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Bridging emotional design with mobile technology: Towards the needs of dementia informal caregivers

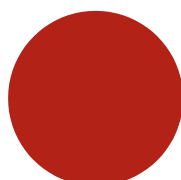
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Bridging emotional design with mobile technology: Towards the needs of dementia informal caregivers

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Resumo

O cuidado informal para Pessoas que Vivem com Demência (PVD) apresenta desafios multifacetados que englobam dimensões emocionais, práticas e sociais. Este estudo explora as experiências dos cuidadores informais em Portugal e investiga o potencial da tecnologia, particularmente soluções de Saúde Digital móvel, para atender às suas necessidades. Uma abordagem de métodos mistos, incorporando questionários e entrevistas semi-estruturadas, reuniu informações sobre as experiências pessoais dos participantes enquanto cuidadores e no uso da tecnologia. Os resultados revelam desafios emocionais, limitações práticas e estigmas sociais enfrentados pelos cuidadores, sublinhando a necessidade crítica de sistemas de apoio aprimorados.

Além disso, o estudo identifica deficiências nos aplicativos móveis existentes projetados para cuidadores e destaca o potencial dos princípios do Design Emocional (DE) para abordar essas deficiências. Para validar o potencial do conhecimento reunido, este estudo também inclui o desenvolvimento e teste de um protótipo de uma solução de saúde digital integrada e acessível. Esta solução, composta por uma aplicação móvel Android para cuidadores informais ligada a uma pulseira inteligente para as PVD, foi prototipada usando a ferramenta Figma. Os resultados das sessões de teste, incluindo taxas de conclusão de tarefas e feedback do Questionário de Experiência de Usabilidade, juntamente com um questionário personalizado focado nos princípios e diretrizes do design emocional, demonstraram o impacto positivo da integração dos princípios do design emocional. Em particular, foram observadas melhorias na percepção do utilizador, envolvimento e confiança na solução de saúde digital.

Pesquisas futuras devem focar-se na validação, estudos longitudinais e abordagens de co-design para desenvolver intervenções direcionadas que apoiem efetivamente os cuidadores informais de PVD em Portugal e além. Este estudo contribui para uma compreensão mais profunda das dinâmicas do cuidado informal e sublinha a importância de integrar considerações emocionais no design de soluções de Saúde Digital para melhorar o bem-estar dos cuidadores e aprimorar os resultados do cuidado da demência.

Palavras-chave: Cuidadores Informais, Demência, Saúde Digital, Design Emocional

Abstract

Informal caregiving for People Living with Dementia (PLD) presents multifaceted challenges encompassing emotional, practical, and societal dimensions. This study explores the experiences of informal caregivers in Portugal and investigates the potential role of technology, particularly mobile Digital Health solutions, in addressing their needs. A mixed-methods approach incorporating questionnaire surveys and semi-structured interviews gathered insights regarding participants' caregiving experiences and technology usage. Findings reveal prevalent emotional challenges, practical limitations, and societal stigmas caregivers face, underscoring the critical need for enhanced support systems.

Moreover, the study identifies deficiencies in existing mobile apps designed for caregivers and highlights the potential of Emotional Design (ED) principles to address these shortcomings. To validate the potential of the gathered knowledge, this study also includes developing and testing a prototype for an affordable integrated digital health solution. This solution, comprising a mobile Android application for informal caregivers linked to a wearable smartband for PLD, was prototyped using Figma. Results from testing sessions, including task completion rates and feedback from the Usability Experience Questionnaire, along with a custom questionnaire focused on emotional design principles and guidelines, demonstrated the positive impact of integrating emotional design principles. Notably, enhancements were observed in user perception, engagement, and trust towards the digital health solution.

Future research should focus on validation, longitudinal studies, and co-design approaches to develop targeted interventions that effectively support informal caregivers of PLD in Portugal and beyond. This study contributes to a deeper understanding of informal caregiving dynamics. It underscores the importance of integrating emotional considerations into Digital Health solution design to improve caregiver wellbeing and enhance dementia care outcomes.

Keywords: Informal Caregivers, Dementia, Digital Health, Emotional Design

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I dedicate this body of work to my mother, all those who suffer from a form of dementia, and the brave informal caregivers who stand by their side daily.

Jessica Félix Teixeira

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Abbreviations

HCI	Human-Computer Interaction
PLD	People Living with Dementia

1. Introduction

This inaugural chapter of this dissertation is dedicated to introducing the core elements that underpin this study. It commences by elucidating the theme, scope, and motivational factors driving the research. Subsequently, it highlights the identified problems, outlines the hypotheses and objectives, and introduces the methodologies and research instruments chosen to conduct the study and analyse its results. This introduction concludes by providing an overview of the entire dissertation's structure, offering a glimpse into the main subjects and objectives of the ensuing chapters that will follow.

1.1 Context

This study emerges from a recognition of the increasing number of individuals diagnosed with dementia and the consequent impact, which forces many into the unfamiliar and disruptive role of informal caregiving. These caregivers confront a host of physical and emotional challenges that significantly affect their well-being and quality of life. With this awareness, our goal is to harness insights from the fields of design and technology to craft a prototype solution that can provide much-needed support to these informal caregivers.

The knowledge and insights produced by this research will play a central role in bolstering the success of the proposed prototype. It is expected to extend far-reaching implications for future initiatives centred on implementing emotional design as a framework to enhance the development of mobile technology tools tailored to support informal caregivers of individuals living with dementia. This endeavour offers a clear set of principles and guidelines intended to serve as a valuable resource for future designs, aiming to enhance user experience and emotional resonance significantly. These design parameters also promise to help elevate the level of adoption and the perceived impact on the overall quality of Digital Health solutions.

1.2 Problems, Hypotheses, and Objectives

This study is motivated by an interest in understanding how home-based and affordable Digital Health solutions for informal caregivers of people living with dementia address their user's practical and emotional needs. We intend to start by identifying the main problems and challenges that informal caregivers of people living with dementia face and learn how they are addressed by Digital Health solutions; we will then proceed to pinpoint what is lacking in these solutions.

From there, we will study the impact of applying emotional design principles on a Digital Health platform by developing and testing a custom prototype. With this procedure, we expect to identify emotional design principles that may support a Digital Health solution and assess their impact on aspects such as user satisfaction, user connection, and level of adoption. We also believe that with this study, we may gather some assumptions regarding the possible impact of the proposed solution on the quality of life and care provided by informal caregivers of people living with dementia, which can eventually frame future research on the subject.

The following questions frame this research:

What problems and challenges do informal caregivers of people living with dementia face that a home-based and affordable Digital Health solution can address?

What are the emotional design principles that may support the identified challenges?

Does applying emotional design principles to a Digital Health solution positively impact its user experience and users' level of adoption?

Furthermore, we expect that applying emotional design principles to a Digital Health solution may demonstrate positive longstanding outcomes regarding the informal caregivers of people living with dementia quality of life and quality of care provided.

1.3 Methodology

For this study, we applied a mixed methods approach to gather quantitative and qualitative data on the impact of the developed framework. Throughout the study development stages, we followed a user-centred and participatory design approach since literature demonstrated it to be a highly efficient practice in engaging participants, conceptualizing user expectations and needs, increasing usability and system acceptance (Interaction Design Foundation, 2022b; ISO, 2010). This method was run through an iterative cycle with the following stages: specify the context of use, define requirements, design, and evaluate.

To gather participants for the study, we focused on establishing contact with several non-profit associations which focus on aiding informal caregivers of people living with

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dementia, such as Café Memória, IDDA (Intervenção Domiciliar na Doença de Alzheimer) project, Cuidadores Portugal, Associação Nacional de Cuidadores Informais and Movimento Cuidadores Informais. We included in the study all individuals who met the following criteria: Portuguese adults (more than 18 years old) which provide unpaid care to a person living with dementia in a home setting and use a smartphone. We did not consider a minimum of hours of care or the need to have a familiar relationship with the person cared for as an exclusion criteria. We expected to include at least five participants in the study.

To gather the qualitative and quantitative data necessary to outline the requirements for the framework development, we presented to the study participants with both a questionnaire and a semi-structured interview. The questionnaire served the main purpose of gathering demographic data about the caregivers and the person they care for, details of the care setting and time spent with the person cared for, self-perceived knowledge about dementia and competence in dealing with dementia effects, and technology familiarity.

The semi-structured interviews were conducted through videoconference, with an expected duration of 90 minutes, and recorded for later data analysis. The content was formulated according to the study objectives and main research questions, we strove to understand what the informal caregivers' main needs were, what they felt may empower them, how they evaluated the medical aid and/or professional support received and the perceived benefits that technology might provide to benefit their situation.

To evaluate the usability and perceived impact of the developed framework, we started by conducting both in-person and remote usability testing sessions where the participants were instructed to "Think Aloud". This usability tool is no more than to ask the participants to verbalise their thoughts as they moved through the interface and performed the test plan tasks (Nielsen Norman Group, 2012). Following these sessions the participants were asked to answer the User Experience Questionnaire (UEQ) and a custom questionnaire focused on evaluating the perceived technology acceptance.

To complement the gathered data, we added a final open field question to the custom questionnaire, with the intent to gather qualitative feedback on the framework usability and perceived value and impact of the solution.

1.4 Dissertation Structure

In addition to this introductory section, this dissertation comprises several chapters, each contributing to a comprehensive understanding of the research.

Chapter 2 delves into a literature review, spanning two critical topics intersecting the context of this study. The first, termed "Social landscape," probes into the challenges and

needs faced by informal caregivers of people living with dementia. It also explores Digital Health technologies designed to address these difficulties, with a particular emphasis on mobile technology's application. The second topic explores the concept of “Emotional Design”, elucidating its holistic approach and how it can be employed as a framework with principles and guidelines for developing emotionally engaging digital solutions.

Moving on to Chapter 3, this section will unveil the results of our user research, assembled from questionnaire data and insights gained through semi-structured interviews. These findings form the basis for the subsequent development of user personas and scenarios presented in Chapter 4.

Chapter 5 introduces the conceptualization and design of our prototype solution, which merges mobile technology and emotional design principles. It follows the synthesis of user requirements gained from the preceding chapter and unfolds the various stages of prototype development, encompassing inception, the process of wireframe design (from low to high-fidelity screens), and active interactions with users to solicit valuable feedback.

Chapter 6 is dedicated to the presentation of the final user testing instruments and the comprehensive analysis of results derived from user testing sessions, complemented by accompanying questionnaires.

Finally, Chapter 7 engages in a detailed discussion of the overall findings, underscoring the study's conclusions while considering any perceived limitations.

2. State-of-the-Art

This chapter presents the findings of our literature review. We have approached this research according to two main topics: the social landscape of Dementia and the field of Emotional Design.

In the Social Landscape of Dementia section, we will present the literature review on the main topics of Dementia, the informal caregivers of people living with dementia, and Digital Health technologies for Dementia support. We believe that a deep understanding of this medical condition is necessary to not only understand its toll on our society but also to be able to relate its effects and symptoms with the challenges and needs that affect the informal caregivers of people living with dementia. Will also reflect on how we can perceive the adequacy of the solutions presented by Digital Health technology so far, evaluate what has been successfully addressed, what is still missing, and the reasons why.

In the upcoming section of our state-of-the-art report, our primary objective is to elucidate the findings derived from our literature review on the field of Emotional Design. We will start by understanding what emotional design is, what it means designing for emotion, and the underlying elements that support this concept. We intend to identify a set of current emotional design principles and guidelines. Subsequently, we will evaluate the perceived outcomes arising from applying emotional design principles to developing Digital Health solutions. This approach will serve as the foundation upon which we will construct a framework, guiding our methodology and design decisions as we advance with the development of our prototype.

2.1 What is Dementia

Dementia is an umbrella term for medical conditions that affect the brain and are characterized by a deterioration of cognitive function beyond what is expected from the natural aging process. This deterioration highly impacts a person's ability to function

independently and perform daily life activities, affecting thinking, remembering, and reasoning skills. It is also preceded and even accompanied by changes in behaviour, mood, and emotional control (World Health Organization, 2022a).

As the term refers, there are multiple forms of dementia, being the most common Alzheimer's disease, which is presumed to account for 60 to 70% of all cases and is characterized by a strong hereditary risk factor, followed by vascular dementia, dementia with Lewy bodies and the group of frontotemporal diseases. Dementia can also be developed after the event of a stroke or in the context of certain infections like HIV, the occurrence of repetitive blunt traumas to the brain, the deficit of some nutrients, and even the harmful use of alcohol. The boundaries between these conditions are indistinct and sometimes mixed forms do co-exist (Centers for Disease Control and Prevention, 2022).

Although dementia affects each person in different ways, depending on their health conditions and cognitive function prior to becoming ill, the signs and symptoms of these conditions can be commonly understood in three stages (World Health Organization, 2022a).

The early stage is characterized by symptoms like forgetfulness, losing track of time, and becoming lost in familiar places, which usually manifest gradually, making them easily overlooked. These difficulties can also be mistakenly assumed for other conditions, such as depression (Harvard Medical School, 2022), or as a normal part of the aging process. At this stage, the person can still function independently.

The middle stage is typically the longest—it can last for several years—and it's when the signs and symptoms become clearer. These may include becoming unaware of time and space, increased difficulty in establishing communications, becoming confused while at home, experiencing personality and behaviour changes, which include wandering, becoming suspicious and delusional. At this point, the person requires an increased level of care, as it loses the ability to perform routine tasks without assistance.

The late stage is characterized by total dependence and inactivity. Memory disturbances and physical symptoms get more severe and include changes in walking, sitting, and eventually swallowing, difficulty recognizing friends and family, and in communicating pain, even though they still may express some words or even sentences. At this final stage, the person may be completely unable to establish any type of engagement.

Although not part of the natural process of aging, the main risk factor known for dementia is age. But not exclusively, young onset dementia—development of symptoms before the age of 65—is believed to account for 9% of cases. Additional known risk factors include depression, social isolation, low educational level, cognitive inactivity, and air pollution (Peters et al., 2019). Recent research suggests that making healthy life choices such as eating a healthy diet, being physically active, not smoking and striving

for cognitive stimulation may decrease the risk of cognitive deterioration and developing dementia (Alzheimer's Association, 2022).

Currently, there is no cure for dementia, only treatments that can help manage the symptoms and may temporarily slow down the disease's progress (Alzheimer's Society, 2022).

2.2 How Dementia affects the world population

People worldwide are living longer and healthier lives due to the evolution and improvements in our health systems during the past century. Life expectancy has increased exponentially in recent years, and in 2020, the number of people above 60 years old surpassed the number of children younger than 5 years old (World Health Organization, 2022b). Since age is the primary risk factor for dementia, this continued increase in life expectancy also raises the likelihood of people developing this condition.

Dementia is currently one of the major causes of disability and care dependence among older people worldwide. Characterized by a lack of awareness and understanding, which causes difficulties towards a diagnosis and care, this condition presents an overwhelming impact not only on the people living with dementia but also on their caregivers and families. According to the Global status report on the public health response to dementia (2021) published by the WHO, most countries' healthcare and social systems are not presently, let alone future, prepared to support the people living with dementia and their caregivers.

Currently, it is estimated that more than 55 million people are living with dementia, and it is anticipated, as the demographic structure of the global population changes, that this number will triple by 2050. Due to an aging population and better access to medical services and treatments that help diagnose dementia, high-income countries present a higher prevalence of dementia when compared to low-income countries. However, as these countries continue to develop and their populations age, dementia prevalence will increase. *“By 2050, two-thirds of the world's population over 60 years will live in low- and middle-income countries”* (World Health Organization, 2022b).

In global terms, the prevalence of dementia is higher in older age groups (there is a marked difference between adults aged 65 and over) and is also higher for women over than men in all age groups and across all regions. There are several reasons appointed for this discrepancy, those include not only biological differences and a higher life expectancy in most countries, but also a different level of exposure in accessing the same opportunities for education and cognitive stimulation as men. Apart from having a high rate of care dependence, dementia also presents a high mortality rate, being the seventh

leading cause of death among all diseases. Also here, women account for 65% percent of the total number of dementia-related deaths (World Health Organization, 2021).

Dementia presents a significant and wide-ranging social and economic impact, affecting individuals, families, communities, and entire countries. The global cost of dementia in 2019 was estimated to be 1.3 trillion US\$ this value can be attributed to several direct and indirect factors. In summary, the direct factors are related to medical costs incurred in the healthcare system, such as hospital care and medication, and social costs incurred outside the healthcare system as community-based services and care provided by long-term institutional facilities. The indirect factors are where the informal care provided by families, friends, and neighbours is accounted for, this is a hidden and huge number that represents nearly 50% of the global costs with dementia (World Health Organization, 2022a). In 2019, more than 89 billion hours of informal care were provided to people living with dementia, which corresponds to approximately 5 hours of care per day per person. Informal care has a higher prevalence in countries with low resources, which reflects the lack of formal support provided by the healthcare systems for dementia.

2.2.1 The context of Portugal

Europe is the second region in the world with the highest prevalence of dementia, with nearly 14.1 million cases (World Health Organization, 2021). In the Dementia Yearbook 2019 developed by Alzheimer Europe, where a profile for 37 European countries on the trends and changes of people with dementia was depicted, we were able to access an in-depth overview of the current prevalence of dementia and the future predictions of the people living in dementia in Portugal. Portugal will face a slight decrease in its population in the upcoming years, but still the numbers of people with dementia will more than double by 2050, which puts Portugal in one of the worst positions when considering the European broader trend of the number of people living with dementia.

Deep knowledge about the demographic data and numbers of people living with dementia, from a global to a more regional perspective, is crucial for the research community and governments to develop and carry out strategic social and economic policies that accurately support this problem. As we have determined, we are confronted with a significant scarcity of solutions across all fronts—from inadequate recognition of the issue to inadequate healthcare, economic, and social assistance. So, it is clear that there is a space and an urgent necessity to develop technological solutions that may help to improve the quality of life of the people suffering from dementia but also of their caregivers and families.

