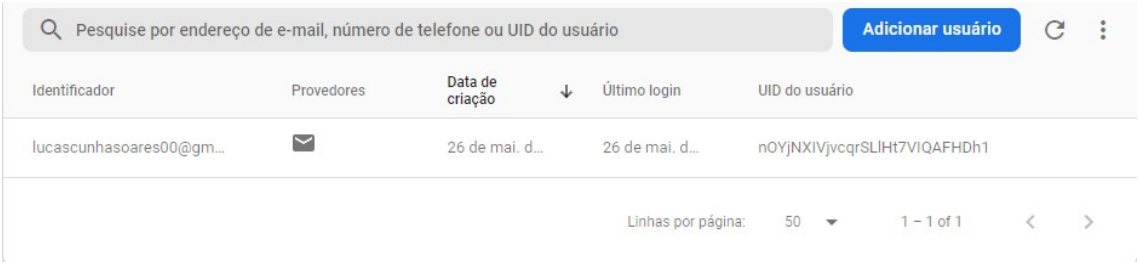
6.4.1.1 Authentication

Users can register and log into the app with Firebase Authentication by using their email address and password, as presented by Figure 6.10a. For the users, this functionality offers a trustworthy and secure authentication method. Because of that, there is no need to worry about managing password hashing and storage, as Firebase already handles that matter.

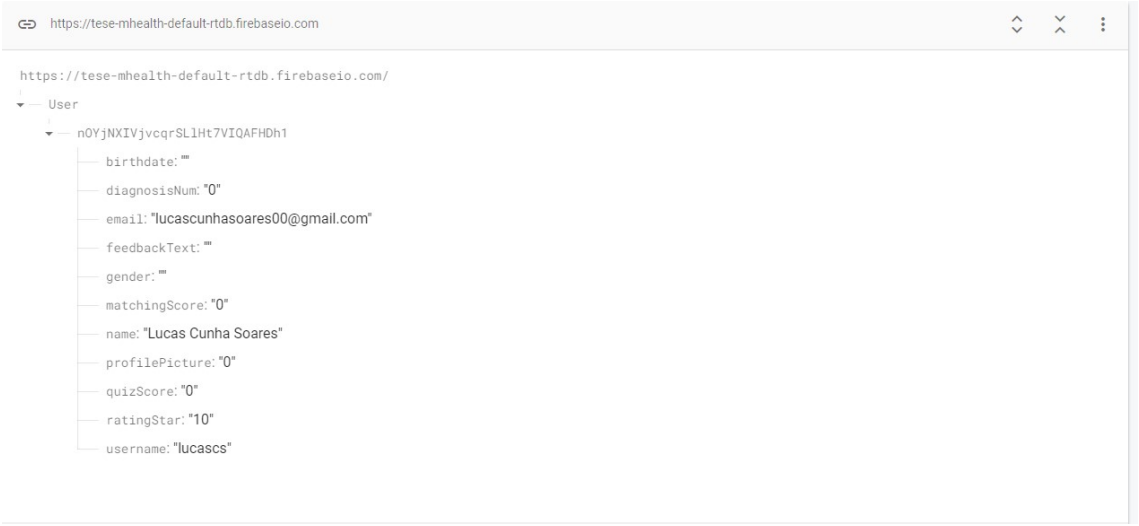
6.4.1.2 Realtime Database

A NoSQL database like the Firebase Realtime Database offers real-time synchronisation features. Data can maintain synchronisation across numerous devices and deliver immediate updates to connected clients by storing user data in the real-time database. This is especially helpful for real-time changes and notifications, ensuring user information is always current across all devices.

In addition, various user-related information can be stored using Firebase Realtime Database, including email, username, name, gender, age, user feedback, diagnosis, game scores, and profile picture (as seen in Figure 6.10b). The NoSQL data model's adaptability enables arranging and organising the data following the project's needs. Also, user-specific data is simple to save and access, allowing for tailored functionality and personalised experiences in their app.



(a) Firebase Authentication



(b) Firebase Realtime Database

Figure 6.10: Firebase Structure

6.4.2 Sign-up Implementation

The sign-up implementation in the app consists of two activities, each associated with one screen. The first is for the initial sign-up screen, where users enter their email, password, and confirm password. The other is responsible for gathering additional user details, such as full name and username. Email verification is also requested to complete the sign-up process.

6.4.2.1 Initial Sign-up Activity

In this activity, the user's email is requested together with a password that must fulfil the following requirements (Figure 6.11a):

- A minimum of eight characters;
- At least one number;
- At least one uppercase;
- At least one special character.

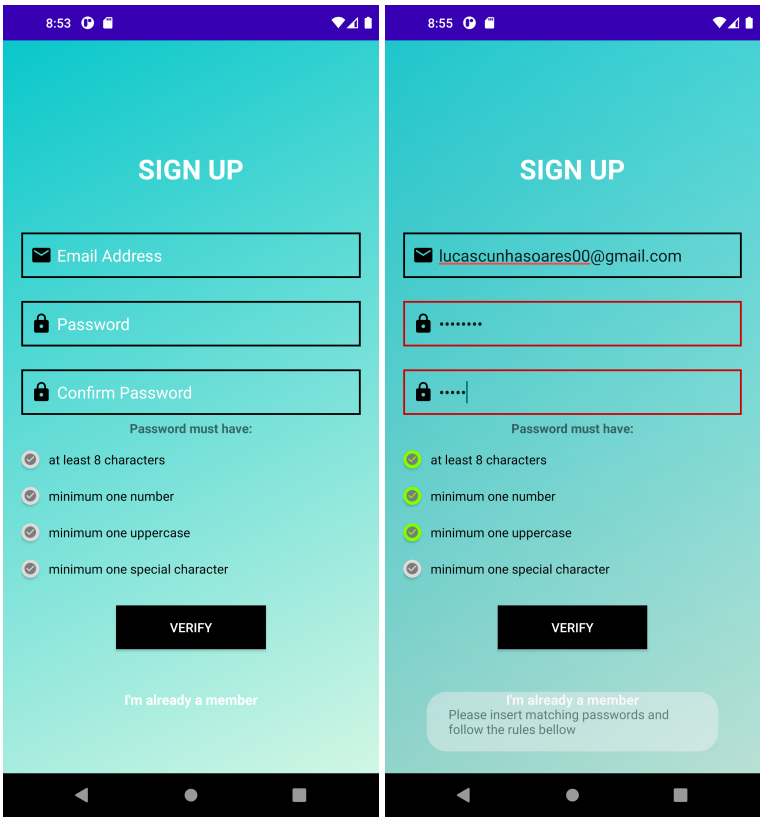
Additionally, the app requires the user to confirm his password by retyping it. If the email is invalid, the password does not follow the requirements, or the passwords do not match, the user will receive simple feedback on what is wrong with its attempt via a small popup (Figure 6.11b). Upon successful account creation, this activity sends a verification email to the user's provided email address. After that, the user is redirected to the next activity.

There is also an "I'm already a member" button at the bottom of the screen that, if pressed, directs the user to the Log-in activity.

6.4.2.2 Complete Sign-up Activity

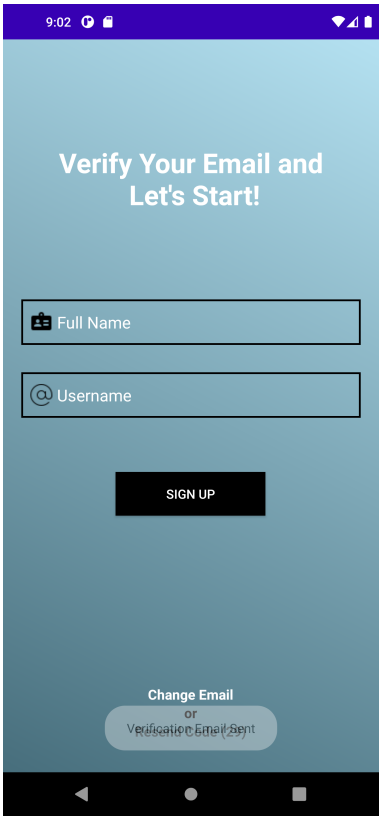
This activity gathers additional user details, such as their full name and username, to complete the sign-up process (Figure 6.11c). Before the sign-up is considered for completion, the user's email must be verified, so the activity asks the user to check their email in case it still needs to be verified (Figure 6.11d). The email is a standard email sent by Firebase's authentication service, and it is displayed in Figure 6.12a. If the verification is completed successfully, the message in Figure 6.12b pops up; if verification is unsuccessful, it is the one in Figure 6.12c. If the user wishes to change his email, the "Change Email" can be clicked, and the user will be redirected back to the last activity. A "Resend Code" button and a thirty-second countdown are below the "Change Email" button, and the button will be enabled at the end of that time so the user can press it to resend the verification email.

After the email verification process, the application will request that the full name and username input fields are validated for length and the presence of valid characters. The app will also check if the username entered does not already exist in the Firebase Realtime Database. After completing the sign-up process, the user is redirected to the log-in activity, and the data is stored in the Firebase.

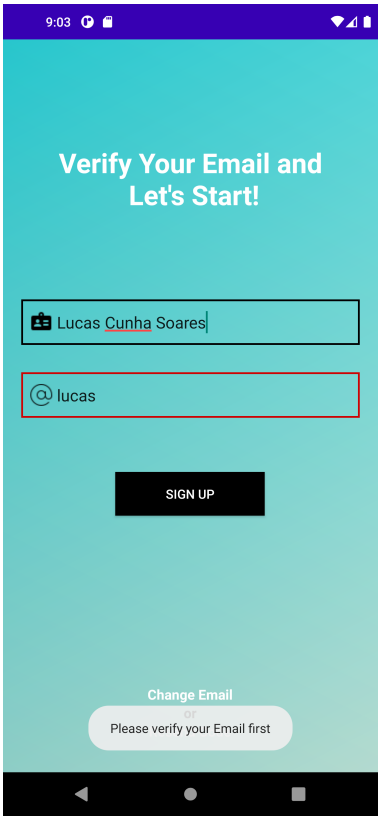


(a) Initial screen

(b) Sign-up failed

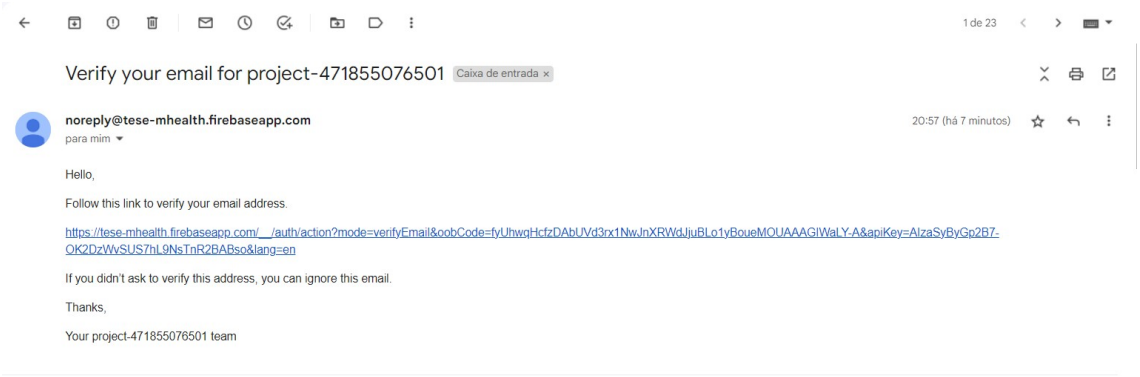


(c) Complete sign-up

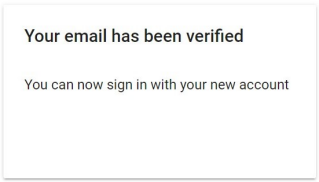


(d) Verification failed

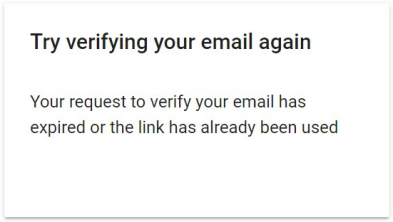
Figure 6.11: Sign-up Screens



(a) Verification email



(b) Verification successful



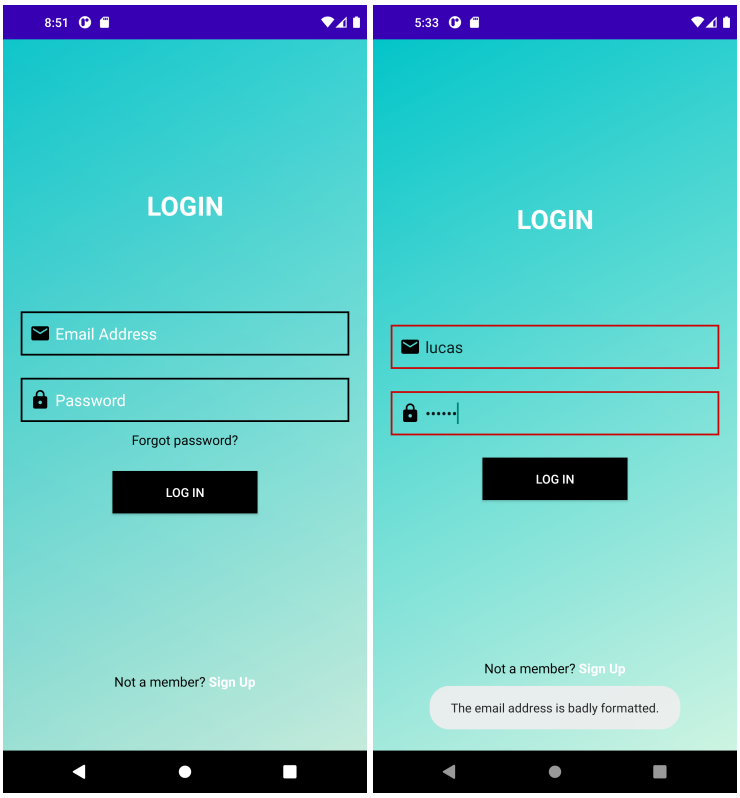
(c) Verification failed

Figure 6.12: Email Verification Process

6.4.3 Log-in Implementation

Establishing and securing user accounts and providing personalised access to app features and data is crucial. Because of that, The log-in activity was implemented to ensure that only authenticated users with valid credentials can access the app's features and data. It helps protect user accounts from unauthorised access, and once logged in, the app can provide personalised experiences tailored to each user. User-specific data, settings, and scores can be loaded, ensuring a customised and relevant experience.