2.3 Informal caregivers of people living with Dementia

In the previous chapter, we were already able to establish the importance and dimension of the informal care provided to people living with dementia by family members or other unpaid carers, without any additional support. As the number of people living with dementia rises it would be expected that the amount of professional care would rise accordingly, but unfortunately this is not the case to be expected. In consequence, this scenario demonstrates an increasing burden on informal caregivers that provide care not only when People Living with Dementia (PLD) is living at home but also when they are admitted to a long-term care facility (Zwaanswijk et al., 2013).

Providing informal care can be a serious burden. Due to the recent COVID-19, these challenges have been significantly heightened, leading to a breakdown in informal home-based care, which in turn affects the ability of PLD to live in a community for longer and places additional strain on the healthcare and social systems (World Health Organization, 2021). This scenario reinforces the urgent call to address dementia on all fronts. Current policies and government plans remain underfunded due to the continuous reliance on informal caregiving. Although dependent on different social and gender norms, the general expectation remains that families must provide the care, with women being more affected by this belief since they are accounted to provide a disproportionate number of hours of care—approximately 70% of the global hours of care—with a more prominent incidence in low-income countries (World Health Organization, 2021).

2.3.1 Main problems and needs

The informal caregivers of PLD, are exposed to a multitude of factors that are not only intrinsically connected to the different dimensions of dementia, but also to the type of country and region they reside. Their needs and challenges may differ and evolve according to several conditions such as: the type of diagnosis, the age of the person at the time of the diagnosis and the current stage of the condition. For example, caregivers of people living with early-onset dementia report higher levels of stress and burden compared to those caring for older PLD, as the disease presents a higher level of disruption during a stage in life when the caregiver and care recipient may still have young children at home and be at the peak of their working life (Ducharme et al., 2014). And as we have already established, people living in low-income countries or rural areas may face significant barriers to accessing support provided by governmental healthcare, social systems and respite services.

These caregivers face numerous, financial, social, psychological, and physical stress factors, which can harm their mental and physical health, mainly when the care provided is frequent and prolonged for an extensive period (Zwaanswijk et al., 2013). All these

factors actively contribute to a higher mortality rate for the informal caregivers of PLD when compared to the general population (Alzheimer's Association, 2023).

One significant challenge for informal caregivers is financial strain. Providing necessary care may require informal caregivers to reduce their working hours or quit their jobs, resulting in a loss of income. Furthermore, informal caregivers may face additional healthcare costs, such as prescription medication and medical bills, as well as expenses associated with obtaining respite services. Necessary home modifications to ensure safety and mobility may also represent a significant expense.

Another challenge is the lack of social support. Caring for someone with dementia may become a lonely task. Thus, informal caregivers are more likely to experience social isolation and feelings of loneliness. It is crucial to help these caregivers to find a sense of belonging and community.

Finally, we have the psychological and physical impact of caregiving for a PLD. Caring for a person with dementia can lead to a situation in which care is needed over a 24-hour period, and this situation can remain for a prolonged period, as the dementia process usually extends over several years. This presents an immense physical impact on the caregivers especially when the person with dementia loses the ability to care for herself and as a loss of mobility. Furthermore, these caregivers often experience sleep deprivation due to the unpredictable sleep patterns of the care recipient (Almutairi et al., 2022).

Not only this is relevant, but also the drastic changes in the care recipient's behaviour can be extremely exhausting and difficult to adapt. These caregivers experience a lack of training and education that would be crucial to help them deal with these difficult situations, in summary they are not well prepared and lack knowledge of formal support.

All this can exacerbate the levels of stress, anxiety, and depression, which can eventually lead to burnout. It is also essential to take into consideration that these caregivers face a continuous process of loss and grief as they witness a gradual decline in their loved one's cognitive and physical abilities, leading to an impact and change on their relationship.

“The quality of life of persons with dementia lies also in their carer's hands. That's why we need to support carers and enable them to provide good care to persons with dementia.” (World Health Organization, 2021)

The main problems and needs of informal caregivers of PLD have already been the focus of extensive research and studies. In Table 1 we present the detailed findings of our literature review, structured into three main categories— (1) the lack of information and advice, (2) the need for practical support and (3) the need for emotional support.

State-of-the-Art

Table 1: Problems and needs experienced by informal caregivers in caring for a person living with dementia, adapted from Alzheimer's Association, (2023); World Health Organization, (2021); Ducharme et al., (2014) and Zwaanswijk et al., (2013).

<i>Categories</i>	<i>Problems and needs experienced by informal caregivers in caring for a person living with dementia</i>
Lack of Information and Advice	About the symptoms and progression of dementia Available professional support options in the region How to deal with the changes in behaviour What to do when the person with dementia is afraid, angry, confused or even in apathy How to deal with the aggression of the person with dementia How to undertake activities with the person with dementia How to adapt the home to provide better care About the support offered by nursing homes About legal regulations and how to apply for financial support
Practical Support	Needs assistance with the housekeeping (e.g. cleaning, repairs, garden, etc) Needs assistance to undertake physically demanding activities (e.g. bathing, dressing, hygiene routine, etc) Needs someone to look after the person with dementia now and then
Emotional Support	Loneliness Finds it difficult to balance work-life with being an informal caregiver Less contacts with relatives and friends Feels emotionally overwhelmed Constant worrying that the behaviour of the person with dementia may cause unsafe situations around the house Constant worrying that health problems may occur due to the person with dementia difficulty in communicating physical ailments Difficulty in making decision for the person with dementia Dreads the need for the admission to a nursing home Cannot adequately cope with the grief over the deteriorating situation of the person with dementia.

Furthermore, people living with dementia and their caregivers still face the enduring burden of stigma, discrimination, social exclusion, and human rights violations within our global society. This lack of awareness and understanding perpetuates the pervasive stigmatization and discrimination against PLD, hindering progress in dementia diagnosis, treatment, care, and support.

Some of these human rights violations encompass coercive or involuntary treatment, institutionalization against one's will, disregard for an individual's legal capacity to make decisions, and depriving a person of its dignity and autonomy. Moreover, dementia is often misconstrued as a natural and inevitable aspect of aging. This misconception creates barriers to timely diagnosis and appropriate care, even within healthcare systems and among healthcare providers. Alarming, as many as 62% of healthcare practitioners believe that dementia is an inevitable consequence of aging (World Health Organization, 2021).

Initiating public awareness campaigns in collaboration with civil society, individuals with dementia, their caregivers, and other relevant stakeholders serves as the cornerstone for identifying and dismantling obstacles. This concerted effort aims to ensure that people living with dementia can safely reside within their own communities and enjoy equitable access to their environments.

Urgent and comprehensive action is imperative to ensure that all countries establish dementia policies and plans, either as standalone initiatives or integrated components of existing healthcare frameworks. These policies should encompass elements of dementia awareness, stigma reduction, inclusivity, and risk mitigation (World Health Organization, 2021).

2.4 Digital Health solutions for Dementia informal caregiving

As we have already established, informal caregivers of PLD face numerous challenges that directly impact the quality of care provided and the PLD's overall well-being and quality of life. Therefore, these caregivers must have access to a range of services and support strategies specifically designed to address the physical and mental demands inherent in their caregiving role. The global dementia plan, as the World Health Organization recommended in their latest report, underscores the importance of providing accessible and evidence-based resources, including informational materials, comprehensive training programs, and essential respite services, to empower caregivers (World Health Organization, 2021).

During the global pandemic, various policies and special allowances were implemented to address the hardships faced by families. However, informal caregivers

were often overlooked in these new social and financial benefits. This policy gap has yielded both negative and positive consequences. On one hand, it has intensified the burden on informal caregivers, compelling them to juggle their caregiving responsibilities while working full-time from home, potentially leading to a higher risk of premature institutionalization. On the other hand, this gap has catalysed the development and surge of digital interventions aimed at facilitating training and support for these caregivers in hopes that it could mitigate the impact of this additional pressure (World Health Organization, 2021). During this period, many healthcare appointments and support groups, for instance, transitioned to virtual formats, leading to a rise in older adults' adoption of video conferencing tools to stay connected with family, friends, and healthcare services. Today, informal caregivers express growing confidence in utilizing internet-capable devices to access resources and find on-demand tools, which they perceive as advantageous for them and the person they care for (Gitlin et al., 2022).

Digital Health defined as the use of information and communication technologies to support health, wellbeing, and healthcare, has proven effective in reducing symptoms of anxiety and depression, alleviating subjective burdens, and boosting positive aspects of caregiving, including caregiver self-efficacy and confidence, resulting in an overall enhancement of the quality of life among caregivers of PLD (Christie et al., 2018; World Health Organization, 2021). With these encouraging outcomes, experts have advocated for the implementation and advancement of robust technologies and innovative interventions to support these informal caregivers (Werner et al., 2022). Several objectives for Digital Health adoption in dementia care have already been established, encompassing the improvement of clinical care, caregiver education and support, assistance with daily activities, cognitive and emotional aid, in-home health and behavioural monitoring, facilitation of social interaction, and the establishment of remote communication and emergency systems (Bastoni et al., 2021). Solutions that integrate general health information with tailored caregiving strategies are recognized as having a higher likelihood of achieving the positive results previously mentioned. Furthermore, these technological solutions have the notable advantage of extending the accessibility threshold for participation (Møller Jensen et al., 2019). With increasingly accessible internet connections, these solutions can reach isolated populations with difficulties accessing conventional services. Additionally, they provide the added benefit of greater flexibility and personalized services (Christie et al., 2018; Schaller et al., 2015).

The widespread adoption of smartphone technologies has surged over the past decade. These devices have progressively grown more sophisticated while remaining affordable, thus playing a pivotal role in promoting digital inclusion (Guessi Margarido et al., 2022). Due to its multiple functions such as Internet access, telecommunication, notifications, access to built-in components (e.g., camera, global positioning system, and biometric sensors) and integration with other external devices connected through

Bluetooth or Wi-Fi, smartphones demonstrate great aptitude to answer the challenges of informal caregivers of PLD (Brown et al., 2019). Moreover, some native apps can also be accessed offline, again expanding the reach of these solutions to the population of rural locations with limited or no access to the Internet (Guessi Margarido et al., 2022). System designers should leverage these technologies to design context-aware native apps capable of offering crucial personalized and real-time support capable of evolving and adapting to the changing needs throughout the disease. Reviews of mobile apps for informal caregivers have shown their feasibility and acceptance as an intervention strategy (Werner et al., 2022). However, sustainable implementation of these apps requires involving all stakeholders. Users must be thoroughly engaged in an iterative and systematic evaluation process from the beginning of development (Schaller et al., 2015).

A systematic review research study of 2021 highlighted that the number of mobile health applications has already exceeded 259,000 with a significant portion of these apps targeting informal caregivers (Sala-González et al., 2021). Our study, focusing specifically on informal caregivers of people living with dementia (PLD) and the use of mobile technology, is dedicated to analysing the current literature at the intersection of these critical topics.

Our primary findings draw from the scoping review study titled “Smartphone Applications for Informal Caregivers of Chronically Ill Patients” by Guessi Margarido et al., (2022) which dedicates a comprehensive section to informal caregivers of PLD, the systematic review “Mobile Apps for Helping Informal Caregivers” by Sala-González et al., (2021), which of the eleven research studies reviewed, three were focused on the informal caregivers of PLD and the study “Quality of Mobile Apps for Care Partners of People with Alzheimer Disease and Related Dementias: Mobile App Rating Scale Evaluation” by Werner et al., (2022) which is focused on evaluating the quality of publicly available apps for informal caregivers of PLD on the US Apple app and Google Play stores.

The native apps featured in the scoping review by Guessi Margarido et al., (2022) primarily aimed to support informal caregivers, were supported by scientific research, and mainly originated from research groups in the USA and the Netherlands. Out of the 18 applications examined for the chronic condition of dementia, only six were publicly available. These apps encompassed various features, including caregiver education on dementia, strategies for socialization such as support groups or social networks, and self-care elements like mindfulness and journaling. Regarding design considerations, this study concludes that the analysed native apps offer new avenues for caregivers to access health information and some assist caregivers in addressing specific needs, such as planning activities with PLD, making informed medical decisions, and building caregiving skills. Furthermore, the study suggests that personalization of these apps could effectively address specific and time-sensitive needs. For instance, issues related to the

quantity and quality of general health information, such as information overload and poor readability, could be mitigated through features like filters directing users to specific resources or algorithms making recommendations based on usage data and preferences, such as age, language, or location. In sum, designers and developers should strive to employ adaptive technologies that enhance accessibility for individuals with diverse characteristics and capabilities. Considering both the positive and negative aspects of informal caregivers' experiences is crucial for a well-rounded understanding of their needs. Therefore, the development of a comprehensive caregiving theory is particularly beneficial for the successful implementation of personalization features in mobile native apps.

The findings of the systematic review by Sala-González et al., (2021) present a deeper understanding of the reviewed studies, in which only the ones that developed an application and tested its design and user experience, were included. The three studies targeting the informal caregivers of dementia originated from the USA and Norway, and all presented solutions to deal with both practical and emotional challenges. These mobile applications share common core features, including the provision of care recipient information encompassing sociodemographic, clinical data, and daily living activities. They also facilitate access to educational content and offer links to caregiver-specific websites. Moreover, they assess caregivers' psychological well-being, promote the sharing of caregiving experiences with peers, enable communication with healthcare professionals, track behavioural and mood disturbances, and send notifications about medications and doctor appointments. Among these features, the overall participants of these studies particularly valued those dedicated to assessing the well-being of informal caregivers, streamlining communication with healthcare professionals, supporting the assessment of behavioural changes, and offering educational videos with practical advice. The aesthetic appeal of these mobile applications received positive feedback from the study's participants as well. Additionally, this scoping review draws important conclusions regarding recommendations for essential enhancements in these applications and highlights overlooked features. The most frequently mentioned areas for improvement include addressing social and financial concerns, offering caregiving activity suggestions, enabling synchronization with other devices for information sharing among caregivers, and extending the utility of these mobile applications to encompass friends and family members. Furthermore, participants emphasized the value of incorporating various forms of media, such as pictures and videos, into the educational content provided.

The research undertaken by Werner et al., (2022) centres on two primary objectives: firstly, to assess the quality of publicly available apps in app stores, and secondly, to identify the distinguishing design features associated with both low and high-quality apps. In total, the study scrutinized seventeen apps. The findings revealed that, on average, the

quality rating for these apps marginally exceeded the minimum acceptable standard. However, it's worth noting that certain apps received individual ratings that fell below this minimally acceptable quality threshold, with most of them exhibiting dysfunctional features. In terms of functionality, the apps generally offered a limited array of features, with the majority primarily focused on passively delivering educational content. Nevertheless, the effectiveness of this passive strategy remained uncertain and was perceived as limited compared to more active learning approaches. Furthermore, only three apps attempted to address the issue of coordinating caregiving efforts within a network, but they often proved non-functional or lacked active user participation. In evaluating the value of identified features, this study classified its findings into four dimensions: engagement, functionality, aesthetics, and information. Overall, apps scored highest in functionality, encompassing app performance, ease of use, navigation, and gestural design. Conversely, low-scoring design features included unresponsiveness, sluggishness, steep learning curves, and a lack of instructional guidance. Conversely, features that received high scores were those demonstrating logical design, consistency, and the provision of visual cues aligning with user expectations. Following closely is the aesthetics dimension, which involves considerations like layout, graphics, and visual appeal. Here, low-quality and blurred graphics, an absence of colour, and a lack of multimedia content resulted in lower scores. On the other hand, clear and intuitive user interfaces, along with creative and impactful use of colour, attained higher ratings. Engagement and Information were the dimensions that fell below the acceptable quality threshold. Engagement, which encompasses entertainment value, customization options, interactivity, and alignment with the target audience, suffered from a lack of operable customization features and the presence of non-functional content types such as chat, videos, and forums. In terms of the information dimension, which includes factors like the quantity of information, visual presentation, credibility, objectives, and app descriptions, design features such as an overwhelming amount of information, absence of cited sources, questionable links, the absence of visual aids, and the inclusion of advertising within the application contributed to lower overall scores. In conclusion, this study states that the variability among these apps and the generally low rating across all dimensions emphasizes the need to embrace quality-focused design and development approaches like User-Centred Design (UCD). Elevating the quality of aesthetics and functionality can be achieved by applying emotionally resonant UCD principles and the active involvement of intended users in participatory processes throughout all stages of future app design and development. In the Table 2 we present a summary of the main findings of each study mentioned above.

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Table 2: Main identified features and issues on the reviewed studies on Mobile applications for the support of informal caregivers of PLD, by Guessi Margarido et al., (2022); Werner et al., (2022) and Sala-González et al., (2021).

<i>Main identified features and recommendations</i>			
Studies	Nº of apps reviewed	Features	Recommendations
Smartphone Applications for Informal Caregivers of Chronically Ill Patients (Guessi Margarido et al., 2022)	18	Educational content; Building caregiving skills (Planning activities with PLD and supporting medical decisions); Socialization strategies (support groups and social networks); Self-care (mindfulness and journaling).	Increase the number of publicly available apps (only 6 were public); Personalization addressed to time-sensitive needs; Filtering to help reduce information overload and poor readability; Adaptive technology to enhance accessibility.
Mobile Apps for Helping Informal Caregivers (Sala-González et al., 2021)	3	Care recipient information (sociodemographic, clinical data, planned activities); Educational content; Caregivers' psychological well-being (sharing experiences with peers); Communication with healthcare professionals; Tracking of behaviour and mood disturbances; Notifications for medications and medical appointments.	Addressing social and financial concerns; Suggest caregiving activities; Information sharing among devices (include family and friends); Include different forms of media in educational content.
Quality of Mobile Apps for Care Partners of People with Alzheimer's Disease and Related Dementias: Mobile App Rating Scale Evaluation (Werner et al., 2022)	17	Educational content; Coordinating caregiving efforts network.	Increase features offer; Adapt learning curve to users' level of skill; Provide visual cues that align with user expectations; Include different form of media content; Creative and impactful use of colour and high-quality graphics; Offer customization options; Improve information overload and ensure content credibility; Don't use advertising within the app; Ensure overall functionality.