For this implementation, the user's input fields for the email address and password are checked with the Firebase authentication when the "Log In" button is clicked (Figure 6.13a). If the email is not valid, the log-in will fail, and a notification in the form of a pop-up will appear informing the user (Figure 6.13b). The same thing will happen if the password does not match the email inserted (Figure 6.13c). Finally, if the email matches the password, the login will be successful, and HealthBridge's landing page will appear (Figure 6.13d). On this page, the user is welcomed and presented with the app's logo alongside a "Explore" button that, when pressed, will open the main navigation menu.



(a) Initial screen (b) Incorrect email

(c) Incorrect password (d) Landing page

Figure 6.13: Log-in screen

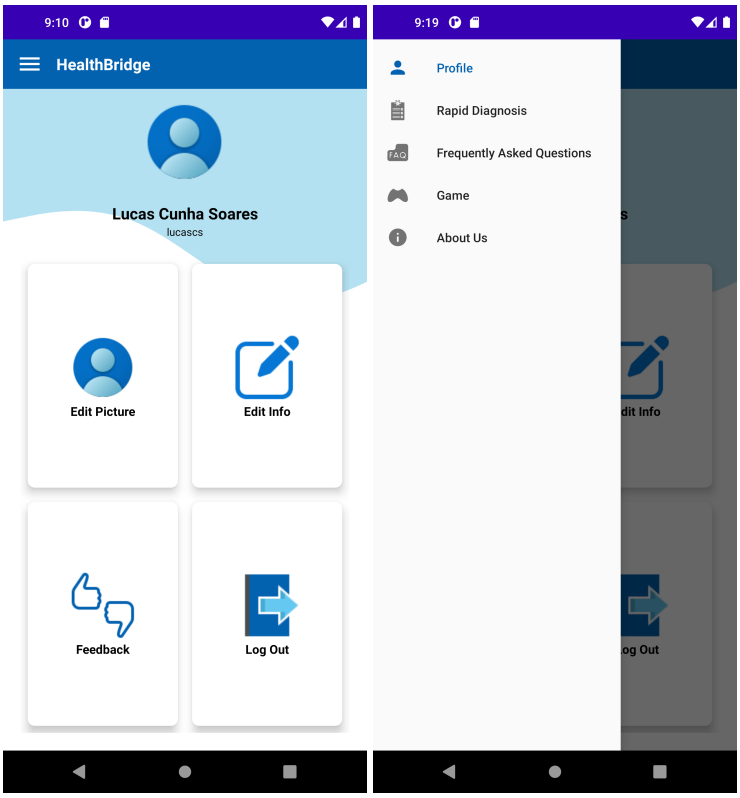
6.4.4 Main Navigation

The navigation component of a mobile application acts as a central, assuming itself as an influential design element capable of navigation in the system and providing a smoother user experience.

Therefore, a lateral navigation bar was implemented. It can be accessed by swiping from left to right on the left edge of the screen of the user's mobile device or by clicking the hamburger button placed on the top left (Figure 6.14a). A hamburger button menu is a widely recognised and understood symbol for accessing a menu in mobile apps. Users may quickly and easily access various app parts or features by adopting this well-known design pattern, which encourages a consistent navigation experience across several displays. Besides, the side slider menu allows for a clean, uncluttered interface, hiding secondary or less frequently accessed options. This design approach optimises the use of the limited screen space on mobile devices, allowing greater focus on the content or main functionality of the application.

The menu gives access to 5 different features (Figure 6.14b):

- **Profile Feature**: presents the Profile screen;
- **Diagnosis Feature**: presents the Rapid Diagnosis screen;
- **FAQ Feature**: presents the Frequently Asked Questions screen;
- **Game Feature**: presents the Game screen;
- **About Us Feature**: presents the About Us screen.



(a) Profile screen (b) Navigation options

Figure 6.14: Navigation Menu

6.4.5 Profile Feature Implementation

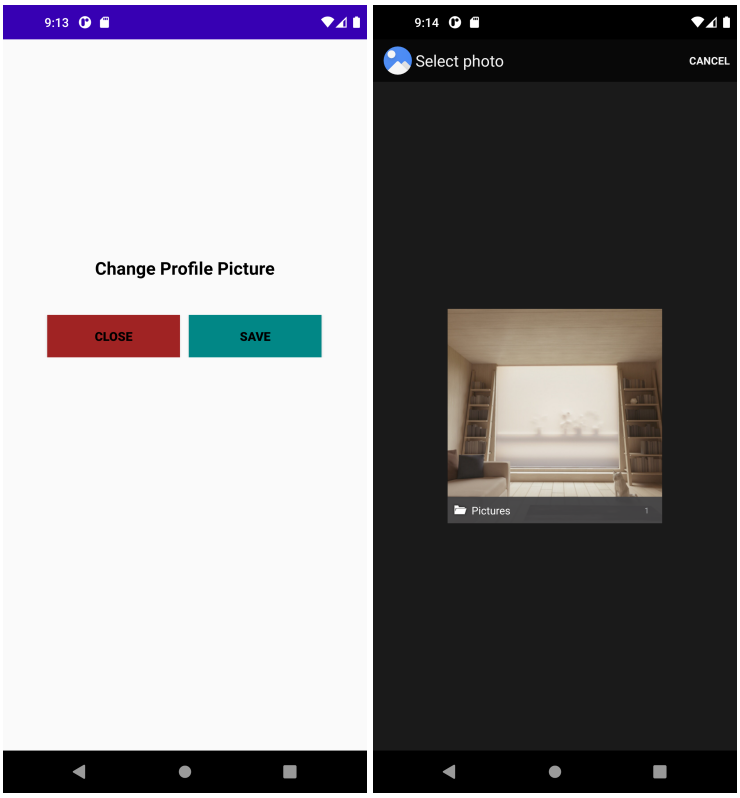
The user's profile is the main screen of the HealthBridge app and the first one that will appear as soon as the user logs in to the HealthBridge app. The profile plays a crucial role in user-centred applications as it serves as a personalised representation of an individual within the system. It holds essential information such as the user's name, username, and profile picture, providing a means for identification and personalisation.

Thus, the profile feature presents the user's full name, username and profile picture, all taken from the information given to the Firebase Realtime Database. This screen is also the gateway for four app features that are made available to the user via four different card buttons (Figure 6.14a):

- Edit Picture;
- Edit Info;
- Feedback;
- Log-out.

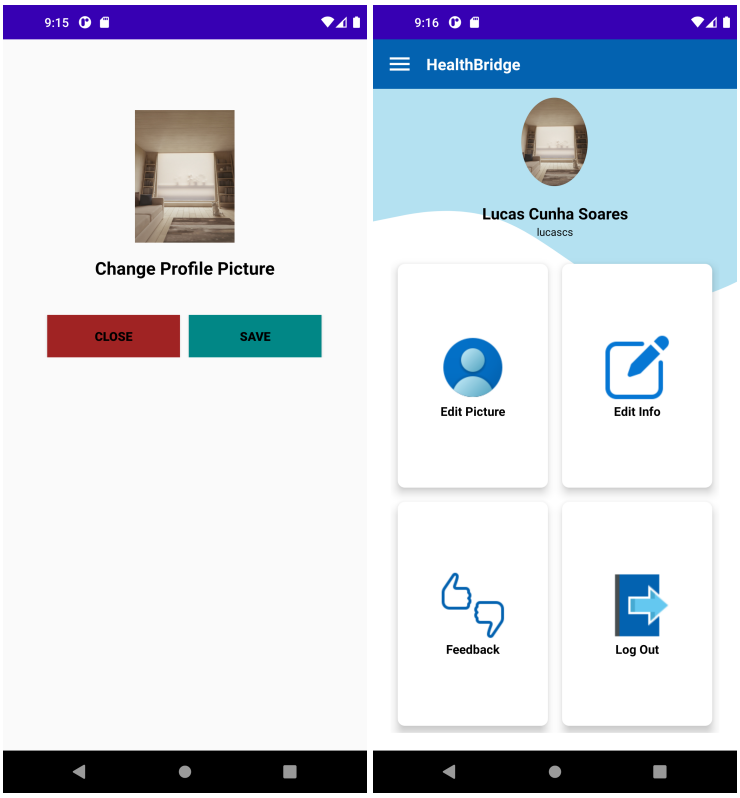
6.4.5.1 Edit Picture Activity

This activity allows users to update their profile pictures within the application from the default drawable or a previously chosen picture. The user's unique ID is used to retrieve the user's current profile image from the Firebase Realtime Database when the activity first launches, in case there is any. The obtained profile photo is then smoothly loaded and cached into an ImageView using the Glide library (Figure 6.15a). The "Change Profile Picture" button opens the image picker, and the user can choose an image from their device's gallery (Figure 6.15b). The selected image's URI is obtained and stored in the Firebase Realtime Database, and the selected then is displayed above the "Change Profile Picture" button (Figure 6.16a). Additionally, the activity provides the users with two buttons, a "save" button and a "close" button. The first makes it possible for the users to upload the picture that was just selected so that it can be displayed in their profile (Figure 6.16b). The second allows users to close the activity at any given time and return to their profile without saving any changes.



(a) Before change (b) Phone gallery

Figure 6.15: Edit profile picture screen (part 1)



(a) After Change (b) Profile's new picture

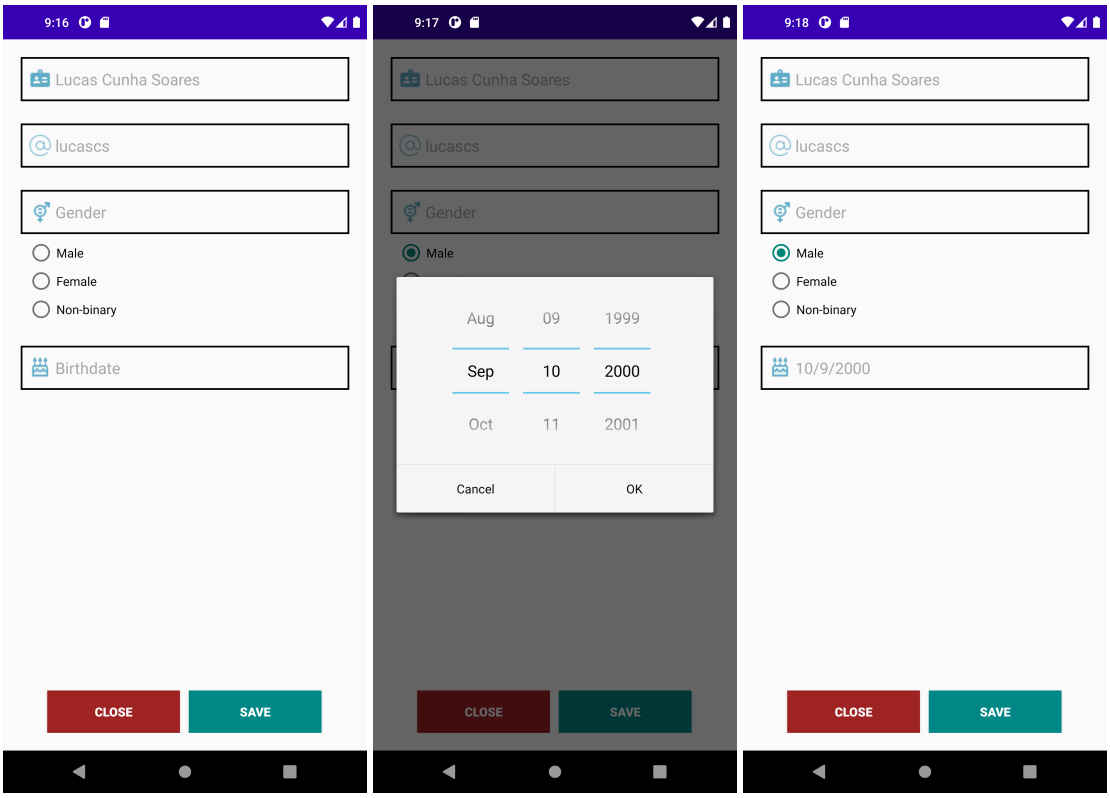
Figure 6.16: Edit profile picture screen (part 2)

6.4.5.2 Edit Info Activity

The Edit Info activity is responsible for allowing users to modify and add their personal information within the application. It provides a user interface with various input fields and buttons to facilitate editing. These fields are full name, username, gender and birthdate (Figure 6.17a).