2.4.1 Intention of informal caregivers of people living with Dementia in adopting Digital Health solutions

As previously mentioned, Digital Health solutions, primarily mobile applications, have the potential to serve as valuable and reliable platforms. They offer a means to provide essential information, facilitate easy connections among informal caregivers, and enable interactions with healthcare professionals, all while supporting caregivers in taking care of themselves. However, despite these significant advantages, the adoption of these solutions among informal caregivers remains notably low (Ghahramani & Wang, 2021). Understanding the underlying reasons behind this phenomenon is crucial for the advancement of future app development in this domain.

The findings of a study conducted by Ghahramani et al., (2021) illuminate that an app's effectiveness in addressing the specific needs of informal caregivers plays the most significant role in influencing their willingness to adopt such solutions. Our previous discussion in this chapter revealed that the overall quality of existing mobile apps designed for informal caregivers of PLD is quite subpar, which aligns with the observed low adoption rates. The study also noted that as the health condition of the care recipient is perceived as more severe or the likelihood of unforeseen health changes increases, caregivers become more inclined to use caregiving-related apps. They will also attribute them more credibility and efficiency.

The COVID-19 pandemic may have propelled the development of Digital Health solutions for informal caregivers of PLD, but it also increased the stress and demands placed on these carers. This has resulted in caregivers having less time to engage in online interventions. Additionally, it's essential to recognize that not all caregivers possess equal access or the requisite knowledge and education to utilize new technologies effectively. Consequently, further efforts are essential to develop online solutions that are culturally sensitive, accessible, and responsive to the socioeconomic needs of caregivers to help overcome the technology gap (World Health Organization, 2021).

2.5 The field of Emotional Design

Emotional design emerged to promote positive emotions in users (Norman, 2005), but this perception has been widely extended beyond its beginning. Over the last decades, there has been a steady research development focused on exploring the relationship between design and emotion.

Understanding that emotions profoundly shape our perception of the world while exerting a substantial influence on decision-making and attention has paved the way for a broader perspective (Triberti et al., 2017). This perspective provides us with an opportunity to not only understand the basic dimensions of emotions but also to learn how

we can manipulate, enhance, and even trigger complex emotional states in users, ultimately offering a more comprehensive and immersive experience (Wang & Yuan, 2019).

Emotional design emerges from this newer context as an approach dedicated to crafting designs that attract the user's attention through changes in the different types of emotional states (these changes can be conscious or unconscious), increasing the likelihood of the users performing a particular behaviour, and thereby enhancing user experiences, (Interaction Design Foundation, 2022a; van Gorp & Adams, 2012).

This design philosophy acknowledges that our interactions with products can elicit emotional responses akin to those experienced in real-world social interactions (Desmet, 2002). Consequently, designers should consider both the psychological and emotional dimensions of a user's interaction with a product for it to be successful in creating a memorable and meaningful impression on the user. Design should not only provide functionality and be aesthetically pleasing, but it also must be emotionally fulfilling. This approach can be seamlessly applied to the design of various entities, whether brands, services, or products, regardless of their digital or physical nature (Jeon, 2017; van Gorp & Adams, 2012).

In summary, if designers want their products to be successful and to stand out from the crowd (as markets grow more saturated every day) they need to be emotional. In broad terms, this can be achieved by clearly identifying the context of use and then prioritizing the different emotional considerations that strike the balance between the goals of all stakeholders involved: business goals and the user's needs (van Gorp & Adams, 2012). As coined by Sanders (1992), products should strive to be useful, meaning they need to perform the task they were designed for; usable, meaning they are easy to interact with and finally desirable, meaning they should be attractive and be pleasurable. As we have established in the previous chapter, putting user needs at the centre of the design and development process has been proved to increase the level of adoption and overall user satisfaction with a product.

To effectively design for emotion, it is crucial to possess a comprehensive understanding of what emotions are and the diverse ways in which they can be characterized. Emotions stem from our interactions with the environment and have their origins in the brain. We use "Emotion" as a term that refers to the reaction by an individual to events that he deemed relevant to its needs, goals, or concerns. These reactions encompass various physiological, affective, behavioural, and cognitive components, significantly influencing our attention, decision-making, behaviour, and expressions (Brave & Nas, 2002).

Our experiences with the surrounding world are perceived as sensory information relayed to the brain through our senses. The brain associates this sensory input with the feelings experienced during these encounters. Over time, these associations become

ingrained, shaping how we learn and retain information (van Gorp & Adams, 2012). In conclusion, emotional responses are what drives our understanding of both our internal and external environments and what makes us respond appropriately. They profoundly impact our everyday lives, affecting how we categorize information, make decisions, evaluate risks and solve problems (Damásio, 2011).

The stimuli that trigger emotional responses can arise from interactions with external objects or internal thoughts and feelings. However, what generates our emotional response is our constructed mental model of these encounters, not the encounters themselves. Therefore, the design properties of an object play a significant role in the signals users receive and how they mentally represent the object. Each individual's reality model is formed by the information they consciously or unconsciously focus on, absorb, and incorporate. Understanding this concept of a personal reality model is crucial for designers to grasp both user requirements and how products should fulfil those needs (van Gorp & Adams, 2012).

Today, it is widely accepted that no action or decision can occur without some level of engagement with the emotional system, even if this engagement happens unconsciously (Brave & Nas, 2002). To encourage specific behaviours through emotional triggers, it is essential to recognize that emotions originate from different brain regions, vary among themselves, and yield distinct outcomes in information processing. Unconscious emotions, like startle-based fear, have their origins in the most primitive part of our brain, often reflecting our genetic heritage. They are automatically triggered, resulting in a relatively consistent response and, consequently, are more straightforward to design for. Conscious emotions, such as frustration or pride, demand a deeper level of knowledge-based processing, enabling us to actively participate in the decision-making process tied to these emotions. These conscious emotional responses originate on the neocortex part of the brain (or new brain) and deliberate evaluations and appraisals, making them highly subjective, capable of manifesting at different levels of complexity, and subject to potential changes over time (van Gorp & Adams, 2012).

Experiencing emotion is a process that combines two dimensions: the mental and the physical one. The mental dimension refers to our judgments about the value of things, meaning that it deals with our conscious or unconscious evaluation of good and bad, pain or pleasure. When operating at a conscious level these judgements are called appraisals, primary appraisals focus on evaluating if a product or experience helps to achieve a user's goal, while secondary appraisals focus on evaluating if the user has the means to address that product or experience. According to Desmet (2002), we engage in appraisals as we evaluate a design in relation to our own concerns, this process culminates in an emotional response. Incorporating emotional appraisals into design involves identifying and addressing the user's primary concerns to prevent negative emotional reactions and promote positive ones (van Gorp & Adams, 2012).

The second dimension relates to our physiological experience of emotion, with the level of physical arousal determining the intensity of our emotional reactions. Elevated arousal levels consistently intensify the impact of an experience, whether positive or negative. In terms of a user's capacity to engage with an experience, low levels of arousal can lead to feelings of boredom, lack of motivation, and reduced focus. Conversely, higher arousal levels sharpen focus, enhance attention, and heighten a user's motivation to achieve their objectives. However, excessive arousal can also result in tunnel vision and hinder a user's creative thinking (Norman, 2005; van Gorp & Adams, 2012)

In summary, arousal significantly impacts the motivational aspect of our behaviour. Achieving an optimum alignment between motivation and performance entails a thoughtful assessment of the user's level of stimulation regarding the likely circumstances of use. When a user achieves this equilibrium, they enter a state of flow (Csikszentmihalyi, 1990).

Flow, also referred to as "motivated activity" by Norman, is a state of complete motivation and profound absorption in a task, where the perception of time seems to disappear. These experiences of flow are not contingent on the value dimension and can occur in both pleasant and unpleasant conditions. The key factor is that the user believes that he possesses the necessary skills to surpass the challenge ahead, all within an environment conducive to sustained focus, free from disruptions. Flow experiences are marked by the creation of a sense of order in consciousness, skill enhancement, boosted self-confidence, and, most importantly, a profound sense of enjoyment (Csikszentmihalyi, 1990).

Designers can foster the creation of flow experiences by tailoring the challenge level with the user's skills and contextual considerations. For instance, an excessive challenge combined with insufficient skill can induce anxiety, while too little challenge relative to the user's skill can lead to boredom. Therefore, a profound understanding of the origins, characteristics, and outcomes of flow is imperative to identify what aspects can be influenced through design. Among the triggers of flow, elements such as establishing clear and evolving goals, offering immediate feedback, and maintaining a delicate balance between the perceived challenge and the user's skill level have the most substantial impact on designing for emotional engagement (van Gorp & Adams, 2012).

Up to this point, we have introduced several foundational concepts that facilitate our comprehension of what emotions entail and how they impact us, all with the overarching goal of learning how to design for emotional responses. These concepts, coined by different authors, are no more than different perspectives on the process of designing for emotion, which can be correlated with the design goals proposed by Sanders, (2010) and various product elements. A common thread among these models is the notion that individuals react to products much like they do to fellow humans, attributing them with personalities and evaluating them based on social norms. By designing products that align

with the principles we have acquired through our interactions with people, designers have the capacity to assist technology users in cultivating more enriching relationships with digital products (Jeon, 2017; van Gorp & Adams, 2012). In the Table 3 we present the main findings of the considered models by each author.

Table 3: Relationship between design goals, product elements, and design models, adapted from (van Gorp & Adams, 2012)

<i>Design goals, product elements and design models</i>			
Design Goals (Sanders, 1992)	Desirable Aesthetically appealing	Usable Capacity to be understood, learned, and utilized	Useful Accomplishes what it was designed for
Product elements	Aesthetics How the product looks and feels	Interaction How the user interacts with the product	Function What the product does
Relationship to design models	<i>Experience over time</i> 		
Types of Benefits (Jordan, 2000)	Hedonic Benefits Sensory and aesthetics	Practical Benefits Result from the completion of tasks	Emotional Benefits Effect on user's emotions
Type of Appraisals (Desmet, 2002)	Objects Does it appeal to my attitudes?	Agents Does it meet my standards?	Events Does it help reach my goals?
Levels of Processing (Norman, 2005)	Visceral Aesthetics and tactile qualities	Behavioural Effectiveness and ease of use	Reflective Self-image, personal satisfaction, memories
ACT (van Gorp & Adams, 2012)	Attract – Aesthetics oriented How it looks, sounds and feels	Converse – Interaction oriented How it interacts with the user	Transact – Personality oriented Based on the attributed personality

This table juxtaposes the key perspectives of prominent authors over time regarding the design for emotion. Each viewpoint is intricately linked to the user's ongoing engagement with a product and directly corresponds to Sanders' (1992) design goals and the product elements aesthetics, interaction, and function. Within the Desirable goal, associated with the aesthetic aspects of a product, we first encounter Jordan's (2000) Hedonic Benefits, which delve into the pleasure derived from a product's aesthetics. Subsequently, Desmet's Objects Appraisal assesses whether the object aligns with the user's attitudes, and Norman's (2005) Visceral Level captures the immediate and

subconscious processing of aesthetic information, encompassing sight, sound, smell, touch, and taste. Moving to the Usable goal, linked to a product's capacity for use, Jordan's Practical Benefits stem from the completion of small tasks. Desmet's Agents Appraisal describe whether the product meets the user's standards during interaction, and Norman's Behavioural Level focuses on the processing of ease of use and interaction with the product. The final goal, Useful, builds upon the success of the preceding goals, when the user evaluates if the product reliably fulfils long-term intentions. For Jordan (2000), Emotional Benefits arise from extended interaction and goal realization. Desmet's (2002) Events Appraisal relate to the accomplishment of enduring goals that also serve as memorable events, while Norman's Reflective Level hinges on how enduring relationships contribute to the assessment of our self-image and identity (van Gorp & Adams, 2012).

The ACT model, introduced by van Gorp and Adams (2012), considers insights from preceding models and delves into the intricacies of human emotions, particularly the nature of love, offering a digital-centric perspective. Crafted as a more focused and prescriptive framework, the authors designed this model to guide designers in meeting the evolving requirements of each stage in a product's interaction over time. With an emphasis on actionable labels, Attract signifies the necessity for a designed product to be not just appealing but actively engage users' senses. Converse urges designers to perceive product design as a conversation, encompassing both dialogue and narrative elements. Lastly, Transact emphasizes the cultivation of long-term relationships through the successful establishment of trust and credibility, forged in the preceding stages.

Given its specificity and actionable approach, we find the ACT model particularly apt as the foundation for our proposed approach to defining principles and guidelines.

2.6 Principles and guidelines of Emotional design for HCI

In the preceding chapter, we delved into the perspectives of various authors who have significantly contributed to the field of emotional design, establishing models that dissect our interaction with products into three distinct levels of experience: aesthetics, interaction, and commitment (van Gorp & Adams, 2012). These models, inspired by the progression of human-to-human relationships, serve as a foundation for understanding and implementing emotional design.

The evolving landscape of technology, coupled with the prevalence of ubiquitous and wearable sensing capabilities, has unveiled a previously unexplored area within these models: the active role of emotion as a participatory agent, rather than a mere by-product of interaction (Rapp et al., 2017).

Wearable devices capable of real-time monitoring of detailed physiological signals hold great potential for unravelling the complex mechanisms of emotions. While still evolving, these biosensors have already proven successful across various domains, from education to healthcare, providing accurate, clear, detailed, timely, and relevant data that can be incorporated to facilitate decision-making (Alhejaili & Alomainy, 2023).

In the recent systematic literature review conducted by Shen Ba and Xiao Hu, the research concentrated on exploring the correlation between emotion and cognition by leveraging wearable devices in educational settings. Among the 50 journal articles scrutinized, the predominant physiological signals utilized were electrodermal activity and heart rate, highlighting engagement, positivity, and anxiety as the most extensively identified and studied emotions.

In the realm of healthcare, particularly in mental health and well-being, the prevalent physiological signals employed for stress level detection encompass the accelerometer, heart rate, and electrodermal activity. This approach has empowered researchers to discern individuals' stress levels during their daily routines and identify the most common stress triggers. Nonetheless, the utilization of wearable biosensors in real-life experiments introduces several challenges related to the reliability and utility of measurements for extracting emotions (Alhejaili & Alomainy, 2023).

Recognizing this emerging dimension is crucial for comprehensively addressing the dynamics of emotional design in the contemporary technological context.

In this study, we advocate for the integration of these two perspectives as a necessary means to empower designers to engage with emotions in a manner that fosters enduring emotional benefits, including but not limited to loyalty, satisfaction, and overall well-being.

From this point forward we will focus on the knowledge from the ACT Model by van Gorp & Adams (2012) to establish the structure that will encompass our principles and guidelines framework. We will address principles as being broad, foundational, and enduring, providing a fundamental basis for reasoning and decision-making. Guidelines, on the other hand, will be considered detailed and concrete, offering practical advice or direction in specific contexts.

The subsequent sections and Table 4 present a comprehensive compilation of principles and corresponding guidelines, organized according to each stage of the ACT model. These insights have been drawn from an extensive bibliographical survey that relies on the works of reference authors and studies contributing to the theoretical foundation of this thesis. As we progress to the practical implementation of this study, these guiding principles will serve as the framework upon which we will build our methodologies, make informed decisions, and navigate the complexities that lie ahead.

2.6.1 The principles and guidelines of Aesthetics

“Attraction is usually the beginning of the relationship process.” (van Gorp & Adams, 2012) and just as in any relationship, first impressions hold substantial significance. Aesthetics wield the power to influence whether a user feels compelled to approach the product and initiate interaction, they serve as the catalyst for capturing the user's attention at precisely the right moment and within the right context, often conveying meanings through association. This, in turn, can drive users to select one product over another, primarily based on the values and status that this aesthetics convey.

All visual characteristics of a product can elicit different emotional cues or states. We will focus on the following visual dimensions: (1) colour, (2) line and form (3) images and (4) motion (van Gorp & Adams, 2012).

2.6.2 The principles and guidelines of Interaction

Research into relationship dynamics has shown that even between a user and a product, most interactions can be comprehended in terms of two main dynamics: power and status. These user judgments are unconscious and influenced not only by the content of the interaction but also by the form of that content. The dynamic nature of this balance is also directly related to the balance between challenge and skill (van Gorp & Adams, 2012).

Following the initial approach driven by visual characteristics, the interaction between a product and a user evolves into what can be described as a conversation. This discourse holds a great deal of importance in shaping the desired emotional states within the user. If the product fails to effectively assist the user in attaining their intended goals, the product-user relationship may end. Our focus will delve into three key interaction dimensions: (1) Conversation, (2) Manners, and (3) Stereotypes.

2.6.3 The principles and guidelines of Commitment

The last stage of the user-product relationship is predominantly a conscious process, characterized by introspection into the product's impact on the user's self-image and identity. During this stage the user reflects upon his experience, considering whether both aesthetics and interactive features have met their expectations and provided satisfaction. The successful alignment of these criteria fosters product credibility and initiates the development of trust within the user. It is this trust that ultimately cultivates the user's comfort and commitment for the long term (van Gorp & Adams, 2012).

In Sousa's seminal study (2017), the primary objective was to discern a cohesive set of design principles pivotal for enhancing credibility and confidence within the interfaces of e-Health solutions. Following an exhaustive literature review, a conceptual interface,

organized into five distinct dimensions, each housing a collection of meticulously defined principles, underwent evaluation by experts using the Delphi method. The findings conclusively demonstrated that all designated design principles exert a significant influence on the credibility and confidence experienced by users when engaging with e-Health solutions. Below, we present an overview of the most influential dimensions of an interface along with the proposed principles that emerged from the study.