The activity retrieves the user's current information from the Firebase Realtime Database. The full name and username information is displayed to the user, and it is possible to change them, following the rules that were followed when creating the account in the first place. However, information like gender and birthdate are not set when creating an HealthBridge account, so the app gives that possibility to its users. For the users' gender, it is possible to choose from three options: male, female and non-binary. The "birthdate" text is clickable and opens a Date Picker to select the birthdate (Figure 6.17b).

Just like the previously described edit picture activity, the edit info activity also disposes of two buttons, one for saving the info that is changed inside this activity into the Firebase Realtime Database and a closing button to make it possible for the users to exit this activity when desired (Figure 6.17c).



(a) Before change (b) Bithdate selection (c) After change

Figure 6.17: Edit info screen

6.4.5.3 Feedback Activity

The "Feedback" activity is reasonably straightforward, as it just collects a star rating and user text feedback within the application. Therefore, it provides a user interface with a rating bar and an editable multi-line text field for feedback. The activity has a "submit" button for uploading the feedback to the Firebase Realtime Database to be visible to the developers. This feedback can then be used for analysis, improvement, and further interaction with the user. If the user wishes to close the activity at any given time, an "X" close button is placed on the top left side of the screen. Figure 6.18 displays this activity's screen.

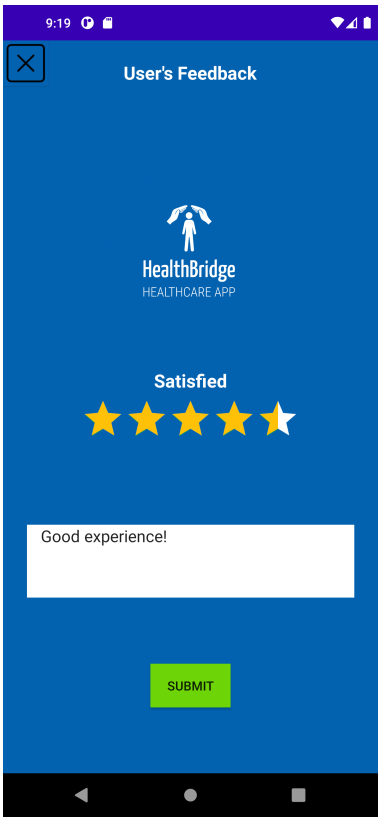


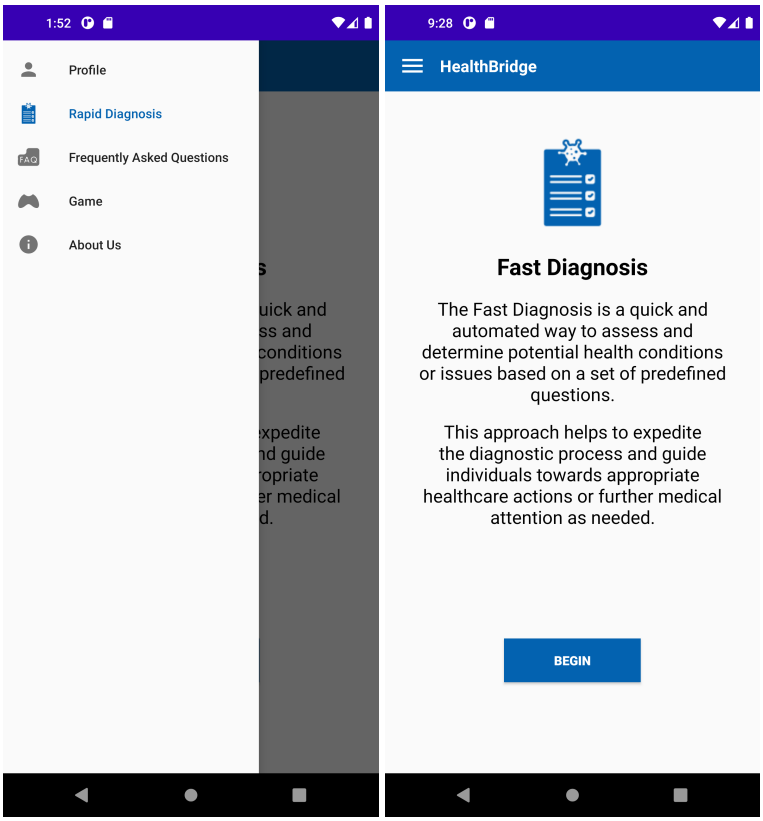
Figure 6.18: Feedback screen

6.4.5.4 Log-out

A log-out button is placed in the final slot of the card buttons displayed in the user's profile (Figure 6.14a). By clicking the log-out button, the users can sign out of their account, ensuring that the users' session is terminated and their access to protected resources is revoked. It also helps to prevent unauthorised access to the users' accounts if the device is shared or lost. Moreover, the user experience is enhanced by offering a clear and accessible log-out feature. It enables users to cancel sessions and change between accounts if necessary quickly. In applications that deal with sensitive data, logging out can be especially helpful as it gives users a sense of control over their data and activity.

6.4.6 Diagnosis Feature Implementation

The user can access the diagnosis feature via the main navigation menu (Figure 6.19a) by pressing "Rapid Diagnosis". This screen first presents the user with an initial text about this feature, its goal and its dynamic process. After careful reading, the user can press the button "begin" and start the diagnosis (Figure 6.19b).



(a) Navigation menu (b) Explanatory text

Figure 6.19: Diagnosis initial screen

The diagnosis feature follows an elementary decision tree. Based on the values of the features, a decision tree algorithm decides by traversing the tree from the root node to the appropriate leaf node. The decision tree evaluates the importance of each internal node's feature and chooses the right branch depending on the evaluation results. Hence, the prediction or result connected to that leaf node is returned after a leaf node is reached in this procedure.

The questions in each decision tree node were built to support the survey participants' doubts and questions. Information gathered from the Portuguese National Health Service (SNS) [73] website and the General Secretariat of the Portuguese Ministry of Health (ACSS) home web page [74] was also extremely important for this matter. As for the Diagnosis procedure itself, it follows the decision tree exhibited in Figure 6.20, where the answers were structured with information present in the two websites mentioned before, along with information provided directly by health-care information experts from health institutions (ACeS - *Agrupamento de Centros de Saúde*) of the Portuguese northern region, that were willing to help. Those answers are:

- **Answer 1**: "Call the emergency services immediately!! Dial 112 in your phone!"
- **Answer 2**: "You may need to register. You can also contact SNS 24 for information: 808 24 24 24"

- **Answer 3**: "You should contact the SNS 24 helpline at 808 24 24 24 for guidance and further instructions. It is important to follow their advice and avoid going directly to healthcare facilities without prior authorisation."
- **Answer 4**: "You should seek help by contacting the SNS Mental Health Line at 808 24 24 24. Remember, it's important to reach out and seek assistance when needed!"
- **Answer 5**: "You can schedule an appointment with your general practitioner or a gynaecologist to discuss your concerns and receive appropriate medical advice. Don't hesitate to reach out and seek professional assistance for any women's health issues you may be facing."
- **Answer 6**: "It is important to seek medical assistance promptly. Contact your paediatrician or visit the nearest healthcare centre for professional evaluation and guidance."
- **Answer 7**: "It is advisable to consult with a primary care physician or specialist. They will assess your condition, provide appropriate medical advice, and create a treatment plan tailored to your needs."
- **Answer 8**: "You can visit a local pharmacy or "farmácia" in Portugal. Pharmacists are highly knowledgeable and can guide medications, dosages, and potential interactions."
- **Answer 9**: "You can visit your local healthcare centre or "Centro de saúde" to receive preventive care, such as vaccinations, screenings, and health check-ups. It is recommended to stay updated with the SNS website or consult with healthcare professionals."
- **Answer 10**: "You can reach out to your local healthcare centre ("Centro de saúde") or contact 808 24 24 24 for guidance and support. They can provide information on available healthcare services, help you find the right specialists or facilities, and assist with scheduling appointments."
- **Answer 11**: "There is no information you need now. However, if there is any additional question, please get in touch with 808 24 24 24 for support!"

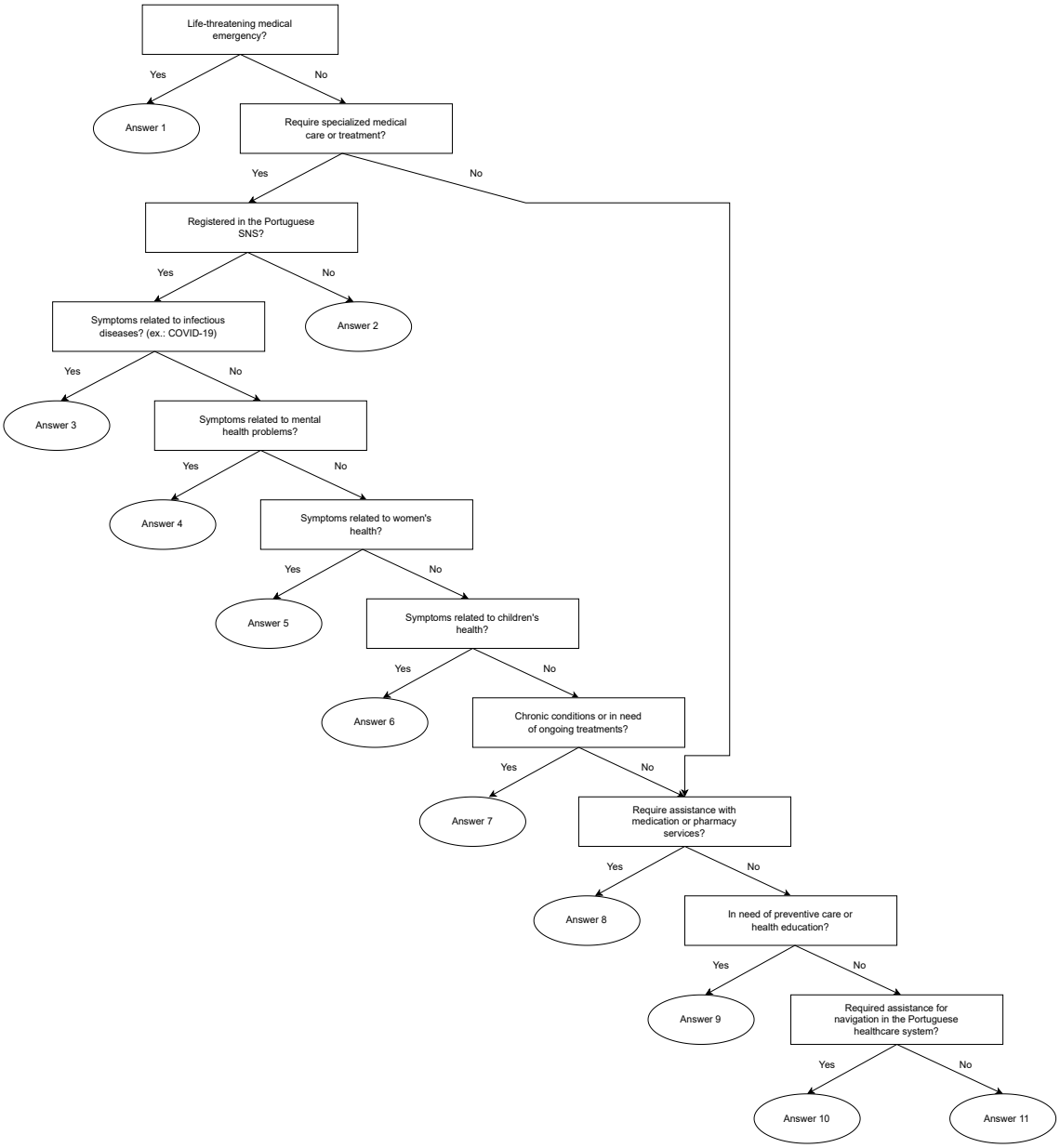
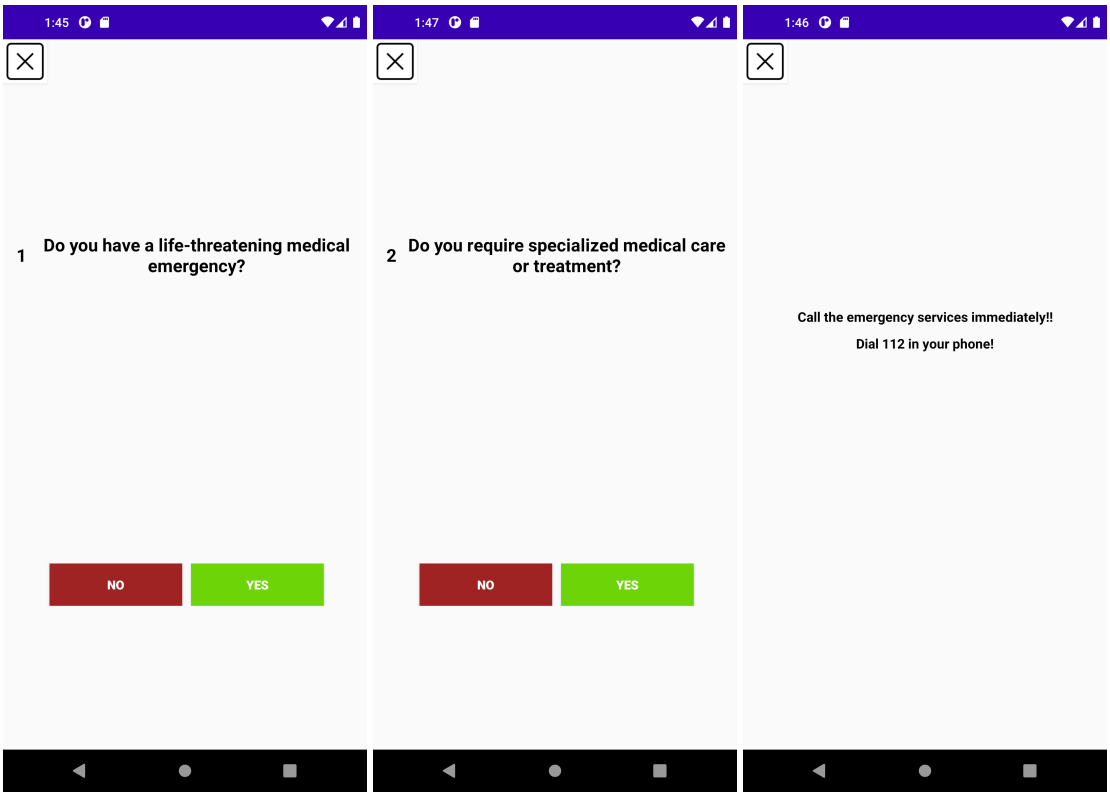


Figure 6.20: Diagnosis decision tree

The screen inside the diagnosis process reveals a simplistic interface where the question of the current decision's tree node is displayed together with the question number. Since the questions are uncomplicated, the user is only presented with a "yes" and a "no" button (Figure 6.21a and 6.21b). By clicking these buttons, the user will progress through the decision tree until reaching a final node where an answer will be presented (Figure 6.21c). Additionally, an "X" close button on the top left side of the screen allows the user to exit the diagnosis at any given time.



(a) First question (b) Second question (c) Diagnosis response

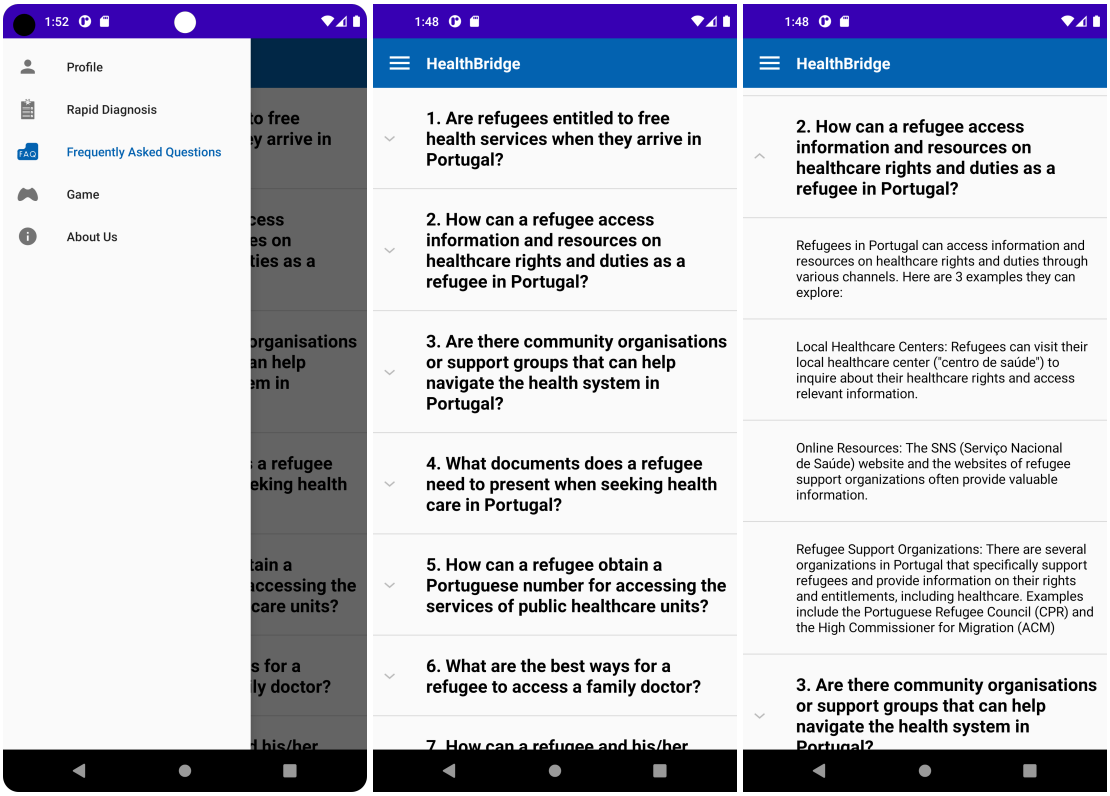
Figure 6.21: Diagnosis screen

6.4.7 FAQ Feature Implementation

Like the other app features, users can easily access the frequently asked question with the main navigation menu (Figure 6.22a). Once the user opens the FAQ section by selecting it from the main navigation menu, they will see the dedicated page specifically designed for displaying FAQs. This page will contain a list of questions that users commonly ask. The questions are displayed in a drop-down format, where only the question is initially visible (Figure 6.22b). When the user clicks on a specific question from the list, the drop-down expands and unveils the corresponding answer (Figure 6.22c). This allows the users to quickly find the information they seek without navigating through multiple pages or searching for it manually.

By organising the FAQs in a drop-down list format, the app provides a user-friendly and intuitive way for users to access the questions and their corresponding answers. It simplifies finding

information and helps users get the answers they need efficiently. The full extent of the FAQ section can be found in Appendix A.2.



(a) Navigation menu (b) FAQ questions (c) FAQ answers

Figure 6.22: FAQ screen

6.4.8 Game Feature Implementation

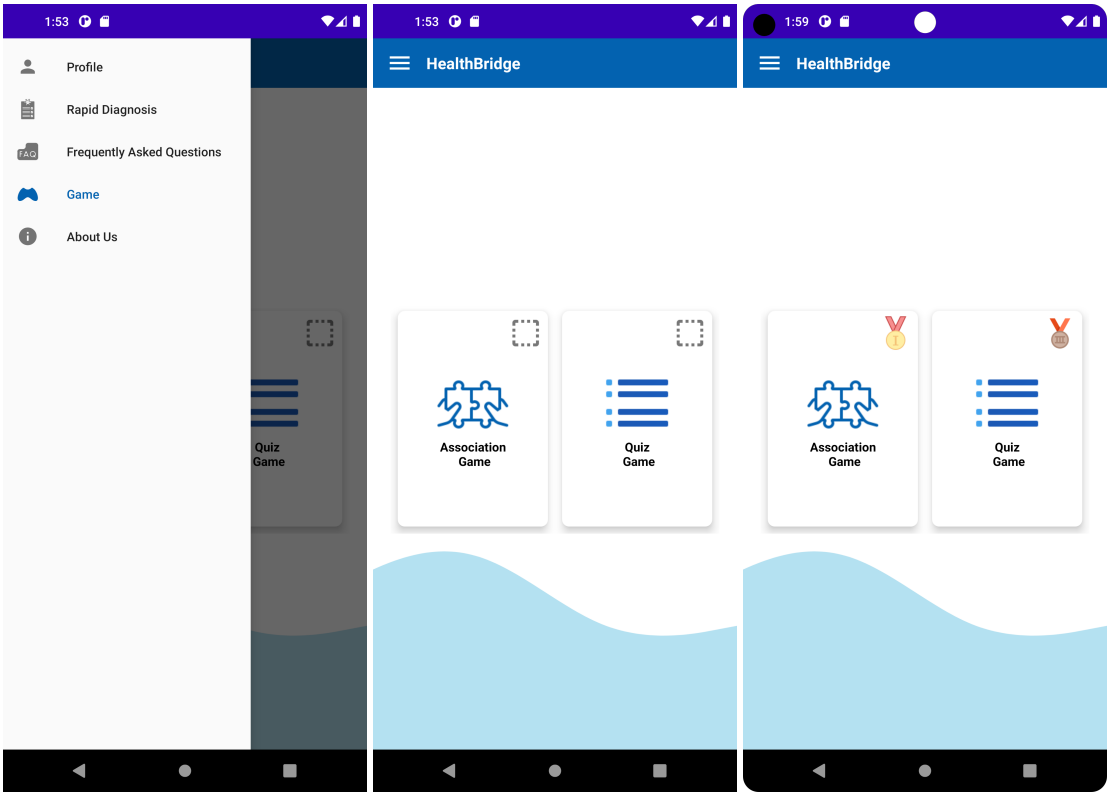
The game feature, accessed via the main navigation menu (Figure 6.23a), has a similar layout to the profile with the card buttons. However, in this case, the game screen has two mini-games that are made available to the user via two different card buttons:

- Association Game;
- Quiz Game.

In addition, on the top right corner of each game's card, there is a slot that will be filled with a reward depending on the user's performance (Figure 6.23b and Figure 6.23c):

- If the score is equal to 0, the user will not receive a reward, the slot will remain empty, and a message of encouragement for the player to try again will appear on the screen;
- If the score is between 1 and 3, the user will be rewarded with the bronze medal;
- If the score is between 4 and 7, the user will receive a silver medal;

- If the score is either 8 or 9, the user will be rewarded a gold medal;
- A diamond will be rewarded if the user gets all 10 questions right.

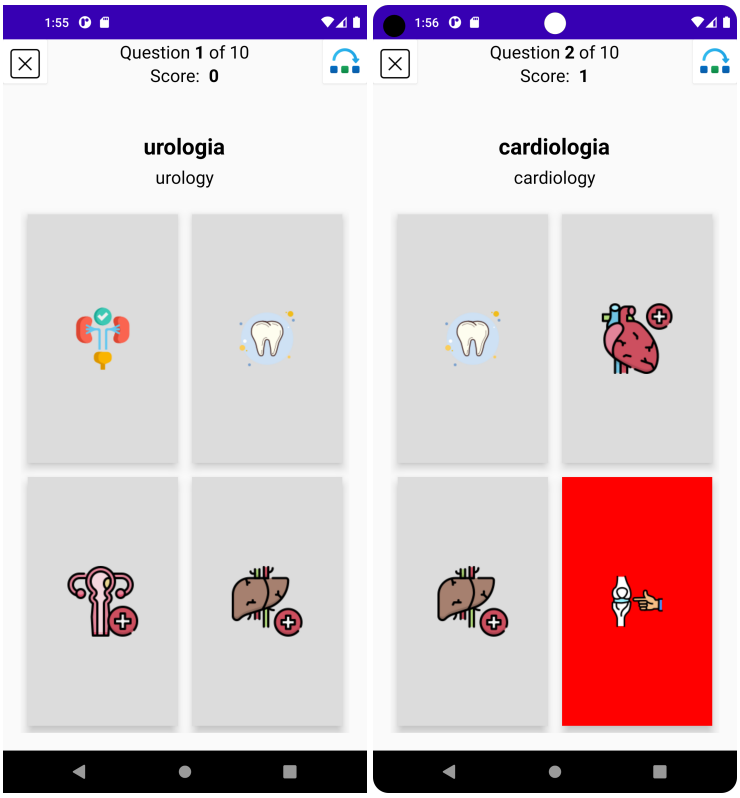


(a) Navigation menu (b) No medals (c) With medals

Figure 6.23: Game screen

6.4.8.1 Association Game

The game logic behind this mini-game is reasonably simple as the screen will showcase a medical speciality written in Portuguese, an English translation below and four images of different medical specialities. The goal is to select the image related to the medial speciality written above, and if the answer is correct, the score will go up, and the background will be green-lit; if the answer is incorrect, the score will not increment, and the background will be red-lit. The game will end when the player goes through all 10 questions, and the player's reward will show on the screen.