Once trust has been established with a product, users are more inclined to strengthen their relationship through various transactions. These actions can range from something as straightforward as submitting a contact form to more substantial interactions, thereby enhancing the product's adoption rate (Ghahramani & Wang, 2021).

Table 4: Proposed framework of principles and guidelines of Emotional Design for Human-Computer Interaction.

<i>Stages</i>	<i>Principles</i>	<i>Guidelines</i>
Aesthetics	Attractiveness: our inclination to approach and engage with something is often triggered by its appeal. People are naturally drawn to entities that they find aesthetically pleasing and that mirror a personality similar to their own. Consequently, attractive products tend to be perceived as more persuasive and credible (van Gorp & Adams, 2012). Personality: aesthetic elements serve as a means to imbue a product with distinct personality traits. Users evaluate a product's personality much like they would assess a person, employing similar criteria. While personality traits are inherently complex, psychologists have identified two primary dimensions that users readily assign to products: (1) dominance versus submissiveness and (2) friendliness versus unfriendliness. Aesthetic elements, when perceived positively, can be used to convey a friendly personality; conversely, when viewed negatively,	(1) Colour: known to significantly influence emotional states, colour holds great importance in effectively communicating emotions and personality (van Gorp & Adams, 2012). <u>Associations:</u> colours and hues can be associated with friendly or unfriendly personalities according to the behaviours that are attributed to them. But this association of colours to emotion must be used carefully, as it can vary among cultures. We can also use colour association to increase the perceived value of a product (e.g. gold). <u>Hue:</u> the hue of a colour is evaluated based on its value. Warm colours like red, yellow, and orange are perceived as more aggressive, dynamic, and generally provoke active feelings, while those in the blue range, cool colours are regarded as more passive and calming and are less likely to cause extreme reactions (Brave & Nas, 2002). <u>Saturation:</u> colour saturation can influence physiological arousal independently of its hue and serves as an effective tool to automatically draw attention to specific sections of a product or interface. Contrast: the contrast of a colour against its background significantly impacts arousal, with higher levels of contrast leading to increased arousal. <u>Preferences:</u> our attention is drawn to colours we like, while we tend to ignore the ones we don't. (2) Line and form: while not as strongly linked to emotion as colour, line and form exert a profound unconscious influence on perceptions of emotion and personality (van Gorp & Adams, 2012). <u>Direction:</u> The directional tendency of a line can evoke contrasting feelings and emotions. Lines moving or pointing upwards express strength, energy, force, ambition, and an uplifting sensation, triggering higher levels of arousal and conveying a powerful perception of strength. In contrast, lines moving or pointing downwards express weakness, a lack of energy, relaxation, or a sense of sadness, triggering low levels of arousal and conveying a less powerful perception of strength. <u>Shape:</u> form plays a significant role in shaping the perception of personality based on its shape, perceived hardness or roughness, and perceived weight. Angular, hard, and heavy

<i>Stages</i>	<i>Principles</i>	<i>Guidelines</i>
	they present an unfriendly disposition. Furthermore, aesthetic elements capable of generating heightened arousal can effectively communicate a more dominant personality, while those that reduce arousal can aptly convey a more submissive persona. The most successful products are those that blend dominant and submissive characteristics in a way that is both consistent and authentic.	forms are commonly perceived as more dominant, whereas rounded, soft, and light forms are seen as more submissive in contrast. (3) Images: play a crucial role in defining a product's personality by effectively conveying emotions through storytelling and triggering memory associations. It's important to note that certain images may inherently evoke either discomfort or delight, due to their evolutionary significance (Brave & Nas, 2002). <u>Size:</u> one of the most crucial and primal visual cues, objects and people that are larger than us are perceived as potential threats. Larger things are known to generally elevate our levels of arousal, and this phenomenon also extends to the use of images. Larger images tend to be particularly arousing and are better remembered and favoured. This can occur either due to the image or screen being large or because the eyes are close to the screen (Brave & Nas, 2002). <u>Distance:</u> the distance between two people marks the intensity of the emotional response for everyone involved, this is also true between the perceived distance of the viewer and an image. Viewers pay more attention to close-ups of people and remember them better, but close interpersonal distance even with images can be positively or negatively arousing. <u>Screen size:</u> the way users view and judge an image is also impacted by the screen size of the device they are using. Devices with larger screens are likely to be more arousing than the ones with smaller screens, due to the increased movement perception in the viewer's peripheral vision. Both close-up images shown on large and smaller screens increase arousal levels, for smaller screens this effect happens due to an increased sense of intimacy. However, designers need to understand that if images appear larger than their actual size on a large screen, they will need to frame those images differently than if the images would be displayed on a phone. Large, highly arousing images are great for enhancing emotional experiences but can also be counterproductive in learning or task-performing contexts. (4) Motion: captures our focus, making us more alert, particularly when it occurs within our peripheral vision. With heightened attention follows improved memory retention, emphasizing the significance of motion sequences in effectively conveying emotions. (van Gorp & Adams, 2012) <u>Quality:</u> viewers will orient their attention toward visual surprises, and motion always demands more attention than stillness. However, the quality of the motion is an essential factor to consider. Motion should emulate the rhythms of nature, with slow and seamless movements enhancing both immersion and characterization.

State-of-the-Art

<i>Stages</i>	<i>Principles</i>	<i>Guidelines</i>
		<u>Transitions</u>: transitions between scenes serve to segment information, aiding users in distinguishing the completion of one unit of content from the beginning of another. These transitions should mirror the organic flow of real-life scene viewing, meaning that long shots should move into closer ones. More cuts present a more stimulating visual style, which can translate into a more dynamic personality, but there is also a balance that needs to be maintained, as having either too many cuts or too few, can lead to a decrease in attention.
Interaction	Power: in design, as demonstrated in the previous section, the perception of power can be communicated through aesthetics, with specific design elements capable of asserting either a more dominant or submissive personality and/or through the perceived product features and capabilities. Simple products can be seen as lacking power, so it is important to strike a balance between simplicity and complexity for the product to appear powerful enough to complete the task at hand. Status: as we treat our product interactions as social interactions, when users cannot complete a task, they may feel inadequate, lacking in capability, and even in self-assigned status. Unless a product is leading and guiding the user, it should always take a submissive approach and ensure that the user feels that he is in control. For this to happen, it's important that a	(1) Conversation: when a user engages with a product in conversation, several emotional cues are introduced to the interaction. Thus, the product should dynamically present content that aligns with the user's emotional context and prevailing situation. By tailoring the interaction style to the design's context, the conversation can be used to convey personality, foster a connection and establish trust and credibility (van Gorp & Adams, 2012). <u>Content</u>: is what helps the product to communicate successfully. Not providing the adequate content to form accurate expectations and complete tasks can result in anger and frustration. A well-defined content strategy is the basis of any product that means to be relevant and useful. Well-designed content possesses four key attributes: (1) factual accuracy, (2) an apt quantity tailored to the conversational context, (3) relevance, and (4) clarity. <u>Tone of voice</u>: a framework that guides the content creation according to a pre-established product personality thereby ensuring coherence in product communication. These guidelines delineate the suitable manner of addressing various emotional scenarios users might encounter during interactions. For instance, a success message demands for a celebratory tone, while content on a help screen should acknowledge the potential for user confusion (van Gorp & Adams, 2012). Moreover, when users encounter an error, it's crucial to inform them about the issue and its potential consequences, but by framing the situation as positively as possible, the negative impact of the situation can be mitigated (Brave & Nas, 2002). <u>Dominance</u>: a product should tailor its language, content, and manners to align with the personality traits suitable for the intended interaction. How products convey information is vital in shaping user's interpretations. Regarding conversation, the product should strive for a complementary personality. For instance, while acting as an instructor, the product can project dominance, yet it should adopt a more submissive stance as an assistant. To foster a sense of dominance, you may be more direct in your statements and be more ambiguous

<i>Stages</i>	<i>Principles</i>	<i>Guidelines</i>
	product is designed in a way that facilitates interaction. Providing timely feedback, prioritizing the user's preferences, choices, and needs, along with offering rewards upon task completion are among the strategies that designers can employ to foster an empowering user interaction. Emotion regulation: At this stage, designers can aim to broaden the scope of emotions within the user-product relationship. This involves utilizing emotions as inputs to modify the product's output. Advances in technology, especially in combination with wearable sensing, have empowered designers to adapt to users' current emotional states. However, this requires designers' capability to identify and measure emotional profiles alongside pre-existing individual contextual characteristics. (Triberti et al., 2017)	when trying to be submissive. Additionally, employing positive language contributes to a friendly and interactive personality, distinct from the implications of negative language usage (van Gorp & Adams, 2012). At times, the product may also have the opportunity to reshape the user's perception of agency. For example, in situations where the user might blame themselves, the product could assume responsibility rather than attempting to redirect the user's negative emotional state (Brave & Nas, 2002). (2) Manners: during an interaction paying attention to the evolving emotional nuances within the dialogue between the user and the product is key to elicit an emotional response and promote a foundation of trust (van Gorp & Adams, 2012). When a product responds slowly, unclearly, or in an unconventional manner it often triggers feelings of anxiety in the user. Therefore, providing users with immediate feedback on their actions is key to promote a state of positive emotions (Brave & Nas, 2002). <i>Etiquette:</i> the fundamental principles of human etiquette extend to product design; products should greet users upon their arrival and request permission for departure. Designers can instil their products with a sense of "manners" by punctuating these instances with verbal cues, sounds, gestures, or even subtle shifts in the screen interface. <i>Praise:</i> typically evokes positive emotions in individuals by validating their efforts, achievements, and qualities (Sugawara et al., 2012). Consequently, products that provide compliments and praise tend to be more favoured than those that critique or remain neutral. Users believe praise from a product; thus, designers can strategically employ praise to celebrate successes or motivate individuals to rebound from setbacks. (3) Stereotypes: firmly embedded in societal norms, cultural expectations, and marketing tactics, the personality of a product frequently implies the perception of gender identity and inevitably becomes intertwined with stereotypes (van Gorp & Adams, 2012). <i>Gender:</i> while societal attitudes and perceptions continue to evolve, certain associations with masculine and feminine voices persist. Designers should consider these associations to tailor their product's personality effectively. Masculine voices are often linked to greater technical skills, extroversion, willpower, and persuasiveness. On the other hand, feminine voices are commonly perceived as more emotional, empathetic, and relatable.
Commitment	Credibility and confidence: According to expert analysis, the	(1) Trust: Establishing trust with a product hinges on maintaining a consistent personality across all communication channels. Achieving this requires aligning the product's personality not only with the

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<i>Stages</i>	<i>Principles</i>	<i>Guidelines</i>
	visual dimension of an e-Health interface stands out as the most impactful in instilling credibility and confidence. Among the 29 identified principles, the following proved to be “the most influential”: "Fashion should not triumph over usability," "Adequacy," "Surface credibility," "Space," "Hierarchy," "Simplicity" and "Typography." Transitioning to the Information Architecture dimension, encompassing 21 principles, "Adequacy," "Content," and "Quality" emerged as critically influential components. In the realm of Interaction, consisting of 19 principles, "System consistency" and "Errors" emerged as the most influential guiding principles. Lastly, the "Social Presence" dimension, comprising 31 principles, revealed a singular critical influencer, "Reputed Credibility," marking it as the less influential dimension in the context of e-Health interface design (de Sousa, 2017).	user group and their goals but also with the appropriate emotional responses in various contexts. To enhance the accurate delineation of a product's personality traits, designers should incorporate emotional characteristics into their user research. Personas and scenarios should be founded on the emotional significance of user contexts, serving as a guide for designers to define the desired personality expression (van Gorp & Adams, 2012).

2.7 Emotional Design applied to Digital Health Solutions for the support of informal caregivers of PLD

Having established Emotional Design as a holistic approach of people and how to design for them, we went searching for solutions that intersect with this area of expertise and the development of Digital Health solutions for the support of informal caregivers of PLD.

The incorporation of emotion as a fundamental design element traces its roots back to industrial design but has gained more recent prominence in the field of Human-Computer Interaction (HCI). This shift was driven by the need to address the limited perspectives on technology (Jeon, 2017). The proliferation of consumer electronics in households brought attention to the emotional impact of these technologies. In 1997, Rosalind Picard's pioneering work emphasized the crucial role emotions play in decision-making, perception, and learning, advocating for computers to be capable of recognizing, understanding, and even expressing emotions. Various other studies have also underscored that the human response to products extends beyond physical fit and information processing, emphasizing the importance of integrating an emotional dimension into design. Today, emotion is a prominent factor in design research, theory, and practice, encompassing all design disciplines and related fields (Jeon, 2017).

Design and emotion inherently align with the pursuit of social innovation, particularly in areas like healthcare and well-being (Jeon, 2017). With this context in mind, we anticipated finding ample evidence of emotional design-based approaches in the development of Digital Health solutions meeting the criteria of our study. Unfortunately, this was not the case, primarily due to the constraints of our study timeline. Our primary findings in this domain were limited to four studies, all focused on Digital Health interventions in general, with none specifically addressing informal caregivers of PLD. Notably, all these studies share a common thread, emphasizing the use of a User-Centred Design approach or participatory design methodology in the development of their proposed solutions. Three of these proposed solutions concentrate on the application of affective computing techniques, which enable the extraction and classification of emotional cues using various sensors to provide external emotional regulation techniques.

Most designers well-versed in the realm of design and emotion would concur that a human-centred design process, with users and stakeholders taking centre stage in a research-driven approach, is pivotal to achieving success. Affective computing stands as a pivotal reference point in the literature for designing with emotion (Jeon, 2017). However, it's worth noting that while these studies primarily focus on presenting their

technological solutions, they do not delve into the specifics of their perspectives on emotional design or the principles they may have employed or contemplated.

This apparent lack of solutions that focus on both technological and emotional design development underscores the significance of our research and the findings of our study for both fields.

2.8 Conclusions

In the initial section of our literature review, our focus centred on the social landscape of dementia, where we highlight the profound impact of dementia on contemporary society, particularly on those providing informal caregiving. The identified needs and challenges manifest across three primary dimensions: the absence of information and advice, the lack of practical support, and a deficiency in emotional assistance. The recent COVID-19 pandemic has accentuated these challenges but has also yielded positive outcomes. Notably, it catalysed the development of digital health solutions to support caregivers and facilitated their increased familiarity with internet-capable devices. Our research affirms the positive impact of digital health solutions in mitigating anxiety and depressive symptoms among caregivers, concurrently enhancing their caregiving skills and confidence. Furthermore, the evolution of mobile technology presents promising opportunities for developing digital health solutions. These solutions can leverage functions such as internet access, telecommunication, integration with various components and external devices, and the availability of select native apps for offline use. This broadens the scope of solutions to reach populations in rural areas with limited or no internet access. However, our exploration of existing mobile apps for supporting informal caregivers of Persons Living with Dementia (PLD) revealed a significant oversight. Among the 38 apps evaluated across three studies, we found a limited range of features. While many aimed to address the information and advice needs of caregivers, this information was often presented passively, lacking personalization, filtering options to manage information overload, and attention to information credibility. Notably, most of these apps were not publicly available and did not function optimally. These findings underscore the importance of our study, as our objective is to delve into a mobile solution that can comprehensively address the most pertinent needs and challenges. Additionally, we seek to explore the potential role that Emotional Design can play in bridging the identified gaps in existing solutions.

In the second section of our literature review, we explore the evolution of Emotional Design, tracing its roots from a focus solely on promoting positive emotions in users to a broader perspective that considers the triggering of more complex emotional states. Our investigation establishes that Emotional Design parallels our real-life social interactions,

emphasizing the necessity of comprehending human emotional experiences to inform designers in how to design emotionally resonant products. Emotional experiences unfold across two dimensions: the mental, involving judgments about the value of things, and the physical, encompassing our physiological responses to emotion. Achieving the right balance between user arousal and the challenge at hand is pivotal, fostering a state of flow and emotional engagement. Numerous authors have proposed models for designing for emotion, each aligned with common design goals and product elements. Focusing on the most recent model, we identify a previously overlooked aspect—the role of emotion as a participatory agent, not just a by-product of interaction. We highlight the successful use of wearable biosensors for emotion measurement, despite challenges in reliability and utility. Leveraging these insights, we construct our own framework of principles and guidelines for designing for emotion, structured around the three stages of a user's relationship with a product: aesthetics, interaction, and commitment. This framework will guide the formulation of an effective digital health solution for the challenges identified in our study.

Our literature review reveals a significant gap in the intersection of design and emotion. Despite the acknowledged importance of emotions in the user experience, there is a dearth of solutions integrating technological and emotional design elements, particularly tailored to the needs of informal caregivers of Persons Living with Dementia (PLD). In essence, our study stands as a critical reference point, emphasizing the imperative connection between technological solutions and a profound understanding of emotional design principles. The absence of comprehensive approaches in existing literature underscores the relevance and importance of our research, offering valuable insights for both the design field and the crucial realm of supporting informal caregivers in the context of Digital Health solutions.

3. User research: discovery stage

In this section, we will present the quantitative and qualitative findings obtained through a questionnaire and semi-structured interviews, which we selected as the most suitable research instruments within the context of our established methodology. These results are a direct response to one of our main research questions: “What problems and challenges do informal caregivers face a home-based and affordable Digital Health solution can address? Our data collection approach via the questionnaire and interview aimed at understanding two main aspects of our research inquiry. Firstly, we delved into the practical and emotional needs and challenges experienced by informal caregivers of PLD. Secondly, we explored the role of technology in the daily lives of these caregivers and its impact on their care provision. Furthermore, we sought to contextualize our findings within the existing body of literature on these topics, providing valuable insights into the alignment or divergence of our results with prior research.