(a) First Question (b) Wrong answer

(c) Right answer (d) Finished game

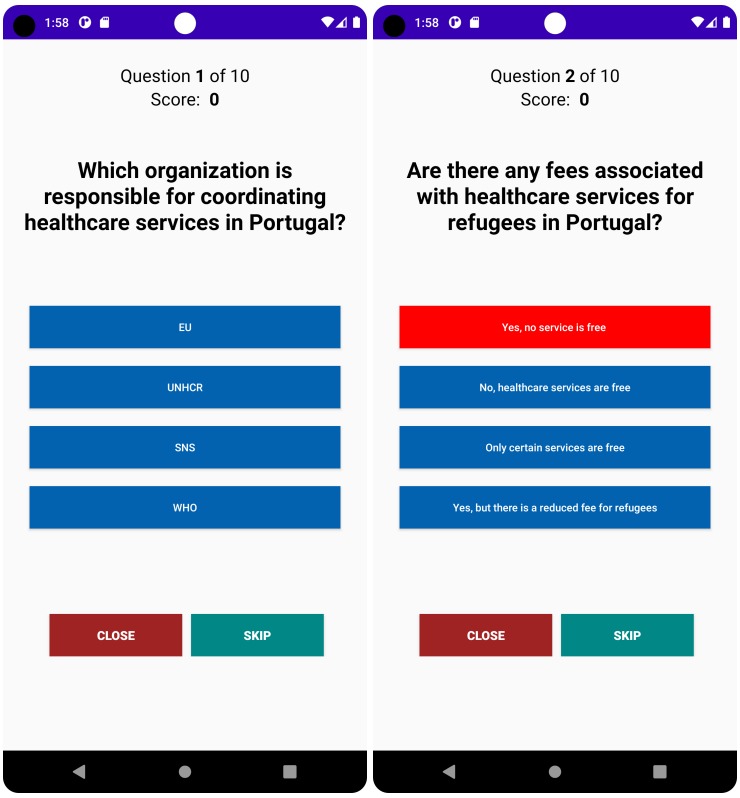
Figure 6.24: Association game screen

The game presents the player with various medical specialities, including urology, cardiology, ophthalmology, gynaecology, orthopaedics, dermatology, nursing, paediatrics, obstetrics, and psychiatry. These specialities are displayed randomised, providing a dynamic and unpredictable experience. Additionally, the alternatives within each speciality are presented randomly, further enhancing the challenge and requiring the player to think critically and make informed decisions. To enhance the user experience, the game provides convenient navigation options. An "X" button is positioned at the top left corner, allowing the player to close the game anytime with a simple click. Similarly, a skip button is located at the top right corner, enabling the player to proceed to the next question without selecting an answer and affecting their current score. These intuitive navigation buttons offer flexibility and control throughout the game.

6.4.8.2 Quiz Game

The quiz mini-game is also reasonably simple: the screen shows a question and four possible answers. The player aims to choose the correct response from the available options. The background colour changes to green, and the player's score rises if the selected response is accurate. If the response is incorrect, on the other hand, the score is unaffected, and the background colour changes to red. There are 10 questions throughout the game, and the player's ultimate score is shown at the conclusion. The 10 questions are:

- Which organisation is responsible for coordinating healthcare services in Portugal?
- Are there any fees associated with healthcare services for refugees in Portugal?
- What does SNS stand for?
- Who can access healthcare services in Portugal?
- What should a refugee do in case of a medical emergency?
- What is the telephone number of the SNS helpline in Portugal?
- How can refugees access information and resources on healthcare rights and duties in Portugal?
- Which healthcare service in Portugal provides specialised care for mental health issues?
- How can a refugee register with a family doctor in Portugal?
- What is the main purpose of the Cartão de Utente (User Card) in Portugal?



(a) First question (b) Wrong answer

(c) Right answer (d) Finished game

Figure 6.25: Quiz game screen

The quiz covers various topics regarding healthcare in Portugal and presents a set of questions to keep the gameplay dynamic and unpredictable. Each question is placed randomly, ensuring the player experiences a different challenge each time. The answer choices within each question are placed in a randomised order, adding complexity to different tries and requiring the player to stay focused when making decisions. In addition to the engaging gameplay, the game features convenient navigation options for the player, like the association game. A "close" red button is placed on the bottom left corner, allowing the player to close the game anytime with a simple click. A "skip" blue button in the top right corner allows the player to move on to the next question without selecting an option and changing the current score. These intuitive navigation buttons enhance the user experience by providing flexibility and control throughout the quiz.

6.4.9 About Us Feature Implementation

The About Us part of the HealthBridge app is extremely important since it provides a platform for sharing critical details about the app, its creators, and its goal. This section fulfils various, such as establishing authority, fostering user confidence, and providing transparency. Developers can convey their aims, values, and objectives to users by providing an About Us section in their app. Implementing an About Us section involves creating a dedicated feature within the app that contains relevant information about the app and information about the developer. This section includes the app's logo and the current version (Figure 6.26).

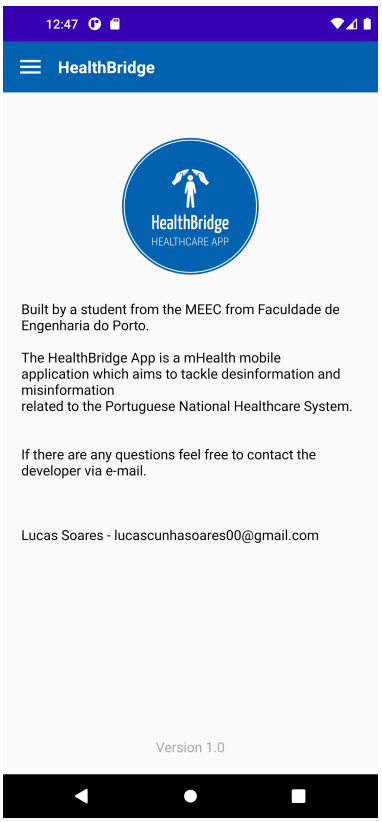


Figure 6.26: About us screen

Chapter 7

Usability Testing

As described in Chapter 4, this project followed a user-centred design. Because of that, the next stage includes testing among potential users and evaluating the effectiveness and user-friendliness of our app. Usability testing plays a crucial role in ensuring that the HealthBridge app meets the needs and expectations of its intended users. Hence, usability testing aims to gather valuable feedback from real users by observing their interactions with the app and, consequently, identify areas of improvement and usability issues and identify correct design decisions. The insights gained from usability testing allow the refinement and enhancement of the user experience, ultimately creating a more intuitive and enjoyable app.

The usability testing phase of this study was predominantly conducted online, using the Zoom platform, owing to time and location limitations. The testing commenced on 10/05/2023 and concluded on 29/05/2023. The participants primarily consisted of individuals previously participating in the survey phase. Each testing session lasted approximately 40 minutes, providing ample time to assess the usability and functionality of the mobile application. Additionally, the results and findings from the usability testing sessions will present, highlighting key observations, user struggles and areas of success. So, the testing was subdivided into three different phases:

1. **Pre-Testing Phase**: A characterisation of the samples' socio-demographic information was formulated to understand the participant's digital literacy, apart from the obvious insight into the diversity of the sample.

2. **Testing Phase**: Participants were asked to perform different sets of tasks within the HealthBridge app and express their thoughts while performing them. Besides, at the end of each task, participants should rate the perceived ease of performing it using a Linear scale [1-5], ranging from 1 being "very difficult" to 5 being "very easy". For analysis purposes, the average of the ratings given for each task by the participants will be calculated, and where:

    - Ratings between 0 and 2 are considered low levels of ease of execution;
    - Ratings between 2 and 4 are considered medium levels of ease of execution;
    - Ratings between 4 and 5 are considered high levels of ease of execution.

3. **Post-Testing Phase**: This phase was divided into two types of questions. The first one encouraged participants to indicate their degree of agreement on a five-point Likert scale ranging from 1 being "totally disagree" to 5 being "totally agree":

    - Overall, the app is easy to use;
    - I would not need support to use this mobile application;
    - The app is useful for accessing and internalising information related to healthcare in Portugal;
    - The app is easy to understand the concept and idea behind the application;
    - The app is organised;
    - The app has an appealing interface and visual design;
    - I consider the app to be smooth and efficient;
    - The content of the app was concise and easy to understand;
    - You would recommend the app to other potential users.

    For analysis purposes, the average of the ratings given for each statement by the participants will be calculated the same as for the last testing phase.

    The second phase of the post-testing phase presented users with more open-answer questions:

    - Were there any particular features or functionalities that stood out to you?
    - Were there any missing features or functionalities you expected to see in the app?
    - Did you encounter any issues or bugs while using specific features?
    - What did you think of incorporating games into an app like this one?
    - Do you have any suggestions or ideas for improving the app's usability or user experience?
    - Were there any areas where you felt the app could provide more guidance or explanations?
    - Is there anything else you would like to share about your experience using the app?

7.1 Pre-Testing Phase

As previously mentioned, this first phase of the usability evaluation of the HealthBridge app will focus on extracting the socio-demographic information of the participants. A minimum recruitment target of five participants was set to match the number of sufficient participants as at least four to five participants are, in most cases, sufficient to identify 80 to 85% of the usability problems of an interface [75, 76]. To obtain a diverse spectrum of contexts and perspectives on the app's performance, a heterogeneous sample of participants with similar gender distribution that

would cover a wide range of age groups was recruited. The following Table showcases the sample socio-demographic characterisation.

Table 7.1: Table with usability testing participants' socio-demographic data

#	Sex	Age	Country	Residence	Interview Type	Comfort with Smartphone [1-5]
1	Male	35	Ukraine	Porto	Video call	5
2	Female	36	Russia	Porto	Video call	5
3	Female	65	Ukraine	Lisboa	Video call	5
4	Female	35	Tunisia	Braga	Video call	5
5	Male	22	Egypt	Porto	In-person	5

The participants were aged between twenty-two and sixty-five years old, three were female participants, and two were male participants. Of the five participants, four took part in the initial survey. They were willing to be contacted for a possible future interview, leaving their contact information at the end of that survey. Although the recruitment process was conducted with careful attention, certain limitations arose due to the unique circumstances faced by the refugee participants and the project's time constraints. Considering the participants' status as refugees, their preference for video interviews and the need to maintain anonymity were crucial factors in shaping the methodology. Despite these challenges, usability tests were successfully conducted using Zoom, where the remote control functionality proved extremely useful, as it allowed participants to control the Android emulator device on which the HealthBridge application was run.

7.2 Testing Phase

The testing phase followed the pre-testing questions and represented the first contact of potential users with the HealthBridge app. So, to assess each participant's comprehension of the system's fundamental ideas and its level of usability, a collection of testing scenarios was presented to them. After being accomplished, the participants rated these tasks out of 5 based on their ease of execution. Table 7.2 orders each task with its # and the corresponding average rating. The individual rating given by each user can be checked in Appendix A.3.

Table 7.2: Table with user's average rating to each task ease

#	Task	Average rating
T1	Create an account in the HealthBridge app	4.4
T2	Access the account created	5
T3	Navigate through the application menus	5
T4	Comeback to the profile menu and add extra information to the profile	4.6
T5	In the profile, change the profile picture	4.6
T6	Start and finish a diagnosis	4.8
T7	Check out the frequently asked questions	5
T8	Check out the game menu	5
T9	Play the association game and achieve the highest possible score	4.8
T10	Play the quiz game and achieve the highest possible score	4.8
T11	Check out the about us section	5

Before analysing the results, it is essential to highlight that every task was completed successfully by each one of the participants.

Therefore, the results given by the participants point to high levels of ease of execution, as the average of all ratings given for all tasks was 4.8 out of 5. The lowest average rating reported back was from T1, where users underlined a little complexity associated with creating an account for the HealthBridge app and wished for a faster and slightly more straightforward option to sign in, such as with a Google account, even though it is preferable to sign in with an email address in terms of privacy and data protection. Tasks related to profile personalisation were also below the average rating, with some users reporting some complexity in changing and adding data to their profiles. Tasks related to the diagnosis and the two games were quite well received. In contrast, all the users gave a maximum rating to T2, T3, T7, T8 and T10, which are more or less related to accessibility within the HealthBridge app, including navigating menus and accessing different app sections.

Although, it is relevant to outline that every single task got a rating superior to 4, meaning that, as said before, all the tasks were done successfully and efficiently on the user's first interaction with the HealthBridge app, an indicator of its overall accessibility.

7.3 Post-Testing Phase

The initial post-testing phase had participants ranking nine statements according to their degree of agreement, using a similar version of the system used in the testing phase. By presenting participants with various statements, their nuanced perspectives and subjective viewpoints were captured. This approach enables a better understanding of their experiences and preferences quantitatively. The statements addressed a range of usability factors, including the app's clarity, how simple it is to navigate, how intuitive the user interface is, how relevant the features are, and how satisfied users were with the app. Consequently, by ranking these statements on a linear scale, participants could provide feedback beyond simple "yes" or "no" responses.

The distribution of quantifiable results from this post-test questionnaire is shown in Table 7.3, where each statement is attached to one # and an average rating. Appendix A.3 exhibits the individual ratings given by every user.

Table 7.3: Table with user's average rating to each statement accuracy

#	Statement	Average rating
S1	Overall, the app is easy to use	4.8
S2	I would not need support to use this mobile application	4.2
S3	The app is useful for accessing and internalising information related to healthcare in Portugal	4.8
S4	It is easy to understand the concept and idea behind the application	5
S5	The app is organised	4.8
S6	The app has an appealing interface and visual design	4
S7	I consider the app to be smooth and efficient	4.4
S8	The content of the app was concise and easy to understand	4.4
S9	You would recommend the app to other potential users	4.4

The results from this stage are positive, and identically to the previous phase, all statements had an average rating superior to equal or superior to 4. A closer look at the ratings given makes it possible to identify that statements connected to the app's concept and overall usefulness are better rated than statements linked to the app's interface, visual appeal and presentation.