3.1 Questionnaire findings

Our questionnaire served two primary purposes. Firstly, it aimed to broaden the geographical reach and increase the number of study participants. Secondly, it acted as an initial point of contact with potential participants for subsequent semi-structured interviews. Informal caregivers of PLD often face significant time constraints (Ducharme et al., 2014), and people generally feel more at ease sharing their experiences when anonymity is assured (Kang & Hwang, 2023). Therefore, we anticipated that the questionnaire would enhance our data collection efforts and complement the insights gathered during the interviews. The questionnaire was designed to gather both quantitative and qualitative information. The full guide can be found in [Annex A](#). The distribution was carried out from April to May 2023, in collaboration with associations affiliated with informal caregivers and the University of Porto community. Out of the 5 associations contacted, only 2 were able to effectively distribute the questionnaire among

their members. We were able to gather 40 responses, however, one response was excluded as it did not meet our inclusion criteria.

Quantitative results

Our quantitative results served the following key objectives: (1) profiling our sample of participants, the people they care for and subsequently the shared relationship (2) assessing the self-perceived knowledge of the informal caregivers about dementia and finally (3) evaluating their familiarity with technology.

Characteristics of the participating informal caregivers and the people living with dementia are fully reported in [Table 8](#) and [Table 9](#), on [Annex C](#). Twenty-six caregivers (67% of the total sample) are female, which aligns with the findings of our literature review and 20 (51%) have an age range between 45 to 65 years old. As for the people living with dementia, 30 (77%) are female, once again validating the findings of our literature review, 21 (54%) with an age range between 65 and 84 years old and finally 17 (44%) are fully dependent on another person. All participants share a family relationship, with 29 sharing residence (74%), 35 (90%) providing care on a daily basis and 19 (49%) having been providing care for as long as 1 to 5 years. Furthermore, 25 (64%) share their caregiving responsibilities with others.

The self-perceived knowledge and ability to deal with the challenges of dementia results are listed on [Table 10](#), on [Annex C](#). At the time of the diagnosis, 32 (82%) of the informal caregivers felt that they weren't given the necessary information to deal with the situation. In turn, 36 (92%) stated that they have at some point, felt the need to research information on the dementia diagnosis, with 31 (36%) using the internet as a means of research followed by 21 (29%) contacting healthcare professionals. The most researched topics are "Information about what dementia is, its progression and its symptoms" with 29 (27%) responses, closely followed by "Information on how to deal with the behavioural changes of the person with dementia" with 28 (26%) responses. Currently, the informal caregivers of PLD feel that they are more informed about dementia than at the time of diagnosis, but still 20 (51%) stated that they are still not properly informed and 22 (56%) still feel that they aren't adequately qualified to deal with the person with dementia.

[Table 11](#), on [Annex C](#) contains data related to the technology familiarity of informal caregivers of PLD. Notably, a significant majority of caregivers exhibited a high level of familiarity with technology. Thirty-two (90%) caregivers own a smartphone, with 34 (97%) using it to research information on various topics, with 33 (94%) also using it to send and receive emails, and 32 (91%) being able to download and install new applications. Furthermore, 27 (77%) stated that they had other technology devices, such as tablets, smartwatches, home assistants, and others.

Qualitative results

The primary objective of our qualitative results was to uncover and categorize the central practical and emotional challenges experienced daily by informal caregivers. To facilitate comprehensive responses, we designed two open-text questions within the questionnaire, allowing respondents to elaborate as they saw fit. In our analysis of the collected data, we employed the code book analysis method, which is known for its systematic and rigorous approach. This method enabled us to discern underlying patterns and relationships within the dataset.

We initially drew upon the findings of our literature review to establish the initial categories and keywords for our thematic analysis. However, as we delved deeper into the data, our understanding evolved, prompting us to refine and expand our categories. For instance, we introduced a category related to 'feeling societal stigma,' a theme not prominently featured in our initial literature findings but prevalent in our dataset. Additionally, we chose to assess our findings within their contextual framework, distinguishing between positive and negative contexts. This approach enabled us to gain insights into how negative situations were often counterbalanced by positive experiences. We have categorized our findings into four primary domains: (1) Lack of Information and Advice, (2) Practical Challenges, (3) Emotional Challenges and (4) Societal Stigma. Each of these main categories encompasses several sub-categories that provide a more deepened understanding of the challenges faced by informal caregivers of PLD. The complete framework can be found in [Annex B](#).

Figure 1 presents a summary of the main challenges faced daily by informal caregivers of PLD. The complete dataset is available in [Table 12](#) of [Annex C](#).

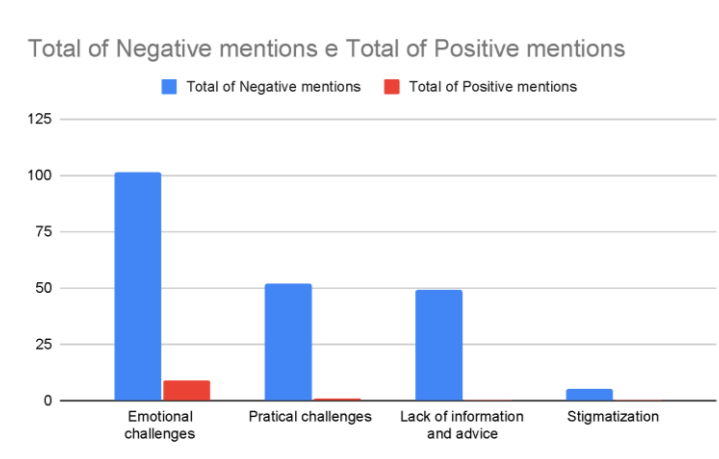


Figure 1: Summary of the main challenges experienced by informal caregivers of PLD, according to questionnaire data.

The most prominent category among respondents was 'Emotional Challenges,' with a total of 101 negative mentions and 9 positive mentions. Within this category, 'Feeling

emotionally overwhelmed' emerged as the most frequently referenced sub-category, with 32 negative mentions *"Feeling like giving up on everything"*, *"Every day I feel a whirlwind of emotions, often all at once."* and 7 positive mentions. Another emotionally charged sub-category was 'Cannot adequately cope with the grief over the deteriorating situation of the person with dementia,' with 23 negative mentions and 2 positive mentions. *"The inability to communicate with my husband... managing our daughters' suffering..."*

The 'Practical Challenges' category ranked second in terms of mentions, with a total of 52 negative mentions and only 1 positive mention. The most prominently referenced sub-category within this domain was 'Needs assistance to undertake physically demanding activities,' which garnered 46 negative mentions. *"My age and the need for help to care for her."*, *"Bathe, feed, mobilize her, and maintain daily hygiene."*

Following closely was the category of 'Lack of Information and Advice,' with 49 negative mentions. *"How to deal with behavioural changes, more information, how to defend myself, who takes care of me!"*

Lastly, the 'Societal Stigma' category received 5 negative mentions, indicating its comparatively lower prevalence in our respondents' experiences.

3.2 Semi-structured Interviews Findings

Our semi-structured interview served the main purpose of deepening our understanding of the challenges faced by the informal caregivers of PLD. Through these interviews, our goal was to gain a comprehensive understanding of their personal narratives, exploring the profound impact of each stage of dementia on their lives. We sought insights into their coping strategies for overcoming these challenges and to gain a deeper understanding of their current daily routines. Additionally, we aimed to uncover the role, if any, that technology plays in their caregiving activities. The findings from these interviews played a crucial role in shaping the development of our User Personas and Use Scenarios, which we will present in the following chapter.

We conducted a total of seven interviews, all facilitated through video calls, ranging in duration from 45 minutes to 2 hours. Despite the limited number of participants, our sample was notably diverse and reflected the main characteristics outlined in our existing literature review. Of the seven participants, four were female and three were male. The age range was primarily between 65 and 84 years old, with two participants being notably younger. Each interview followed a standardized approach: we commenced with a brief introduction, outlining the project's context and motivation, as well as the interviewer's background. We ensured adherence to confidentiality terms before proceeding to the main body of the interview, which was structured into three parts. The first segment aimed to familiarize ourselves with the informal caregiver and the person living with dementia,

exploring their characteristics, relationship dynamics, and the impact of dementia on their lives. The second part delved into their daily routines, elucidating the challenges they encounter and the strategies they employ to navigate them. Finally, the last part focused on the role of technology in their lives, examining its contribution to their caregiving responsibilities. The full interview guide can be found in [Annex A](#). Each interview was audio recorded with the participant's consent, fully transcribed and prepared for analysis afterwards.

Qualitative results

To analyse the gathered information, we employed the same code book analysis structure utilized for the open-ended questions in the questionnaire, detailed in [Annex B](#). While maintaining the main categories, we expanded upon them by including additional keywords to accommodate the extensive and more nuanced content sampled from the interviews. Furthermore, we adhered to the principle of evaluating the context—whether positive or negative—for each finding. Figure 2 provides a summary of the main outcomes from our analysis.

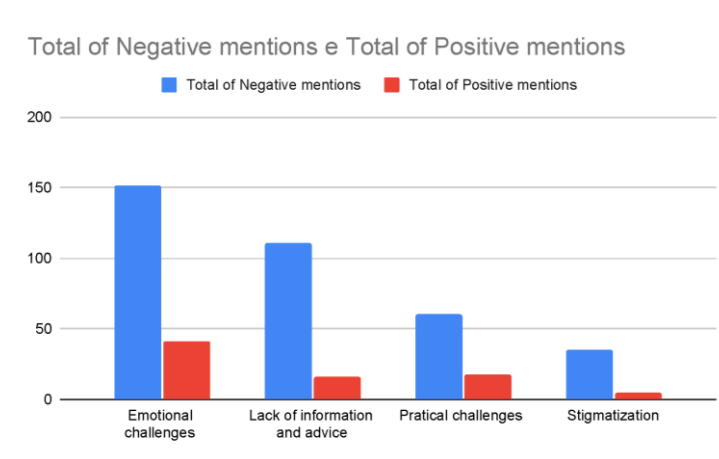


Figure 2: Summary of the main challenges experienced by informal caregivers of PLD, according to semi-structured interview data.

The outcomes of our code book analysis of the entire interview dataset are presented in the table below.

Table 5: Information about the main challenges faced by the informal caregivers interviewed (qualitative analysis)

<i>Main challenges faced by the informal caregivers interviewed</i>	<i>Negative Reference</i>	<i>Positive Reference</i>
Lack of information and advice		
Lack of information regarding about the symptoms and progression of dementia	32	7
Lack of information on how to deal with the changes in behaviour	27	1
Lack of information on how to deal with the aggression of the person with dementia	11	N/A
Lack of information on how to undertake activities with the person with dementia	10	5
Lack of information on how to adapt the home to provide better care	17	N/A
Lack of information about legal regulations and how to apply for financial support	14	3
Total	111	16
Practical challenges		
Needs assistance with the housekeeping (e.g. cleaning, repairs, garden, etc)	2	N/A
Needs assistance to undertake physically demanding activities (e.g. bathing, dressing, hygiene routine, etc)	40	8
Needs someone to look after the person with dementia now and then	18	10
Total	60	18
Emotional challenges		
Finds it difficult to balance work-life with being an informal caregiver	15	4
Loneliness	25	21
Feels emotionally overwhelmed	37	12
Constant worrying that the behaviour of the person with dementia may cause unsafe situations around the house	34	N/A

<i>Main challenges faced by the informal caregivers interviewed</i>	<i>Negative Reference</i>	<i>Positive Reference</i>
Constant worrying that health problems may occur due to the persons with dementia difficulty in communicating physical ailments	11	N/A
Cannot adequately cope with the grief over the deteriorating situation of the person with dementia.	30	4
Total	152	41
Stigmatization		
Feels stigma from society	35	5
Total	35	5

The most prominent category identified was 'Emotional Challenges,' with a total of 152 negative mentions and 41 positive mentions. Within this category, 'Feels emotionally overwhelmed' emerged as the most frequently mentioned, with 37 negative mentions and 12 positive mentions. Notably, the superior extent of data allowed us to infer that these positive mentions are associated with a sense of mission and a profound feeling of love and commitment towards the individuals these caregivers care for. *“So, this is how it is, it doesn't just happen to others. Unfortunately, it happened to me too, so I have to deal with the situation the best way I can. If I'm not here for her, she'll hardly be as well cared for by anyone else.”* Next, 'Constant worrying that the behaviour of the person with dementia may cause unsafe situations around the house' ranked second, with 34 negative mentions and no positive mentions. All participants reported experiencing various types of unsafe situations, including instances of PLD falling, leaving the house and getting lost, or leaving water and gas running. *“She would easily get lost around the house, lock herself in..., forget about open taps. So, anything that had keys, she would lock without knowing if someone was inside or not. “...the glass shattered all over the kitchen, and when I got home, she was sweeping, but she was barefoot on the glass...”* In the interviews, 'Cannot adequately cope with the grief over the deteriorating situation of the person with dementia' ranked third, with 30 negative mentions and 4 positive mentions. Notably, within this sub-category, younger caregivers expressed a greater sense of loss regarding an idealized future compared to older caregivers. *“It affected me deeply. I felt like I had a child I didn't want, never asked for, and now had an added responsibility that I never wanted to have.”*; *“But now we don't have a date for this. No, we don't know exactly when this starts, nor the middle, nor when it might end, it becomes a very big unknown, many situations that can happen, may not happen...”*; *“As I often say, being*

widowed, suddenly losing a spouse must be very hard, but being widowed every day, managing the loss, the daily grief, is also very, very difficult.”.

Following, the 'Lack of Information and Advice' category emerged with 111 negative mentions and 16 positive mentions. Within this category, 'Lack of information regarding the symptoms and progression of dementia' was the most frequently cited concern, with 32 negative mentions and 7 positive mentions. A prevalent theme among participants was the perceived lack of interest from the healthcare system in providing essential information. “Notably, positive mentions predominantly stemmed from individuals who had positive experiences obtaining training and information from associations and support groups. *“And I remember calling the Parkinson's association for the first time (...) And I felt a great empathy with someone I had never seen.*”. Close behind, is the sub-category 'Lack of information on how to deal with changes in behaviour,' with 27 negative mentions and only 1 positive mention. All participants recounted experiencing various behaviour situations, ranging from mild to aggressive. However, universally, they expressed a lack of preparedness to handle these situations at the time. *“...the most shocking memory I have is when she became very aggressive, and it was almost as if my mother had tried to attack me. It was a difficult situation.*”. The sub-category 'Lack of information on how to adapt the home to provide better care' garnered 17 negative mentions and no positive ones. Similarly, 'Lack of information about legal regulations and how to apply for financial support' received 14 negative mentions and 3 positive mentions, highlighting their significance. Moreover, due to the recent introduction of an 'informal caregiver status' in Portugal's legislation, several participants expressed concerns and dissatisfaction regarding the process and benefits associated with acquiring this status. *“...with the pilot project, it should have been better prepared than it is today.”; “...as an informal caregiver, I was expecting to have a designated nurse. But nothing, no one contacted me.”.*

The category of 'Practical challenges' yielded a total of 60 negative mentions and 18 positive ones, with the sub-category 'Needs assistance to undertake physically demanding activities (e.g., bathing, dressing, hygiene routine, etc)' accounting for 40 negative mentions and 8 positive mentions. Notably, older caregivers emphasized a greater impact within this category. Furthermore, all caregivers emphasized the beneficial outcomes of establishing a routine system, despite initial difficulties, which not only positively impacted their own well-being but also enhanced the care provided to the PLD. *“So, it would be great to have someone who could help us with feeding her, giving her a bath, and changing her diaper.”* “Needs someone to look after the person with dementia now and then” was also highlighted, with 18 negative mentions and 10 positive mentions. Participants emphasized the importance of having this need addressed to maintain their own mental health, carve out personal time for themselves, and maintain a healthy work-life balance. *“...for example, regarding my husband (...) I currently have a strong sense*

of guilt.”; “And with the understanding and goodwill of the school management, where I’ve been for 31 years, they’ve made my schedule easier...”. Finally, the category of 'Societal Stigma,' while the least mentioned, with 35 negative mentions and 5 positive ones, sheds light on a concerning reality. Many caregivers have encountered a lack of empathy and insufficient training from the healthcare system and practitioners when dealing with persons living with dementia. “Assistants and doctors are not prepared to deal with dementia cases. I refuse to leave my husband alone, anywhere, because next thing you know... If they let him leave the hospital... because physically, you look at him, and he seems fine.”; “...patients don’t have to be hidden, there’s no shame. There’s nothing wrong.”

We also explored the role of technology in the lives of informal caregivers of PLD. Every participant confirmed owning a smartphone and using it for various purposes, but not all used it to support their caregiving roles. Five participants used their smartphones or computers to search information about dementia, one also used their for-video calls with a neurologist. Younger participants relied more on technology, using smartphones to manage medication schedules, installing home surveillance cameras, and implementing tracking apps on the PLD's phone to help in case they get lost.

3.3 Limitations

In this study, some limitations should be noted. Firstly, the sample size was relatively small, consisting of only 40 participants for the questionnaire and 7 participants for the semi-structured interviews. Additionally, due to time constraints, our data analysis didn’t delve into the search and evaluation of possible correlations between variables, mainly based on the data collected from the questionnaire. Despite these limitations, the study provides valuable insights into the understanding of the lives of informal caregivers of PLD, mainly the challenges they face, from the emotional ones to the practical, their lack of information and appropriate training, and the societal stigma experienced. Future studies could benefit from a larger and more diverse sample and in-depth analysis of facts correlation.

3.4 Conclusions

In this stage, we aimed to investigate the challenges faced by informal caregivers of People Living with Dementia (PLD) and explore the potential role of technology in addressing these challenges, focusing on the Portuguese context. Through a combination of a questionnaire survey and semi-structured interviews, we gained valuable insights into

the multifaceted experiences of informal caregivers in providing care to PLD, in the context of Portugal.