The second post-testing phase looked to exceed the quantitative metrics and objective measures collected during the other testing sessions. By presenting open-answer questions, the participants provide detailed and qualitative feedback about their experiences using the app, highlighting specific aspects, suggestions, and potential areas for improvement.

Table 7.4 showcases the questions presented in this stage and the # attached to each. The answers given by each participant can be checked in Appendix A.3, matching the # of each question. The answers will be discussed in the next section.

Table 7.4: Table with open-answer questions presented to the participants

#	Question
Q1	Were there any particular features or functionalities that stood out to you?
Q2	Were there any missing features or functionalities you expected to see in the app?
Q3	Did you encounter any issues or bugs while using specific features?
Q4	What did you think of incorporating games into an app like this one?
Q5	Do you have any suggestions or ideas for improving the app's usability or user experience?
Q6	Were there areas where you felt the app could provide more guidance or explanations?
Q7	Is there anything else you would like to share about your experience using the app?

7.4 Analysis of the Results

This section provides an in-depth analysis of the findings extracted from the seven key open-answer questions to evaluate the app. These questions centred on various features and functionalities of the app as well as user expectations and experiences. So, the responses can be examined to learn essential details about the app's advantages and shortcomings. The following discussion seeks to detail these findings and thoroughly grasp users' viewpoints, collecting important qualitative data.

Regarding Q1, users praised the profile editing feature's user-friendly design and extensive modification options for profile information and photos. Users valued the option to customise their profiles since it made the experience more exciting and unique. The diagnosis part also earned praise from users, who thought it was clear and helpful. Also, it was considered valuable that detailed information on various medical doubts was available. The FAQ section also received praise for its capacity to answer frequently asked questions and offer easy access to pertinent information. Users regarded these sections as valuable resources for finding precise, trustworthy health-related information. The addition of games was highly appreciated because users saw them as entertaining and participatory features.

Furthermore, users indicated their desires for additional features and functionality in the app when answering Q2's questions. A feature allowing users to sign up for an account using their Google credentials was frequently suggested. This would make the registration procedure more convenient and efficient. In addition, customers wanted a chat or forum feature that would let them talk to medical experts about specific issues or inquiries. Accessing tailored advice and direction directly from the app was a helpful addition. Support for many languages was another issue raised to serve a wide range of users. Users stressed the relevance of inclusion and accessibility in providing healthcare information. Including reminders for medical appointments and direct support from healthcare professionals was suggested to enhance convenience and continuity of care.

When looking at the answers for Q3, users had no major problems or faults while utilising the app's functions. Some users did, however, experience sporadic lag times when submitting profile images. Although it was not considered crucial, there might be room for improvement to guarantee a seamless and easy user experience. Additionally, participants generally noted no major navigational issues and flawless software operation.

According to the results gathered from Q4, users reacted favourably to the app's inclusion of games. They expressed satisfaction with the games' interactive features and attractive visuals. Users viewed the games as an entertaining but educational diversion from the informational material, and they praised it for striking a mix between entertainment and instructional value. The quiz game was praised for being instructive, entertaining, and exceeding users' expectations. This exemplifies the potential for adding gamification components to health-related apps to engage users and promote learning.

From Q5, users provided insightful suggestions for improving the app's usability and user

experience. One recommendation was to include a tutorial or onboarding process for new users to familiarise themselves with the app's features and functionality. This would ensure a smooth and seamless experience for users, particularly those less familiar with health-related apps. Users also desired an enhanced feedback feature, allowing them to attach screenshots or provide more detailed descriptions. This would facilitate more effective communication between users and app developers, improving issue resolution and future updates. However, those two suggestions do not account for a major issue and should be considered. Moreover, users emphasised the importance of regular updates and upgrades to keep the app relevant and current. Supporting additional languages was also suggested to reach a broader audience and ensure inclusion. Lastly, users recommended the inclusion of in-app notifications or reminders for regular check-ups, vaccination schedules, or health-related events, enhancing user engagement and health management within the app. These three last suggestions are considered more relevant for the time being and will be addressed in the following sections.

Q6 saw users responding favourably to the diagnosis feature, and there were ideas for additional development. Users requested a more involved diagnosis procedure, including direct contact with medical professionals for individualised counsel and direction. This would improve the app's ability to respond to particular user issues and deliver personalised information. Therefore, the results indicate a chance to improve the diagnosis function by giving consumers access to more detailed and individualised information tailored to their needs.

Finally, with Q7, it was possible to understand that overall, users found the app helpful and regarded it as a promising prototype. They expressed satisfaction with their experience and enthusiasm for the app's further development. The quiz game, in particular, exceeded users' expectations regarding informativeness and entertainment value. Recommendations for future expansion included incorporating additional language options to cater to a wider user base. Users also highlighted the need for further development in the app's visual aspect to enhance its overall appeal and attract a larger audience.

In a nutshell, the discussion of the results offers insightful information on how users view and interact with the app's features and functionalities. The positive reviews for the profile editing, diagnosis, FAQ, and game aspects demonstrate their usefulness and interest as app components. Nevertheless, opportunities exist to improve the app's functioning and user experience through user suggestions for new features, usability enhancements, language support, and personalised interactions with healthcare providers. Development can continue, honing and improving the app by taking note of these recommendations and building on its advantages, resulting in a useful and user-centred tool for accessing health information and services.

7.5 Discussion

Based on the findings and comments made by the participants of this testing phase, several avenues for possible future design and research can be explored to expand the impact of the HealthBridge app for fragile communities. By rigorously analysing the feedback from the usability tests in the previous section, it is possible to identify different features suggested for future development, representing valuable improvements for the app.

7.5.1 Multilingual Support

Implementing multilingual support should be considered in future developments as it can greatly improve accessibility and usability for users from diverse linguistic backgrounds. This would involve incorporating language options beyond the current offering to ensure that refugees with various language preferences can effectively navigate and utilise the app's functionalities. The following Figure 7.1 illustrates this concept.

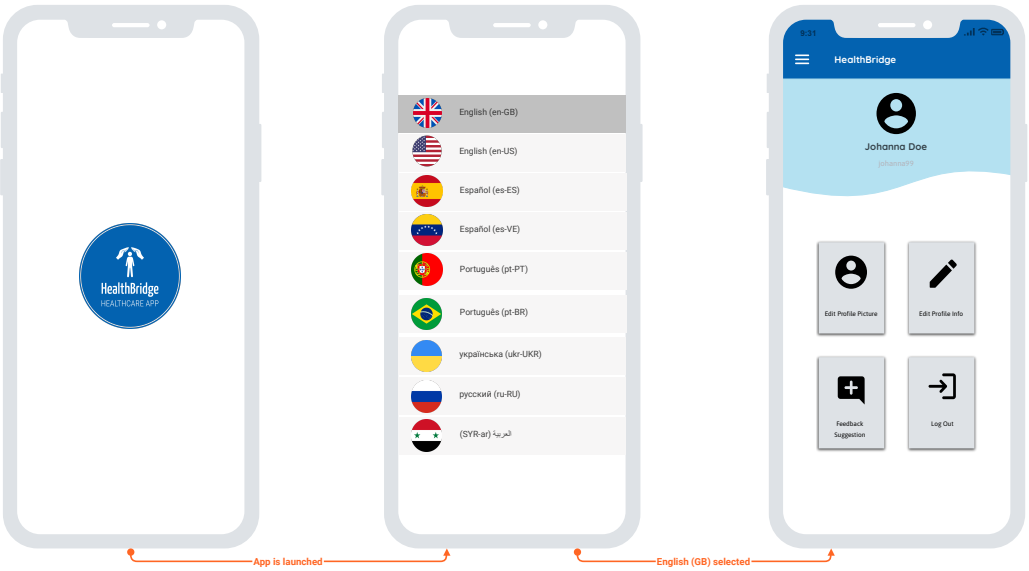


Figure 7.1: Language selection mock-up

7.5.2 Forum Feature

Secondly, user experience can be significantly improved by including a forum or a communication channel to enable direct contact with healthcare practitioners within the app. Users could use this tool to ask particular health-related queries, seek clarification, and get advice from medical experts. The forum might also provide a venue for user interaction, promoting camaraderie and support among the refugee community. Regarding its implementation, it would follow a similar layout to the FAQ with pull-down windows corresponding to the questions submitted by the users, as shown by Figure 7.2, where they will find answers given by healthcare providers, establishing direct contact with them. Additionally, on the top right side of the screen, the users can click a button to submit new questions.

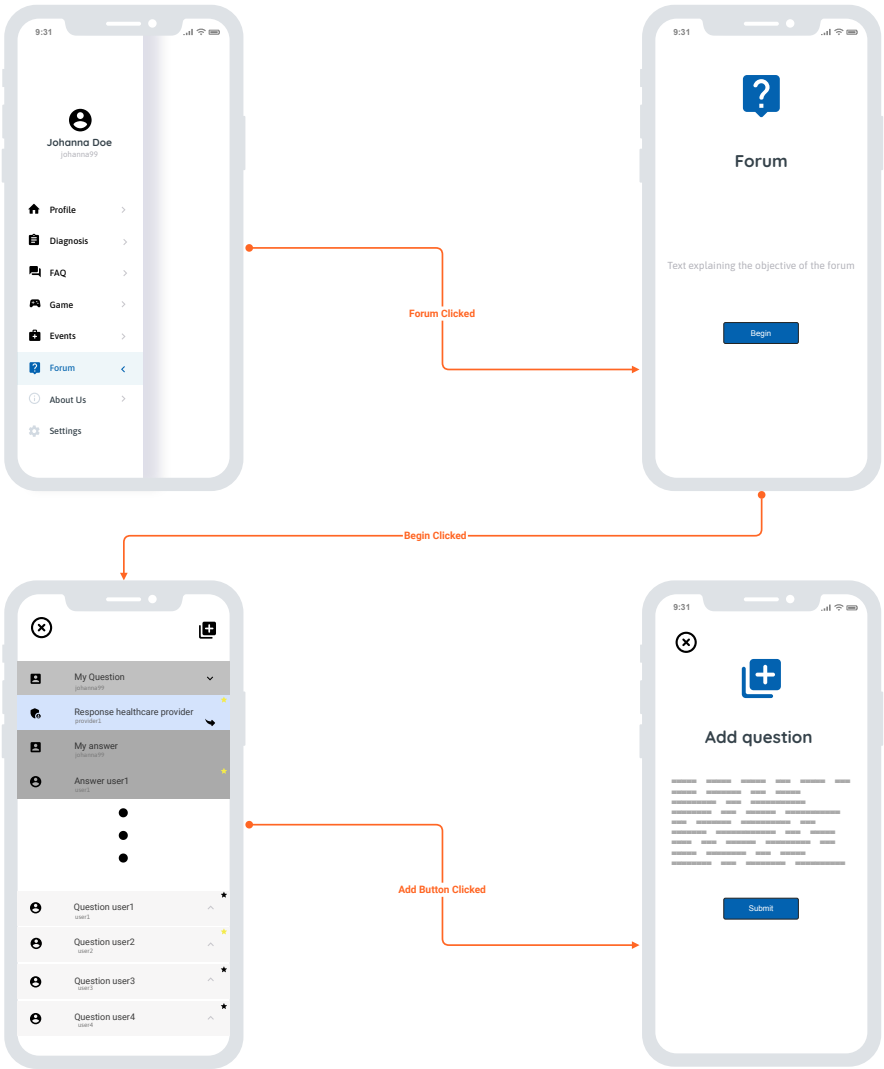


Figure 7.2: Forum mock-up

7.5.3 Events Feature

Additionally, integrating in-app notifications or reminders for regular check-ups, vaccination schedules, or other health-related events added by the user can serve as essential prompts for managing their health. These reminders can help individuals stay on top of their healthcare needs, ensuring they receive timely medical attention and preventive care. Figure 7.3 illustrates how this app section could look when implemented, with two main options. The first is adding new medical events, such as medical appointments and medication reminders. The second would be a calendar where the user could check all the events added. With that, the notification system would warn the users of the proximity of the events.

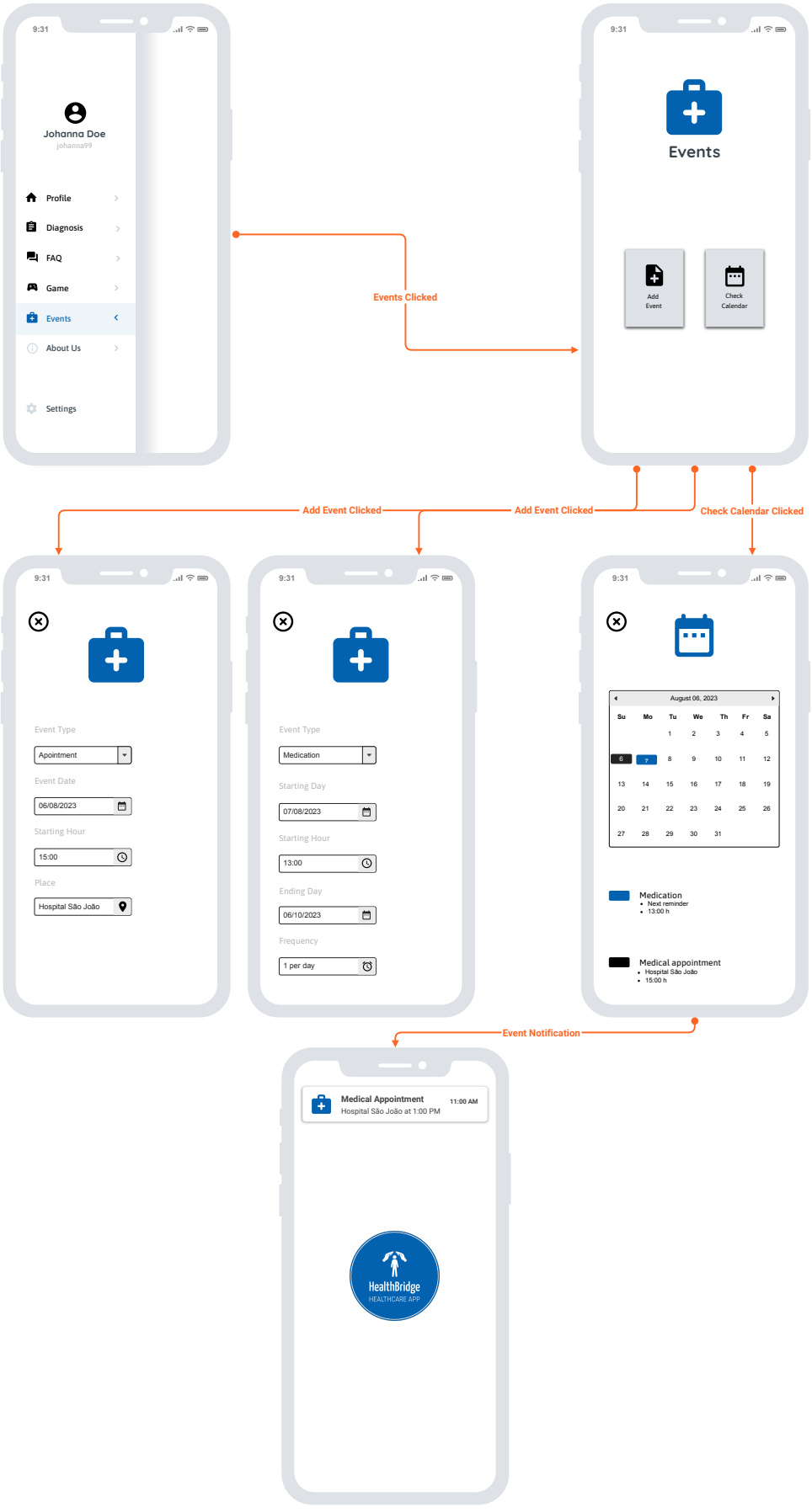


Figure 7.3: Medical Events mock-up

Chapter 8

Conclusions and Future Work

Over the last chapters, the work put into this dissertation has been presented, detailing its theoretical basis and the current state of the literature in its concepts. Additionally, the user-centred three methodological steps were specifically defined in those chapters, formulating the suggested mHealth system for refugee populations.

Consequently, the current chapter of this document looks to clarify the key conclusions of this project, besides establishing contributions to the literature and reviewing its limitations and proper future directions.

8.1 Conclusions

This dissertation aimed to examine the current landscape of mobile health (mHealth) solutions designed for vulnerable communities, with a particular emphasis on refugees, and to create a mobile application that uses the research findings to enlighten and empower these people.

Initially, the dissertation's research illuminated the state of mobile health initiatives aimed at vulnerable populations, with a particular emphasis on refugees. A detailed grasp of the difficulties and potential in this subject was attained by carefully examining the available literature and active projects. Thus, this information formed the basis for creating a mobile application that caters to the particular requirements of these vulnerable populations.

This mobile application's conception resulted in its prototype's development, substantially contributing to the mHealth industry. The application was specifically created to inform and empower refugees by utilising the knowledge gathered from the research and giving them access to crucial healthcare information, resources, and assistance. User-centred design principles were given top priority during the development process to ensure that the application's features and functionalities correspond with the particular needs and preferences of the target user group. The created prototype can close significant gaps in healthcare access and enhance the well-being of refugees by utilising mobile technology. The app is useful because it provides up-to-date information on subjects, including healthcare services, disease prevention, and neighbourhood resources.

The application gives refugees the information and resources they need to make educated decisions about their health and well-being, ultimately leading to better results and a higher quality of life.

Indeed, it is crucial to recognise that creating this mobile application is only the start of a larger initiative to solve vulnerable groups' healthcare issues. The application will require ongoing updates, improvements, and extensions to maintain its usefulness and efficacy. Some ideas and possible future implementations are showcased and explained in the previous section 7.5. Furthermore, continuous collaboration with concerned parties, such as healthcare providers, NGOs, and community organisations, will be essential to maximise the impact and reach of the application.

In conclusion, this dissertation has accomplished its objective of developing a mobile application that leverages research to support and empower vulnerable populations, including refugees. It has made significant strides in advancing mHealth solutions by addressing the healthcare gaps in Portugal. Also, the application aligns with the United Nations Sustainable Development Goals, particularly Goal 3 (Good Health and Well-being), Goal 10 (Reduced Inequalities), and Goal 17 (Partnerships for the Goals) [10].

8.2 Limitations

Although this dissertation achieved its main goals, building a mobile application capable of educating, empowering refugees and solving the difficulties surrounding access to healthcare in Portugal for vulnerable communities, some limitations should be noted:

- **Time Constraints**: This dissertation's research and development process faced some time constraints that have slightly impacted gathering requirements and conducting usability testing with the refugee population since engaging with vulnerable communities, such as refugees, often requires additional time and effort due to language barriers, cultural sensitivities, and logistical challenges.
- **Resource Limitations**: A mobile application's development and maintenance require continuing resources, such as funding and infrastructure. Maintaining the application and ensuring its long-term viability may present difficulties without sufficient resources or financing.
- **Platform Limitation**: The HealthBridge app is limited to Android Systems. As a result, users of iOS devices and other operating systems cannot use and gain access to the features and functionalities of the app. The app's impact and reach would increase if made available on other platforms, enabling a wider spectrum of consumers to use it for healthcare purposes.

Despite these drawbacks, this dissertation is a significant step toward utilising mobile technology to meet the healthcare requirements of vulnerable people, especially refugees. Future research and development initiatives might build on this work by acknowledging and considering these constraints, boosting the efficacy of mHealth solutions for vulnerable populations.

8.3 Future Work

Future steps should prioritise collaboration with healthcare providers to improve the effectiveness and impact of mHealth interventions for vulnerable communities. These types of partnerships can aid the development of features like safe data sharing, health record integration, and real-time professional communication with healthcare providers. Interoperability with the SNS app [77] could also be a possibility in the future, as it would enable seamless integration of healthcare services and data exchange, allowing users to access their SNS health records directly.

Moreover, involving linguists, translators, and cultural specialists is crucial to address language and cultural barriers refugees and other vulnerable populations face. The involvement of these professionals will not only enhance the linguistic and cultural aspects of the app but also contribute to its overall effectiveness, usability, and user satisfaction. Their expertise will enable the development of user-friendly interfaces, clear and concise health information, and tailored features that address the specific needs and preferences of the target population. Thus, a possible partnership for future developments with FLUP (Faculdade de Letras da Universidade do Porto) can be beneficial. Their expertise in language studies can contribute to developing user-friendly interfaces, clear health information, and tailored features that resonate with the target population.

A collaborative approach can pave the way for more inclusive, accessible, and effective healthcare services, ultimately improving health outcomes and empowering vulnerable populations to take control of their well-being.

Appendix A

Interviews

A.1 Survey Template

A.1.1 Consent for the interview

Declaration of Consent
∗If the answer is No, the survey ends

Number	Question	Type	Choices
(1)	The participant declares consent	Simple Multiple Choice	Yes
			No*

A.1.2 Socio-Demographic Questions

Socio-Demographic Characteristics

Number	Question	Type	Choices
(1)	Sex	Simple Multiple Choice	Male
			Female
(2)	Age	Short Answer	-
(3)	Home country	Simple Multiple Choice	Every Country
(4)	Region of residence in Portugal	Simple Multiple Choice	Every Region in Portugal
(5)	Time living in Portugal	Short Answer	-
(6)	Educational level	Simple Multiple Choice	Without educational levels
			Basic I (1-4 years)
			Continues on next page

Table A.2 continued from previous page

Number	Question	Type	Choices
			Basic II (5-6 years)
			Basic III (7-9 years)
			Secondary School (10-12 years)
			Bachelor's degree
			Licensed degree
			Master's degree
			PhD
(7)	Profession	Simple Multiple Choice	Occupation in the armed forces
			Representatives of legislative power and executive organizations
			Intellectual and scientific experts
			Technicians and intermediary-level occupations
			Administrative staff
			Workers of personal, protection and safety services and salespeople
			Workers skilled in farming and agricultural trades
			Workers skilled in industrial, construction, and operational trades
			Unqualified workers
			Student
			Unemployed
			Retired
(8)	Number of family members with whom you have travelled?	Simple Multiple Choice	0
			1
			2
			3

Continues on next page

Table A.2 continued from previous page

Number	Question	Type	Choices
			4
			5
			6 or more
(9)	Do you have a smartphone?	Simple Multiple Choice	Yes
			No
(10)	Difficulties in accessing healthcare services since leaving your home country	Long Answer	-

A.1.3 Familiarity with mHealth

Determination of the interviewee's familiarity with mHealth
* If the answer is Yes, sub-questions will appear to the interviewee

Number	Question	Type	Choices
(1)	Familiar with mHealth concept?	Simple Multiple Choice	Yes
			No
(2)	Ever used mHealth services?	Simple Multiple Choice	Yes*
			No
(2) a)	What type of mHealth service?	Multiple Choice	Health information and education
			Remote consultations with healthcare providers
			Medication reminders
			Other option
(2) b)	How satisfied with that service?	Likert scale [1-5]	1-Very dissatisfied 5-Very satisfied

A.1.4 Current healthcare needs

Questions about the interviewee's current healthcare needs
* If the answer is Yes, sub-questions will appear to the interviewee

Number	Question	Type	Choices
(1)	What types of healthcare services do you currently have access to?	Multiple Choice	Primary care
			Specialty care
			Mental health services
			Reproductive health services
			None of the above
(2)	What type of healthcare information would you consider important?	Multiple Choice	What healthcare services are available and how can they be accessed
			How to enrollee in a health centre
			How to obtain health insurance coverage and what are the options for financial assistance with healthcare costs services
			How to communicate effectively with a healthcare provider
			What resources are available for health education and promoting overall wellness
			In case of pregnancy or an early born baby, where can the appropriate healthcare be found
			Other option
(3)	No access to healthcare services needed?	Simple Multiple Choice	Yes*
			No
(3) a)	Specify the healthcare services	Short Answer	-

Continues on next page

Table A.4 continued from previous page

Number	Question	Type	Choices
(4)	Ever faced any language barriers in healthcare?	Simple Multiple Choice	Yes
			No
(5)	Preference in healthcare in native language	Simple Multiple Choice	Yes
			No
(6)	How do you access healthcare information?	Multiple Choice	Internet
			Word of mouth
			Healthcare providers
			Other option

A.1.5 Important characteristics of mHealth apps

Questions about the interviewee's interest on a mobile healthcare app
* If the answer is Yes, sub-questions will appear to the interviewee

Number	Question	Type	Choices
(1)	Interest in an healthcare mobile app	Simple Multiple Choice	Yes
			No
			Maybe
(1) b)	Importance of characteristics that the mobile app could have	Likert scale [1-5] (1-Not important 5-Very important)	Multilingual support
			Ease of use
			Address barriers to healthcare access
			Remote consultations
			Privacy and confidentiality
			Compatibility with a variety of devices
			Maintain the user engaged
			Evaluation and improvement of the support

A.1.6 Future contact with the interviewee

Questions to know if the interviewee is willing to be interviewed again in the future
* If the answer is No, the survey ends

Number	Question	Type	Choices
(1)	The participant accepts a future contact	Simple Multiple Choice	Yes
			No*
(1) a)	Means of future interview	Multiple Choice	E-mail interview
			Phone interview
			Video call interview
			In person interview
(1) b)	Contact for future interview	Short Answer	-

A.2 FAQ Section Template

FAQ section questions and answers

Question	Answer
Are refugees entitled to free health services when they arrive in Portugal?	YES. Refugees who arrive in Portugal are entitled to free health services. The Portuguese government provides access to healthcare services for refugees, ensuring that their basic healthcare needs are met. This includes access to primary healthcare, emergency care, hospital services, and other necessary medical treatments. The National Health Service (Serviço Nacional de Saúde - SNS) in Portugal is crucial in providing healthcare services to refugees, regardless of their legal status or financial situation.
How can a refugee access information and resources on healthcare rights and duties as a refugee in Portugal?	Refugees in Portugal can access information and resources on healthcare rights and duties through various channels. Here are 3 examples they can explore: • **Local Healthcare Centers**: Refugees can visit their local healthcare centre (C̈entro de Saúde)̈ to inquire about their healthcare rights and access relevant information; • **Online Resources**: The SNS (Serviço Nacional de Saúde) website and the websites of refugee support organisations often provide valuable information; • **Refugee Support Organizations**: Several organisations in Portugal specifically support refugees and provide information on their rights and entitlements, including healthcare. Examples include the Portuguese Refugee Council (CPR) and the High Commissioner for Migration (ACM).