Our findings not only confirmed the demographic characteristics observed in prior user research but also shed light on several key themes. Foremost among these were the emotional challenges inherent in caregiving, with caregivers grappling with feelings of overwhelm and grief as they navigated the progressive decline of the PLD. Notably, our study revealed that the age at the time of diagnosis, both for the PLD and their caregivers, exerted a profound influence on the level of disruption experienced in their lives and their outlook on the future.

Practical challenges, such as the necessity for assistance with physically demanding activities, emerged as another prevalent issue among participants. This burden was particularly pronounced among older caregivers, who grappled not only with their advancing age but also with declining health. Additionally, caregivers consistently highlighted the significant barrier posed by a lack of information and advice, underscoring the critical need for enhanced support and resources in this regard.

A notable revelation from our study was the experience of Societal Stigma, a category that had not been extensively documented in prior literature. This finding underscores the persistent lack of awareness and societal support for individuals living with dementia and their caregivers in Portugal, highlighting the urgent need for broader societal engagement and education initiatives, starting with healthcare practitioners.

The role of technology in caregiving emerged as a promising area, particularly among younger participants who exhibited a greater reliance on digital solutions. From managing medication schedules to implementing home surveillance systems, technology offered innovative ways to support caregivers in their daily responsibilities.

However, our study also had its limitations. The relatively small sample size and the lack of correlation analysis between variables warrants further investigation.

Moving forward, future research should aim to address the limitations of our study by incorporating larger and more diverse samples and conducting in-depth correlation analyses. By doing so, we can further enhance our understanding of the complex dynamics of informal caregiving and develop more targeted interventions to support caregivers and improve the quality of care for PLD.

In conclusion, our study sheds light on the intricate dynamics of informal caregiving for PLD in Portugal, emphasizing the pressing need for targeted interventions and enhanced support systems. By addressing the emotional, practical, and societal challenges faced by caregivers, we can strive towards a more compassionate and inclusive approach to dementia care.

4. User research: explore stage

After evaluating the results obtained from our user research instruments, we progressed to the next stage of our research: the development of key deliverables. These deliverables were instrumental in translating our research data into actionable insights, guiding design decisions, and ensuring that the final product meets the users' needs and expectations.

Our process began with the creation of user personas, which represent the different user types interacting with our product (Cooper, 2004; Nielsen, 2013). For each persona, we identified the most relevant situations, needs, and goals, allowing us to pinpoint specific user requirements. This analysis culminated in the formulation of several user stories, which were essential for defining the system requirements of our Minimum Viable Product (MVP). Before designing the initial drafts of our application, we conducted a thorough task analysis for each user story to ensure comprehensive understanding and effective implementation.

Below is a detailed description of each stage in our user research exploration process.

4.1 User personas

As coined by Alan Cooper, "personas" stem from a simple concept but are a highly effective and sophisticated tool for achieving good interaction design (Cooper, 2004). Personas are not real people; they are descriptions of imaginary users. These users don't exist as specific individuals, but their descriptions are crafted in a way that makes them seem realistic to the reader. This realism is not simply fabricated; instead, personas are constructed with significant rigor and precision based on relevant information gathered from potential and actual users during the investigation process. They are rooted in knowledge about real people (Cooper, 2004). In our study, the creation of our personas was directly based on the results of our questionnaires and semi-structured interviews.

Having these established personas helps all project participants to not only share a unified understanding of who the end-users are but also to identify with them and consider their needs instead of their own. According to Nielsen (2013) this helps to potentially avoid bias in product development. Knowing the personas also fosters empathy with the users, as it puts project participants in the personas' shoes, providing insight into their desires, how they will use the product (whether it is digital or non-digital), and an idea of the future situations or contexts in which it will be used (Nielsen, 2013). The development of personas introduced various concepts like user archetypes, user models, lifestyle snapshots, and model users. However, there is no singular approach to applying the method, nor is there an exact definition of what should be included in a persona description (Interaction Design Foundation, 2024a).

Our initial step in creating personas was to carefully select the appropriate methodology and content for the profiles. Given our study's dedication to a user-centred approach and our prior establishment of emotional design principles in our framework, understanding the user's emotional context and prevailing situations became paramount. This knowledge was essential for effectively implementing the principles of emotion regulation and conversational guidelines during the interaction stage. In line with these considerations, we opted to closely follow the "10 Steps to Personas" framework devised by Lene Nielsen and detailed in her book, "Personas - User Focused Design." (Nielsen, 2013). We were drawn to this framework for its strong emphasis on user-centricity, its comprehensive guidance in persona development, and most of all, for its focus on empathy and emotional resonance (Nielsen, 2013).

The 10 Steps to Personas model consist of four main parts: (1) Data collection and analysis; (2) Persona descriptions; (3) Scenarios for problem and idea development; and (4) Organizational acceptance and design team involvement. Each part comprises several steps. However, not all projects need to follow every step. In our study, for instance, we did not include the steps from part four (Nielsen, 2013).

The first part of the process encompasses the initial two steps: 'Collection of data' and 'Forming a hypothesis.' With our data already collected and analysed, we began by developing a general understanding of the various users within our focus area. This involved examining demographic profiles and correlating this information with the primary challenges they faced. We found that our sample had a prominent demographic of women, but within this group, there were two distinct age ranges that exhibited significant differences in their approaches to the same challenges. Additionally, our slightly smaller male sample revealed important aspects regarding their emotional responses to various challenges. Based on these insights, we decided to define three main user personas. Each persona was closely aligned with a specific stage of dementia, the most common types of dementia, and the differing experiences of being an informal caregiver for a PLD at a younger age and at an older age. With this definition, we

completed Step 4: “Establishing a number” and proceeded to Step 5 “You describe the personas”.

In the process of describing our three personas, we adopted "The Engaging Perspective" proposed by Nielsen, which emphasizes the importance of storytelling in making personas relatable and engaging. This approach aims to avoid automated, stereotypical persona creation that fails to resonate with designers and project participants. By bridging the gap between abstract data and tangible user experiences, storytelling enhances the design process. Nielsen's method draws parallels to character development in film scripts. For a persona description to be compelling, it should include a physiological dimension, which helps create a collective visual representation of the persona; a sociological dimension, providing an explicit understanding of the persona's social background; and a psychological dimension, focusing on the persona's inner psychological characteristics and emotional relationship with the focus area and other characters. Moreover, the writing style of the persona description significantly impacts how easily the reader can remember the story. According to Bruner (1990), although bullet lists may be easier to write, a well-narrated description is more effective at embedding the story in memory. Narrated descriptions create a more memorable and engaging character than abstract lists (Bruner, 1990).

With these principles in mind, we began by defining distinct attributes for our personas. We assigned names and ages and presented visual representations through carefully selected photos. These images serve a dual purpose: they support the information, helping it resurface when the image is seen, and they suggest that the persona might be a real person. The images, as seen in Figure 3, were chosen to convey specific postures, age ranges, and environments that effectively reflect their social backgrounds (Nielsen, 2013).

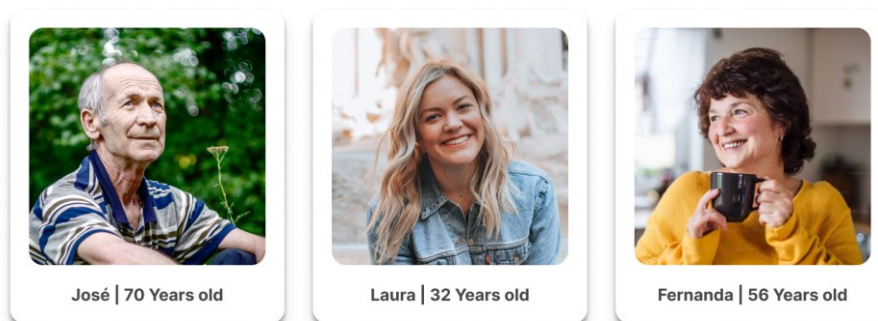


Figure 3: Photos, names and age range of each persona.

Next, we developed a comprehensive social background for each persona. This was essential for designers and project participants to grasp how each persona would behave in different contexts and their attitudes toward our digital health application. We detailed

their personal relationships with spouses and children, educational levels, and current job roles. For our study, it was also important to understand their geographic location within Portugal, the type of residence they lived in, and their specific hobbies and interests. To gain insight into each persona's psyche and understand their mindset, we created an emotional profile for each persona. This profile was closely related to our focus area, emphasizing their emotional attitudes toward their roles as informal caregivers. To add realism, we included a specific quote for each persona that encapsulated their profile. It is important to recognize that while these profiles highlight specific psychological characteristics, individuals may experience contradictory feelings in certain situations, revealing different aspects of their emotional landscape. With our personas fully defined, we then presented their relationships and everyday lives within the focus area. We divided this focus area into two main stages: the initial stage of dementia diagnosis and the beginning of the persona's role as an informal caregiver, and the more advanced stage, representing their current daily life. This division allowed us to understand the progression and evolution of caregiving responsibilities for each persona. For each stage, we outlined various challenges and needs, which were then used to create a set of situational scenarios. As we focus on developing a digital product, it was necessary to provide context on how our personas relate to technology and their level of expertise with media usage. We closely linked this information to our focus area, highlighting the role technology plays in their caregiving responsibilities. Finally, considering that informal caregiving can be a solitary responsibility, we also included details about each persona's influencers and close relationships. This information is crucial to understand whom they might seek for help, support, and sharing responsibilities. Figure 4 provides a detailed description of one of our personas. The complete set of personas can be found in [Annex D](#).

User research: explore stage

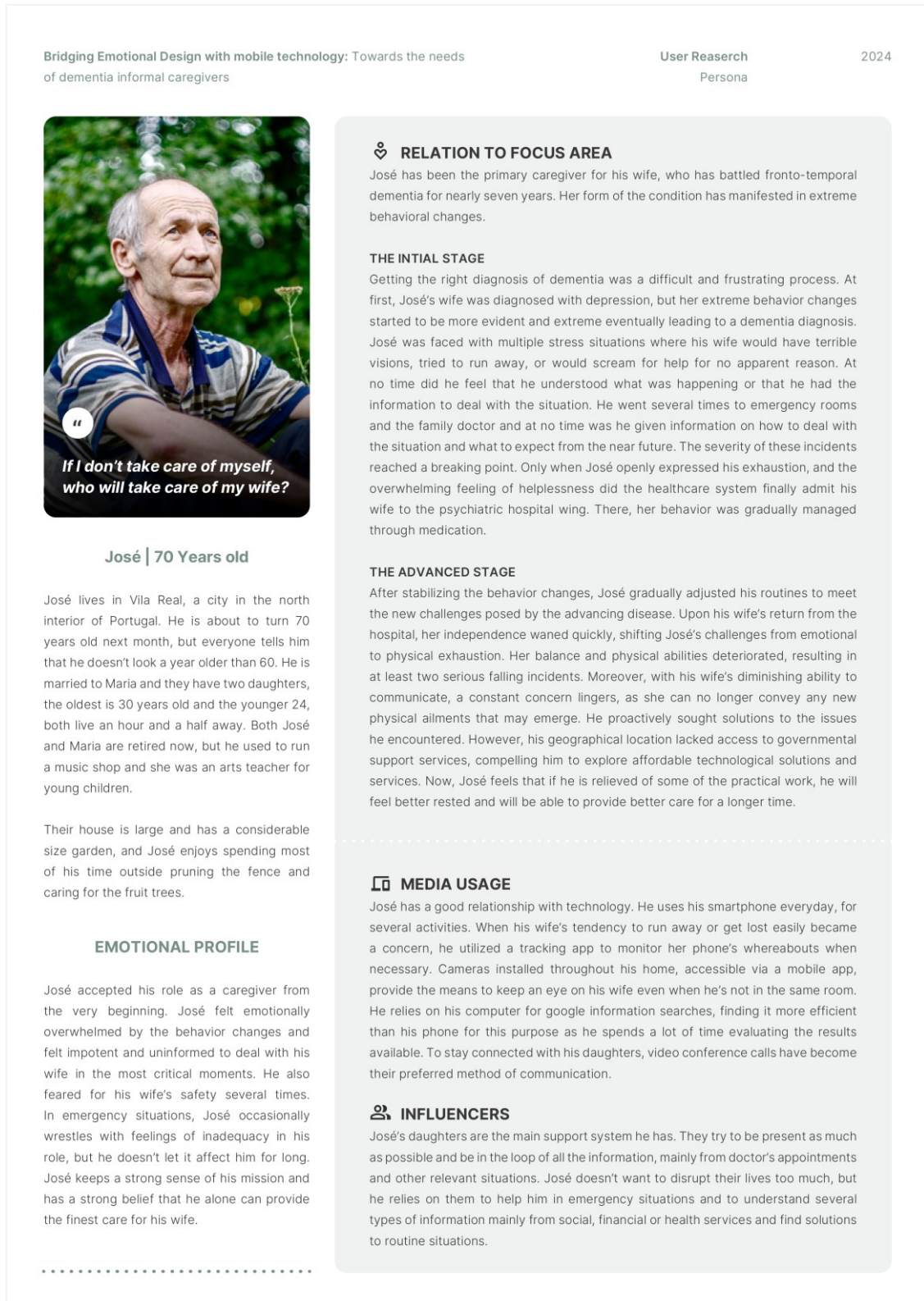


Figure 4: Full description of the user persona “José”

4.2 Situations, scenarios and goals

With our personas well established, we proceeded to Step 6, "Situations." Nielsen defines situations as the context in which the product will be used. From a given situation, numerous user interactions and actions can result. This is when our personas transition from static characters to active participants in a scenario. In each, the persona will try to fulfil a specific goal, driving the plot forward, this makes the persona description more flexible and open to several paths (Nielsen, 2013).

Nielsen also distinguishes between the use of situations in product design and IT systems development. In product design, which is the focus of our study, the goal of using situations and scenarios is to generate ideas for a new product rather than to describe interactions with an existing system. In this context, the situation serves to depict a part of the user's everyday life and triggers a corresponding scenario that inspires and facilitates the development of new product ideas (Nielsen, 2013).

In our process, we first pinpointed the necessary situations based on each persona description. We paid particular attention to their personal relationships with the focus area, which led us to define separate situations for the initial stage of the dementia diagnosis and the more advanced stage of the disease. For each situation, we also defined specific goals.

To help us ideate the necessary requirements for our product we proceeded to Step 9 "Scenario", where we developed each situation into a detailed, story-like narrative. According to Brunner, "We tend to understand our experiences, the social world that surrounds us, and our daily routines as meaningful stories organized as narratives." In these scenarios, each persona acts upon a given situation and tries to fulfil their goals with the tools they have available. This approach helped us understand not only the evolution of their emotional disposition through the scenario development but also how they use the technology at their disposal. Additionally, it allowed us to identify the difficulties and obstacles they may face and how their interactions with influencer parties might impact the resolution of the scenario and the fulfilment of the main goal. All scenarios were written based on knowledge of the users from our data collection, and my own experiences with people and situations like what we describe.

[Table 13](#), comprising all situations, goals and scenarios written, can be consulted in [Annex E](#). With this final step we concluded the construction of the necessary instruments to guide the requirements of our Digital Health solution.

4.3 User stories and task analysis

Having detailed information from the process of creating our personas and scenarios significantly improved the efficiency and effectiveness with which we developed our user

stories and ideated the features of our solution. User stories are concise statements about a feature written from the perspective of a user. They are goal-oriented and do not specify a solution, serving instead to guide the team in devising the most optimal solution to address the user problem. From the analysis and ideation based on a user story, the corresponding features are derived.

Although there is no standard format for creating user stories, the Interaction Design Foundation presents the following format as the most common: "As a [user], I want [goal or action] so that [outcome or reason]." (Interaction Design Foundation, 2024b). This format helps ensure that each user story is focused on the user's needs and the desired outcomes, facilitating the development of effective and user-centred features. Based on this format, we translated all the previously constructed knowledge into a set of user stories. Some were specific to a persona, while others served multiple persona profiles. To address the main categories of challenges identified in our user research—lack of information and advice, lack of practical support, lack of emotional support, and societal stigma—we constructed an affinity map.

This diagram in Figure 5 allowed us to visualize the distribution of our user stories across each challenge category. We found that our user stories were most prominent in the cluster addressing the lack of information and advice, followed by practical support. Although it initially seemed we were lacking in addressing emotional support—the most prominent category in our user research data—we inferred that addressing several practical necessities also alleviated the overall emotional burden. Additionally, we concluded that the more informed and connected to a supportive community our informal caregivers are, the more supported and capable they feel.

Regarding societal stigma, we believe that our solution can help address this issue indirectly. By raising awareness, providing education, fostering support networks, and promoting positive narratives, we aim to create a more understanding and supportive environment for caregivers.

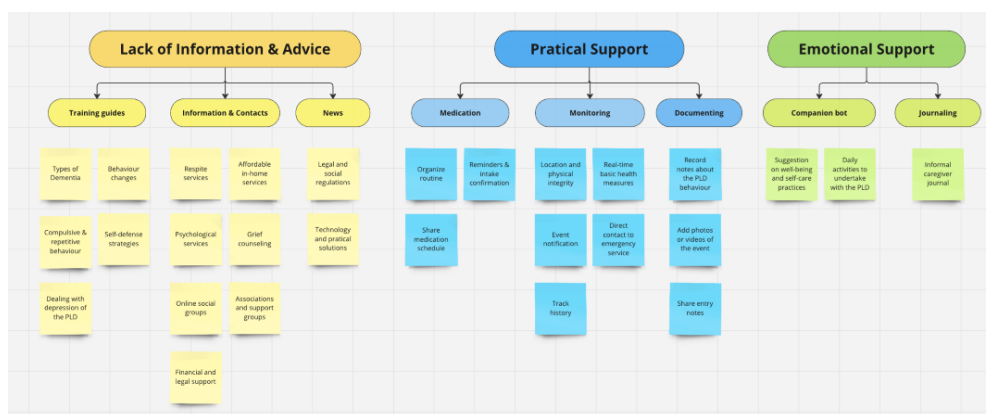


Figure 5: Affinity map demonstrating the distribution of user stories according to the categories of the main challenges.

During this process, we also addressed the necessity of finding the most suitable wearable device to support the monitoring features derived from our user stories. These features address a situation that is inevitable in the progress of dementia disease. As the condition advances, PLD experience a significant decline in their ability to communicate and express their needs, eventually reaching a point where they are unable to engage at all. Our user research findings reveal that the progression of dementia not only intensifies the emotional burden on informal caregivers but also leads to significant practical concerns. Caregivers frequently worry about missing underlying health issues until they escalate into emergencies. Some caregivers have sought solutions, as exemplified by one of our user personas profiles: “Laura”, which can be consulted in [Annex D](#). Laura’s mother uses a device developed by the Red Cross¹ that functions as a bracelet or necklace with an alarm button, allowing her to summon assistance in emergencies. While this device offers some reassurance, it has limitations. It requires the user to proactively activate the alarm, which is not feasible for individuals in the more advanced stages of dementia who may be unable to operate such devices. This highlights the need for a more comprehensive solution that can continuously monitor health and automatically alert caregivers to potential issues, ensuring timely intervention without relying on the PLD’s ability to act.

To address these concerns, we focused on finding a device that could provide caregivers with the necessary tools to monitor and manage health issues proactively. This device would be worn by the PLD and would transmit vital information to the mobile app used by the informal caregiver. By ensuring timely intervention, this feature aims to alleviate caregiver anxiety and reduce the risk of emergencies. The most common and widely accessible wearable devices, such as Google’s FitBit², though affordable, do not cover all the monitoring measures we deemed important. Consequently, we explored more advanced solutions, regardless of their affordability and wide availability. In our research, the EmbracePlus³ wearable from Empatica⁴, an MIT spin-off focused on offering continuous and unobtrusive monitoring solutions for people with neurological conditions, stood out. This device covers all necessary biomarkers, such as electrodermal activity, which helps us assess the stress level of the person being cared for, as well as heart rate, respiratory rate, skin temperature, and blood oxygen saturation. Furthermore, it can detect fall events, as it includes an accelerometer and gyroscope that capture raw acceleration and angular velocity data. This device has been widely and successfully tested in several research studies across diverse fields, consistently demonstrating reliable and positive results in patient monitoring (Ba & Hu, 2023; Gerboni et al., 2023). We

¹ <https://www.cruzvermelha.pt/saúde/âmbito-nacional/teleassistência.html>

² <https://www.fitbit.com/global/us/home>

³ <https://www.empatica.com/en-eu/embraceplus/>

⁴ <https://www.empatica.com/en-eu/company/>

anticipate that in the near future, wearable devices like the EmbracePlus will become more accessible to the general population.

With a clearer vision of the features for our digital health solution, we transitioned from user stories to constructing a task analysis. A task analysis involves creating a task flow that outlines the user's journey from start to finish in solving a problem. The primary goal of this process is to keep tasks simple and ensure the journey includes only the necessary steps, making the process as straightforward and efficient as possible (Interaction Design Foundation, 2024e). [Table 14](#), available for reference in [Annex F](#), showcases all user stories aligned with their respective persona profiles and corresponding task analysis.

5. Prototype development

5.1 Sitemap and sketching on paper

With all the necessary written content defined, we proceeded to take pen and paper in hand and start designing our prototype. Our first step was to draft, first on paper and then on Figma—a sitemap, which is essentially a visual organization of our application's content and structure. Sitemaps help us identify gaps, prioritize content, and foster a cohesive design that users can easily navigate by presenting a clear and logical flow (Interaction Design Foundation, 2024c).

When creating our sitemap, we aimed to identify the core screens, such as the PLD dashboard, user profiles, settings, and other main content sections. Establishing hierarchies was crucial to defining the relationships between screens, indicating parent and child views to show how users will navigate through the app. By prioritizing content, we ensured that the most important information is easily accessible, while maintaining consistency in structure to avoid confusion and ensure a seamless user experience.

Our sitemap in Figure 6 wasn't static; from its creation, it underwent iterations and refinements based on the prototype's evolution, which is necessary for continuously improving the user experience. A well-defined sitemap serves as a foundational tool for the design process, guiding the development of wireframes and the overall user interface (Interaction Design Foundation, 2024c).

Prototype development

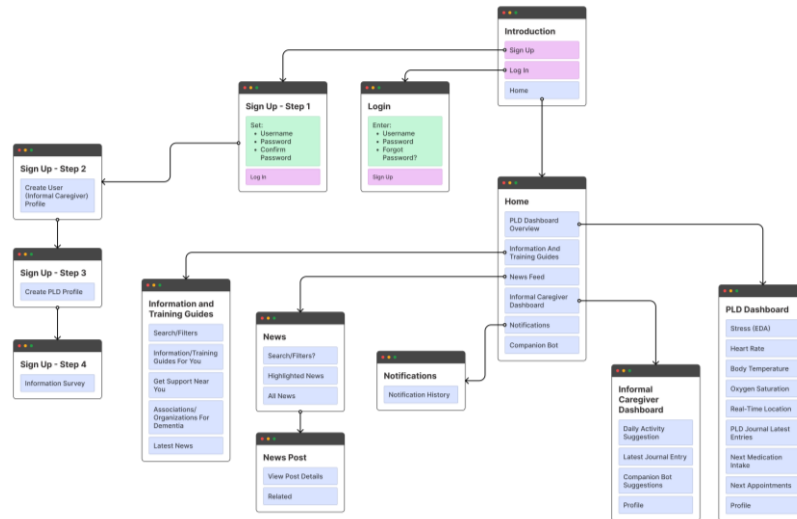


Figure 6: Initial draft of our sitemap.

With an overview of the main areas of our application set, we began sketching each flow screen individually on paper. This process allowed us to quickly test various ideas about which components to add and how they would fit together. We didn't focus solely on the visual aspects but also considered some text content, naming of sections, and types of animations or graphics to use. These considerations were added as notes for further development in the design process, as shown in Figure 7. As our user research focused on the experiences of Portuguese informal caregivers and some of the app features were designed to provide services available in Portugal, all written content for the app was drafted in Portuguese from the outset. Since we were advocating for an affordable solution, we focused on designing our app specifically for smartphones running on the Android system. From the beginning, we referenced the latest version of Google's Material Design system to ensure our Android mobile app would comply with familiar behaviours for Android users (Google, 2024b). This provided us with a solid knowledge base, enabling us to work faster and focus on customizing our unique features. Additionally, during the sketching process we examined several applications that had already devised solutions for features similar to ours. For example, we looked at the app Medisafe⁵, specialized in medication management, the Flo⁶ app, for menstruation and pill management, the Google Fit⁷ app, for tracking physical activity and the Google Keep⁸ app, for notes.

⁵ <https://www.medisafe.com/download-medisafe-app/>

⁶ <https://flo.health/>

⁷ <https://www.google.com/fit/>

⁸ <https://keep.google.com/>

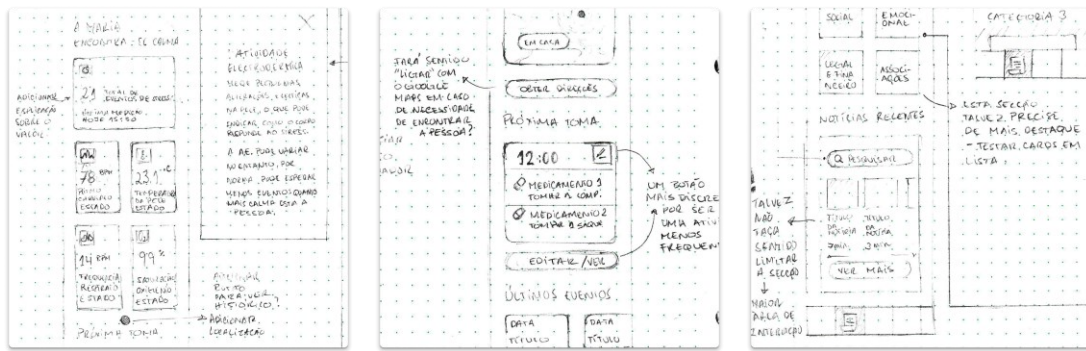


Figure 7: Snippets from paper sketches featuring various types of annotations.

We then used our [Designing for Emotion framework](#) to guide our decisions from paper sketches to the final high-fidelity prototype in Figma. The first step was to look to our Aesthetic principles and guidelines to help us define desired personality traits, as depicted in Figure 8. Given our application's purpose of supporting informal caregivers by providing information, training, and advice, we aimed to convey a friendly personality. However, the app also needed to guide caregivers in potential emergency situations, requiring a balance between dominance and submission.

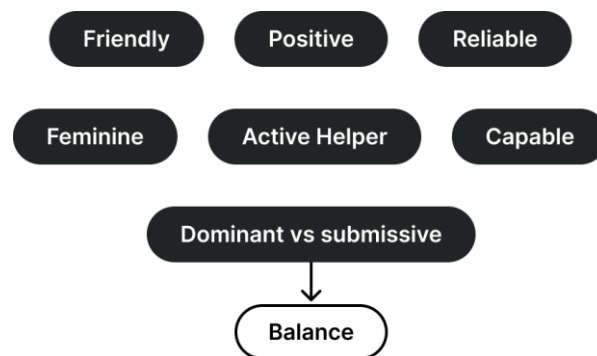


Figure 8: Concept cloud regarding our principles and guidelines for the process of designing for emotion

In the initial paper sketches, we focused on establishing the main forms, aiming to balance hard and rounded shapes. We opted for predominantly rounded shapes but needed to carefully balance their roundness and softness. We decided on fully round buttons, which we could later counterbalance with high-contrast colours. Additionally, we added less rounded corners to components like cards and text fields to achieve the desired feeling.

Next, we considered our Interaction principles. While defining the complete flow of interaction, we ensured the app provided necessary information tailored to users' preferences and timely feedback at each step to make them feel empowered and capable

Prototype development

of achieving their goals. A major example of this approach was creating a friendly app presentation flow and enhancing the standard "Register" process. We used this step to immediately create profiles for the informal caregiver and the PLD, and tailor the content displayed by the app, accordingly, as shown in Figure 9. This required asking for more information than usual during registration, so we had to clearly communicate that this information would enhance their experience. This was crucial for instilling a sense of trust in users from the beginning, which could be confirmed and strengthened through continued use of the app, aligning with our [principles of Commitment](#).

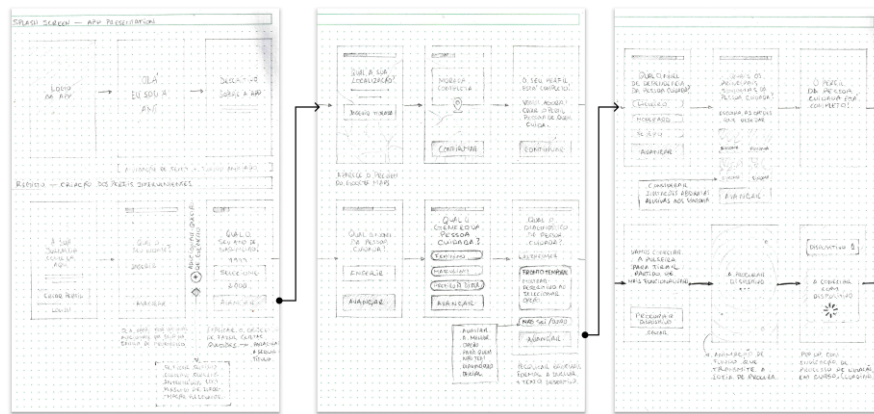


Figure 9: Paper sketches outlining the profile creation workflow

We also focused on presenting all information with clear sources and ensuring technical information was understandable, with an option to learn more if needed. For all components, as depicted in Figure 10, we specified gesture interactions and ensured that all navigation areas were appropriately sized. The complete set of sketches are available for consultation in [Annex G](#).

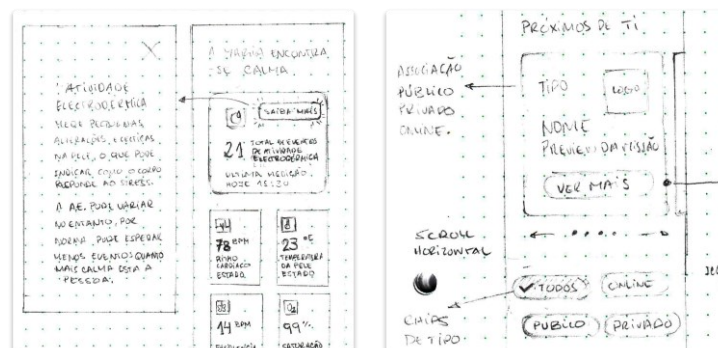


Figure 10: Snippets from paper sketches featuring notes on information type and gesture interactions

5.2 From low to mid-fidelity wireframes and interaction

With all ideas clearly outlined on paper, we proceeded to Figma⁹, a collaborative design tool specializing in product design, design systems, and prototyping. We began by establishing the screen size we would be using; since our solution was for Android phones, we selected the current most common size—the Android large, with 360 pixels width by 800 pixels height. This decision allowed us to establish standard specifications regarding layout, including setting the outer content margins at 16 pixels and defining the main grids for our content display. We implemented grids of one, two, and three columns and created a specific four-column grid for primary content in horizontal scroll, ensuring consistency in margin and gutter size, as shown in Figure 11.



Figure 11: Established layout grids

Next, we created the main components of our design system based on the established container proportions and grids. As depicted in Figure 12, we started with essential structural elements such as buttons, input fields, the top bar, the menu bar, list items, the search bar, and content placeholders for icons, images, and other types of content. The construction of these elements, primarily focused on proportion and interaction states, was heavily influenced by the Google Material Design System.

⁹ <https://www.figma.com/>

Prototype development

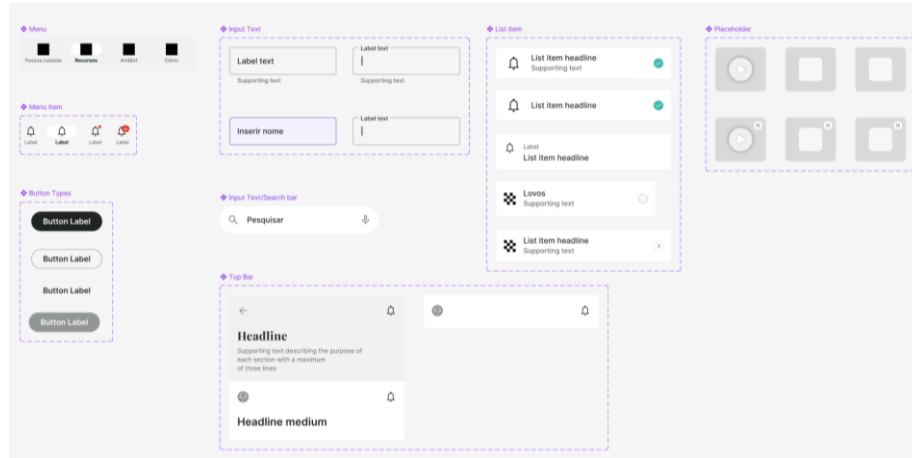


Figure 12: First set of components designed in Figma

Another crucial factor we decided early in the process was the typography. Although this decision could be adjusted later, we wanted a clear understanding of element sizes and spacing from the outset, so we took time to explore various options. To keep our solution affordable, we opted for a free and open-source font. We turned to the Google Fonts web service¹⁰, which offers a reliable and diverse set of font families. We specifically looked for sans-serif font families with a wide range of weights to meet our various needs. Sans-serif fonts, lacking the decorative strokes of serif fonts, are preferred for digital applications due to their superior clarity and readability on screens across different resolutions (Dogusoy et al., 2016). With their modern and minimalist design, these fonts are well-suited for body text in digital formats, reducing cognitive load and making it easier for users to process information (Adobe, 2024). We chose the font Inter, as shown in Figure 13, which is widely used in these contexts, for two main reasons. First, its shape is more pronounced in height than in width, which aids readability, especially in mixed and lower-case text. Second, its overall letter format is well-balanced between rounded and hard shapes, helping us maintain the personality traits established in Figure 8 and achieve the desired balance between dominance and submission.

¹⁰ <https://fonts.google.com/>

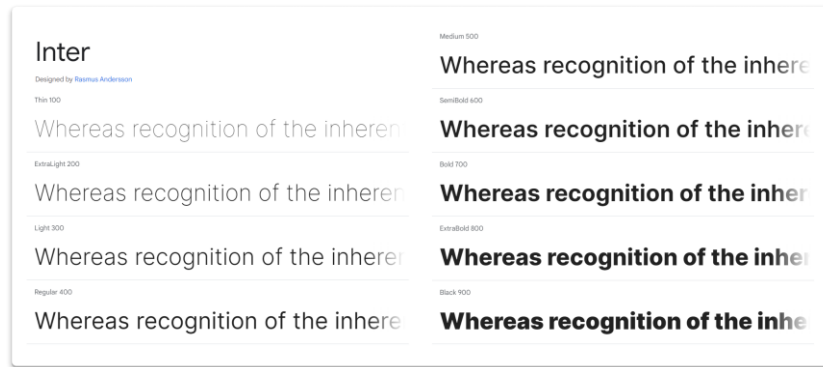


Figure 13: Inter font type styles

In addition to selecting the appropriate font, we prioritized contrast, particularly between background and foreground elements. To keep the process efficient and ensure we maintained the right contrast without getting distracted by colour preferences, we initially used a neutral palette that could be easily adjusted later. Both fonts and colours were managed by creating styles in Figma, a feature that allows for seamless updates without needing to modify each component individually. This not only expedited the design process but also facilitated quick testing.