Continues on next page

Table A.7 continued from previous page

Question	Answer
Are there community organisations or support groups that can help navigate the health system in Portugal?	YES, there are community organisations and support groups in Portugal that can assist refugees in navigating the health system like: • **Portuguese Refugee Council (CPR)**: CPR is a non-governmental organisation supporting refugees and asylum seekers in Portugal. They offer various services, including legal support, social integration programs, and information on healthcare rights and access; • **High Commissioner for Migration (ACM)**: ACM is an institution that promotes and coordinates policies related to migration and asylum in Portugal. They provide information, support, and guidance to refugees and can assist in navigating the health system; • You can also contact the nearest Local Healthcare Center for more information.

Continues on next page

Table A.7 continued from previous page

Question	Answer
What documents does a refugee need to present when seeking health care in Portugal?	When seeking healthcare in Portugal as a refugee, it is generally required to present the following documents: • **Identification Document**: Refugees should carry their identification documents, such as a passport or a residence permit issued by the Portuguese authorities; • **Health Card**: In Portugal, individuals are typically issued a healthcare identification card known as the "Cartão de Utente" or "SNS Card." Refugees should obtain this card, which serves as proof of their eligibility for healthcare services in the Portuguese National Health Service (SNS); • Even without documents and in acute illness, citizens are always attended to.
How can a refugee obtain a Portuguese number for accessing the services of public healthcare units?	Refugees can go DIRECTLY to the nearest healthcare centre in Portugal to seek medical assistance, even without obtaining a Portuguese number or completing the formal registration process. The Portuguese National Health Service (SNS) ensures that all individuals, including refugees, have the right to emergency and essential healthcare services, regardless of their administrative status. However, it is important to note that completing the registration process with the SNS and obtaining a Portuguese number (NIF) is recommended for accessing a broader range of healthcare services and enjoying comprehensive care under the public healthcare system. It facilitates smoother access to routine medical appointments, specialised treatments, and ongoing healthcare support.

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Table A.7 continued from previous page

Question	Answer
What are the best ways for a refugee to access a family doctor?	To access a family doctor in Portugal, refugees can follow these steps: 1. Register with the Portuguese National Health Service (SNS): Refugees should complete the registration process with the SNS by obtaining a Portuguese number (NIF) and registering at their local health centre (Centro de Saúde). The registration allows them to be assigned a family doctor; 2. Locate the nearest health centre: Refugees can find the closest health centre in their area by using online resources, contacting the SNS hotline (808 24 24 24), or asking for assistance from community organisations or support groups; 3. Schedule an appointment: Once registered with the SNS, refugees can schedule an appointment with a family doctor at their designated health centre. This can be done through various methods, such as calling the health centre directly, using the SNS mobile app (MySNS Carteira), or booking an appointment at the health centre reception.
How can a refugee and their family members register at a health centre?	All needed is to go to your nearest Health Centre where you will be given all the information. Identification documents owned must be presented.

Continues on next page

Table A.7 continued from previous page

Question	Answer
How can a refugee associate and change an address to the hospital?	To associate or change an address with a hospital in Portugal, refugees can follow these steps: 1. Gather necessary documents: Prepare the required documents, which typically include: • Passport or identification document; • Residence Permit for Refugees or other relevant immigration documentation; • Proof of new address (such as a rental contract, utility bill, or official document from the local municipality). 2. Visit the hospital: Go to the hospital where the refugee seeks medical care. It's recommended to visit the hospital's administrative or registration department. This procedure can also be done in a local healthcare centre ("Centro de saúde"); 3. Provide necessary information: Present the required documents to the hospital staff. They may ask for the refugee's personal information, such as name, date of birth, contact details, and the new address; 4. Confirmation of address update: Once the address update is processed, the hospital will confirm the change and associate the new address with the refugee's record. They may provide a confirmation document or receipt for the address change.

Continues on next page

Table A.7 continued from previous page

Question	Answer
What are the best ways for a refugee to make an appointment with a doctor or specialist?	To make an appointment with a doctor or specialist in Portugal, refugees can follow these steps: 1. **Choose a healthcare provider**: Identify the doctor or specialist you wish to consult. This can be a general practitioner (family doctor) or a specialist based on your healthcare needs. Orientation in this matter can also be given by a local healthcare centre ("Centro de saúde"); 2. **Find a healthcare centre**: Locate a clinic where the chosen doctor or specialist practices. You can search online, consult a directory, or ask for recommendations from healthcare professionals, social workers, or community organisations; 3. **Contact the healthcare centre**: Once you have selected a healthcare centre, contact them to schedule an appointment. There are several ways to do this: • **Phone**: Call the healthcare centre directly and speak with the receptionist or appointment desk staff. They will guide you through the process and find a suitable date and time for your appointment; • **Online booking**: Some healthcare centres offer online platforms or portals where you can book appointments. Visit their website or check if they have a dedicated online system for scheduling appointments; • **In-person**: If you prefer face-to-face interaction, you can visit the healthcare centre and book an appointment at the reception desk.

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Table A.7 continued from previous page

Question	Answer
What should a refugee do in case of a medical emergency? Are there specific numbers to call or procedures to follow?	In case of a medical emergency in Portugal, refugees should: • In cases of extreme urgency when it is necessary, for example, to call an ambulance; • Dial the emergency number: The emergency number in Portugal is 112. It is a free-of-charge number that can be dialled from any phone, including mobile phones. This number connects you to the emergency services; • Go to the hospital's "urgências"; • In non-urgent cases, consider dialling the SNS hot-line (808 24 24 24).

Continues on next page

Table A.7 continued from previous page

Question	Answer
Is there any way for a refugee to avoid long waiting lists when seeking access to specialists?	In Portugal, waiting lists for specialist appointments can vary, and refugees and other individuals can experience wait times for certain specialities. However, there are a few strategies that refugees can consider to reduce waiting times or seek alternative options potentially: 1. **Discuss with the family doctor**: If a refugee has a family doctor (general practitioner), they can discuss their need for a specialist referral. The family doctor can assess the urgency of the situation and try to expedite the referral process if necessary; 2. **Request prioritisation**: In some cases, if the medical condition is urgent or requires immediate attention, it may be possible to request prioritisation. This can be done by discussing the situation with the family doctor or the healthcare centre staff. They can guide the available options; 3. **Explore private healthcare options**: While public healthcare is the primary option for refugees, they may also consider private healthcare services. Private healthcare providers typically have shorter waiting times for specialist appointments. However, it's important to note that private healthcare services may involve additional costs, so refugees should consider their financial situation before pursuing this option.

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Table A.7 continued from previous page

Question	Answer
Is there any multilingual support for refugees and foreigners?	YES, in Portugal, there are efforts to provide multilingual support for refugees and foreigners accessing healthcare services: • **Interpreters and translators**: Public healthcare centres may have interpreters or translators available to assist patients with limited proficiency in Portuguese. These professionals can help communicate during medical consultations, appointments, and discussions with healthcare providers; • **Language support services**: Some healthcare centres provide language support services, such as multilingual helplines or dedicated staff who can assist with language-related needs. These services aim to provide information, answer questions, and address concerns in different languages.

Continues on next page

Table A.7 continued from previous page

Question	Answer
How can a refugee access health services for pre-existing illnesses or ongoing treatment in their country of origin?	First, go to the Health Centre for medical or nursing care. Additionally: • **Seek assistance from local organisations**: Local refugee support organisations or NGOs may have connections or resources to help refugees access healthcare services in their country of origin. These organisations can provide guidance, facilitate communication with healthcare providers, and assist with logistics, such as appointment scheduling or medical record transfers; • **Contact relevant healthcare providers**: The refugee can contact healthcare providers or hospitals in their country of origin where they previously received treatment. They can explain their situation, provide medical records or documentation, and inquire about possibly continuing their care remotely or making arrangements for treatment during visits to their home country.

A.3 Usability Testing Template

A.3.1 Pre-Testing Questions

Socio-Demographic Characteristics

Number	Question	Type	Choices
(1)	Sex	Simple Multiple Choice	Male
			Female
(2)	Age	Short Answer	-
(3)	Home country	Simple Multiple Choice	Every Country
(4)	Region of residence in Portugal	Simple Multiple Choice	Every Region in Portugal
(5)	Level of comfort with smartphones?	Simple Multiple Choice	1
			2
			3
			4
			5

A.3.2 Testing Answers

Answers to task's ease of execution by each participant

Participant	Question	Answer
#1	T1	4
	T2	5
	T3	5
	T4	5
	T5	5
	T6	4
	T7	5
	T8	5
	T9	5
	T10	5
	T11	5
#2	T1	5
	T2	5
	T3	5
	T4	4
	T5	5
	T6	5
	T7	5
	T8	5
	T9	5
	T10	5
	T11	5
#3	T1	4
	T2	5
	T3	5
	T4	5
	T5	5
	T6	5
	T7	5
	T8	5
	T9	4
	T10	5
	T11	5
#4	T1	4

Continues on next page

Table A.9 continued from previous page

Participant	Task	Answer
	T2	5
	T3	5
	T4	5
	T5	5
	T6	5
	T7	5
	T8	5
	T9	5
	T10	4
	T11	5
#5	T1	4
	T2	5
	T3	5
	T4	4
	T5	3
	T6	5
	T7	5
	T8	5
	T9	5
	T10	5
	T11	5

A.3.3 Post-Testing Answers

Answers to agreement of the statements by each participant

Participant	Statement	Answer
#1	S1	5
	S2	4
	S3	5
	S4	5
	S5	5
	S6	4
	S7	4
	S8	5
	S9	4
#2	S1	5
	S2	4
	S3	4
	S4	5
	S5	5
	S6	5
	S7	4
	S8	4
	S9	5
#3	S1	5
	S2	4
	S3	5
	S4	5
	S5	5
	S6	4
	S7	5
	S8	4
	S9	5
#4	S1	5
	S2	4
	S3	5
	S4	5
	S5	5
	S6	4
	S7	5

Continues on next page

Table A.10 continued from previous page

Participant	Statement	Answer
	S8	5
	S9	4
#5	S1	4
	S2	5
	S3	5
	S4	5
	S5	4
	S6	3
	S7	4
	S8	4
	S9	4

Answers to open-answer questions

Participant	Question	Answer
#1	Q1	"The profile editing feature was user-friendly, allowing good customisation of profile information and profile picture."
	Q2	"I would like to see a feature that lets the user create an account with Google."
	Q3	"When editing the profile picture, there were occasional delays in image upload."
	Q4	"Enjoyable and interactive element, attractive for children."
	Q5	"Consider adding a tutorial for new users to familiarise themselves with the app."

Continues on next page

Table A.11 continued from previous page

Participant	Question	Answer
	Q6	"The diagnosis."
	Q7	"Overall, the app is helpful and good for a prototype."
#2	Q1	"The diagnosis section was straightforward and provided good information on various medical conditions and symptoms."
	Q2	"A chat for users to communicate with healthcare professionals for specific questions."
	Q3	"No."
	Q4	"Games served as a break from informational content and offered a form of entertainment while still being educational."
	Q5	"Feedback feature could allow users to attach screenshots or provide more detailed descriptions."
	Q6	"Maybe in the FAQ section add an option to talk to a healthcare provider."
	Q7	"It was a good experience, and I hope it develops even more."

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Participant	Question	Answer
#3	Q1	"The FAQ section helped address common questions and provide quick access to relevant information."
	Q2	"Maybe some type of Forum would be a good idea, contacting healthcare providers."
	Q3	"No."
	Q4	"It is a good idea and could be entertaining."
	Q5	"Keep updating and upgrading the app."
	Q6	"The diagnosis was good but could be more complex."
	Q7	"The quiz game was more informative than expected."
#4	Q1	"Nothing specific, diagnosis, FAQ and the games are good informative tools."
	Q2	"Other languages support."
	Q3	"No."
	Q4	"Good idea, more directed to children."
	Q5	"Add other languages."
	Q6	"Yes, the diagnosis could be more complex, directly connecting the user with healthcare providers."

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Participant	Question	Answer
	Q7	"Consider future expansion, incorporate additional language options."
#5	Q1	"The games."
	Q2	"Adding medical appointments with reminders and direct support from healthcare providers."
	Q3	"Some delays on navigation but nothing major."
	Q4	"Very interactive, probably the best-designed app feature."
	Q5	"Provide in-app notifications or reminders for regular check-ups, vaccination schedules, or health-related events that can be added inside the app."
	Q6	"No."
	Q7	"It is a great idea but needs more development in the area of the visual."

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