With the main components ready, we proceeded to assemble each screen. During this process, we paid special attention to the hierarchy of all UI elements and their appropriate grouping. We also added all textual content and most of the icons, focusing mainly on those related to system interactions, such as menu, back arrow, close, notification, share, add, and others. For icon selection, we once again utilized the open-source material from Google. This extensive library covers icons for a wide variety of concepts, from system icons to healthcare and other categories, and allows for customization regarding style, size, weight, and colour (Google, 2024c). We opted for an outline style, as it combines both rounded corners and hard endings with a medium weight, keeping it in line with the aesthetic guidelines of our other components. Below, we highlight the main structural design decisions for each section of our Android application.

Application presentation and Registering process

Following our interaction principles, we treated the interaction between our product and the user as a conversation. Our first step was to present the application to the user. According to our interaction guidelines for conversation, we adhered to social rules of etiquette by attributing a name to our application and initiating the first interaction with a greeting, followed by a brief introduction to the core objective of the app. The content at this stage was primarily textual, as shown in Figure 14. To ensure the first and most important content stood out, we used larger and bolder text, and centred the text group on the screen to achieve optimal focus and white space symmetry.

Prototype development

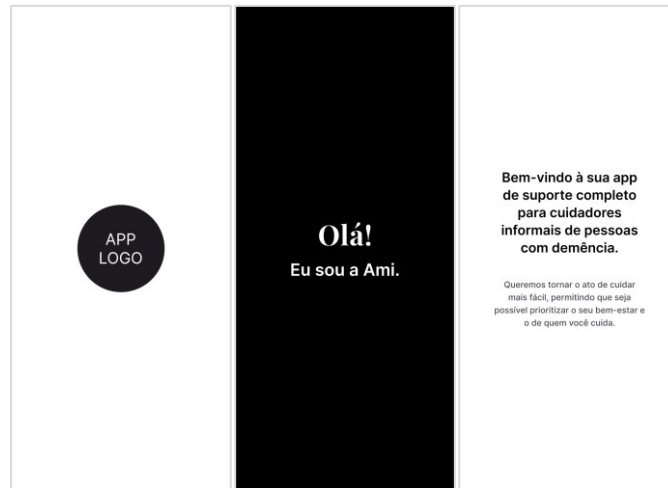


Figure 14: Mid-fidelity: App presentation main screens

Next, it was time for the user to introduce themselves to the app, so we followed the app presentation with the profile creation process for informal caregivers and PLD. To guide the user, we clearly indicated what the next step would be. Each profile creation step followed a consistent structure: a progress bar at the top of the screen to show the user their progress, and a button at the bottom to proceed to the next step. Vertically aligned between these elements, we displayed the question and the corresponding interactive content. For questions that required sensitive information, such as the informal caregiver's address, we included explanatory text below the question, as illustrated in Figure 15. This text informed the user about the necessity of the information and how it would enhance and personalize their experience within the app. Ensuring that the user understands how the app system uses their personal information is crucial for establishing trust from the first interaction.

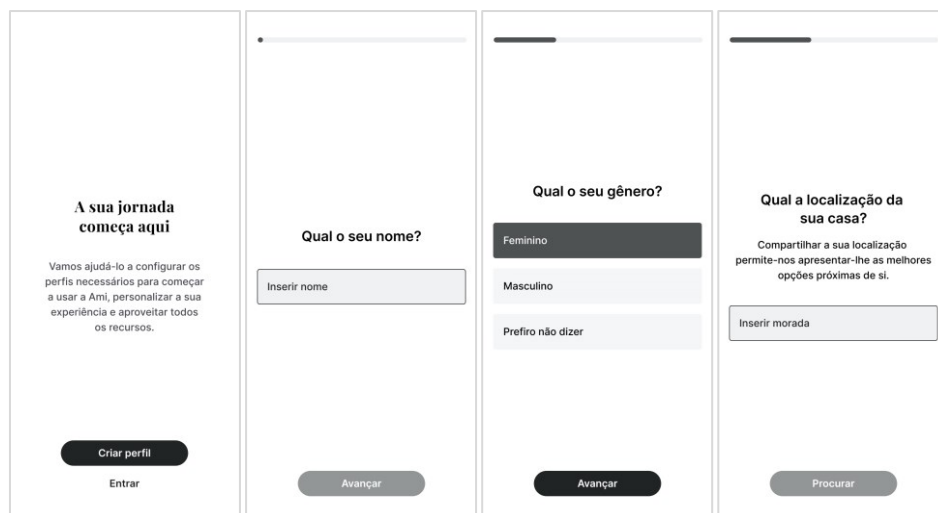


Figure 15: Mid-fidelity: Informal caregiver profile creation main screens

The creation of the PLD profile followed the same structure outlined previously, with additional considerations for two specific situations as highlighted in Figure 16. First, when asking the user to select the type of diagnosis for the PLD, we included descriptions for each option, providing adequate and useful content as indicated by our conversation guidelines. This allowed users to briefly learn about the various types of dementia, helping them assess their own situation and, for some, come to terms with the official diagnosis. Difficulty in accepting the diagnosis and their new life situation was an issue frequently mentioned in the interviews conducted during our user research. Furthermore, it informed those without an official diagnosis, preparing them to seek one from the healthcare system. Second, when asking the user to select the main symptoms displayed by the PLD, we allowed them to choose all relevant options. This indicated our understanding, based on our user research, that each case of PLD has its own specificities and that we are ready to cater to their individual experiences. This section was crucial for creating an initial mental model connection to the content displayed afterwards in the Resources section of the app.

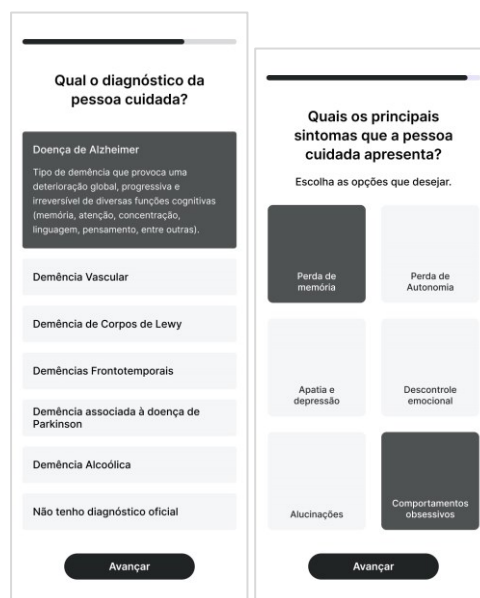


Figure 16: Mid-fidelity: PLD profile creation main screens

Dashboard of the Person Living with Dementia and related areas

The dashboard of the PLD is the main section of our app, designed to be the most frequently used area daily. Here, we have consolidated all features related to monitoring the PLD using data from the EmbracePlus smartband, managing medication prescriptions, and recording important events related to the PLD.

In terms of hierarchy, we first present the current emotional and physical status of the PLD, as shown in Figure 17. To provide a clear understanding of the overall well-

being of the PLD, the top bar title summarizes the status in a sentence, directly addressing the PLD by name to add a personal touch. This is followed by a brief description of the section's purpose, so the user knows what to expect without needing to scroll through the entire section.

Next, we present the biometrics obtained from the smartband. We created two main sections by grouping the information cards. At the top, spanning two columns of the grid, we display data on electrodermal activity (EDA), which indicates the number of stress events experienced by the PLD over time, reflecting their emotional status. Since EDA data can be unfamiliar to many users, we included a small, outlined button that opens a pop-up with a description of what EDA is and how to interpret the data.

The second cluster of information presents four different metrics: heart rate, skin temperature, respiratory frequency, and oxygen saturation. These metrics are generally more familiar, but to ensure clarity, we added status labels to each, indicating levels such as normal, slightly elevated, slightly low, elevated, and low. This helps users relate the numbers to a specific status.

Additionally, we created a history section for this biometric information, accessible via a button at the end of the first feature cluster. This button uses an outline style for medium impact, as accessing this section is not intended to be a daily action and should not visually compete with the information on the biometric cards.

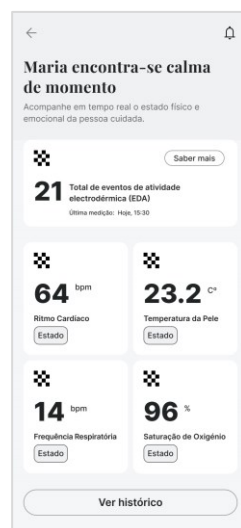


Figure 17: Mid-fidelity: PLD dashboard biometric section

The history section, depicted in Figure 18, consolidates all metric data and presents them in graphs for the current day, week, and month. At the top bar, there is a button to return to the dashboard, the name of the section, and a brief description of its purpose. Below a segmented button, offers three interactions: day, week, and month. The body of this section comprises a graph for each metric, displayed in the same order as on the

dashboard. The graphs are designed to present a simplified version of the data due to the size limitations of a mobile screen. We opted to use the median value for each hour of the day, each day of the week, and each week of the month. To assist less experienced users in understanding the data, each graph includes a brief statement at the top indicating any relevant events, such as significant increases or decreases in values compared to the previous period. Considering the interaction process as a conversation, it is important that the product continuously presents dynamic content that aligns with the user's situation and specificities. At the bottom of the screen, coupled to the menu bar, we added a FAB (Floating Action Button) for sharing the full history report with a third party, such as a family doctor (Google, 2024a). Given the technical nature of this information, we wanted this button to stand out to promote the sharing of this data. The availability of this option was crucial to address a deficiency identified in our literature review: the lack of features dedicated to coordinating caregiving efforts. Additionally, providing this information to health practitioners fosters a more reliable and well-informed relationship among all parties, as they are no longer solely dependent on the informal caregiver's observations.

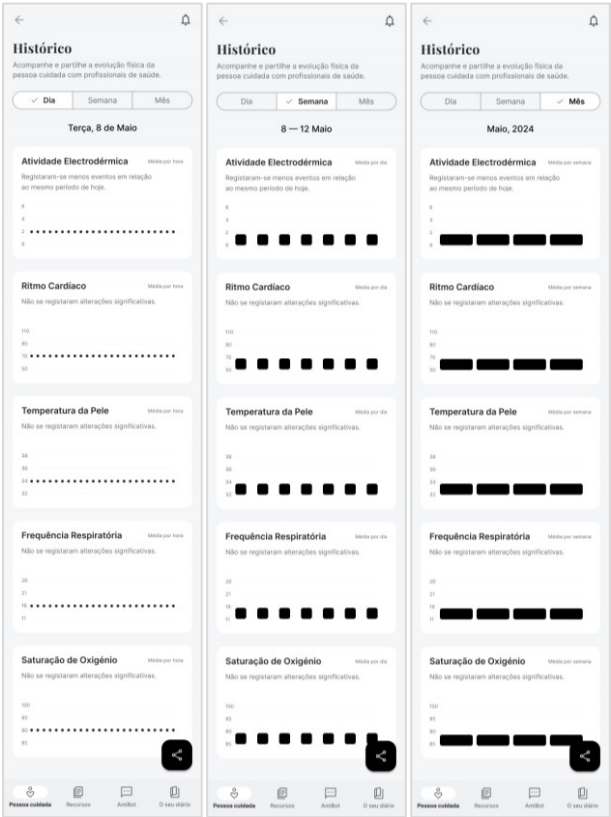


Figure 18: Mid-fidelity: Historic overview of biometric data screens

The next section on the PLD Dashboard is dedicated to presenting the current location of the PLD. It's quite common for individuals with different types of dementia to get lost or wander far from their caregiver or home. With two connected devices, we

can track their individual location (Brown et al., 2019). To display this information, we included a section where the user can see the PLD's current location on a map, see Figure 19. During the profile creation process, we established the home address of the informal caregiver and the PLD, allowing us to present a tag like "Home" if the current location is recognized. Given that the system updates this information at specific intervals, we wanted to ensure the data was available but with minimal visual impact. In case the PLD wanders off alone and the caregiver needs to find them, we added an outlined, medium-impact button just below the map card. This button launches the Google Maps app and provides directions to the PLD's location.



Figure 19: Mid-fidelity: PLD dashboard current location section

Next, as shown in Figure 20, we presented a medication prescription section where users can view the details of the next medication intake. The most crucial information, the time of intake, was prominently displayed by increasing its size, emphasizing the importance of adhering to the prescribed schedule. Below the time, we listed the medications to be taken, including the medication type icon, name, and dosage. Given that medication schedules typically remain stable over extended periods, we used a low-impact icon button for editing, placed near the intake time. This button leads the user to the comprehensive medication area, where various actions can be performed. This section features the same type of top-bar information as the history section. At the top of the main content area, a day-by-week navigation allows interaction by tapping arrows on either side or by using side scroll. Below, users can see all the medication intakes for the day, ordered by time. Additionally, users can confirm medication intake by tapping individual medications or marking all at once. To expedite this task, we used a medium impact, outlined style small button for the latter option.

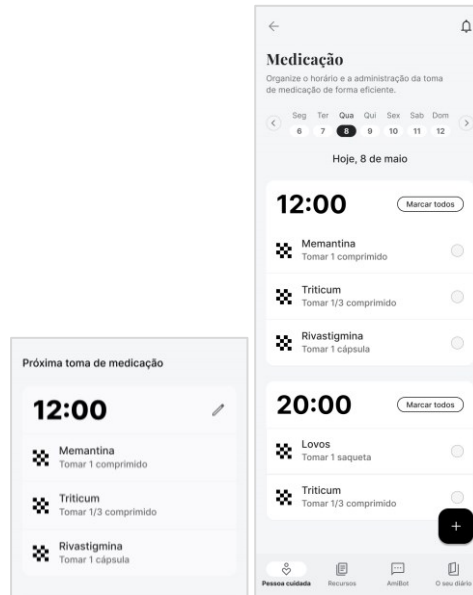


Figure 20: Mid-fidelity: PLD dashboard Medication intake section and Medication prescription schedule screen

Beyond tracking medication history, this section also enables users to add new medications if necessary and share the prescription schedule with third parties, such as family members. Given the importance of these actions, we included a FAB button in the bottom menu bar. In this case, an extended version with both an icon and text label help users understand the main option, supported by a small FAB for sharing the full prescription (Google, 2024a). The process of adding a new medication, see Figure 21, followed the same structural design principles as the profile creation, ensuring coherence and familiarity in user behaviour. The textual content was specifically adapted to suit the purpose of each step in adding a new medication. This process was heavily inspired by the one used in the Medisafe application; however, we simplified some options, retaining only the essentials, as our application focuses on more than just the medication aspect.

Prototype development

Figure 21: Mid-fidelity: Medication prescription and “add new medication” screens

All areas that comprise the body of our PLD dashboard are separated by low-contrast, horizontal solid lines. This design choice helps to clearly delineate the different purposes of each section, enhances readability, and helps users quickly identify and navigate distinct areas of content. This approach also contributes to a more organized and aesthetically pleasing interface, which is particularly important in applications that present a variety of information and features (Interaction Design Foundation, n.d.). We would replicate this design decision across several areas of the full application.

The last section of our PLD dashboard, illustrated in Figure 22, displays the most recent registered events related to the PLD. These events can be added by the informal caregiver as needed or automatically by the system in two specific cases: significant disruptions in biometric data and fall events. The purpose of this section is to allow the informal caregiver to maintain a record of important events concerning the PLD's emotional and physical well-being, which can later be used for discussions with healthcare practitioners or other involved parties. To present this information in the dashboard, we display the most recent events as a series of small information cards

arranged in a row, which can be fully accessed via side scroll. Each card shows the date of the event in all caps and a smaller, lighter font to distinguish it from the title, which appears second in a bigger and bolder style, maintaining proper hierarchy despite the date appearing first. Below the cards, there is quick access to add a new event using the same outlined style and medium-impact buttons as before.

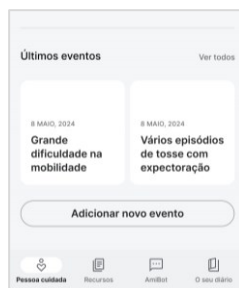


Figure 22: Mid-fidelity: Registered events related to the PLD section

By clicking on a small, low-impact button labelled “View All” located next to the title section, users can access a comprehensive view of all events, as shown on Figure 23. This area is structured similarly to the medication prescription area discussed previously. The top bar provides information to help users orient themselves within the app and allows them to return to the dashboard. This is followed by day-by-week navigation, consistent with previous sections. The body content features significant design changes, consisting of a set of information cards presented from bottom to top, with older events at the bottom and the most recent at the top. Each card provides a summary of the event's full content. The event tag helps differentiate between user-created and system-generated events, reinforced by specific icons to be defined. The event title and description are previewed, with the title differentiated by a larger font size and bolder weight. Below, in smaller text matching the description's weight, we include the time and date of entry. Icons next to the time entry indicate if the event includes biometric information or multimedia content. To visually reinforce the chronology of events occurring on the same day, we added a dashed vertical line connecting all the cards. Using this type of line to connect diary entry cards serves several purposes: it indicates chronological flow, separates entries, tracks progress, and establishes a hierarchy of information. This approach creates a visual connection between related entries while maintaining clarity and organization, which is particularly useful for users tracking multiple events or entries over time (Understanding Graphics, 2024).



Figure 23: Mid-fidelity: View all events registered related to the PLD screen

To highlight the most important action on this screen, we opted to use a FAB (Floating Action Button) to enable the addition of a new event. The date of the event will be automatically set according to the day selected on the initial screen.

As illustrated on Figure 24, the process of adding a new event follows a similar approach to Google Keep for creating notes. By clicking on the displayed placeholder text, which is designed to guide and inform the user about what to add in each section, the keyboard will appear, allowing the user to directly replace the placeholder information with their own content. Additionally, we included the option to add a custom label, biometric information at the time of entry creation, and additional multimedia content. For these options, we used medium-impact buttons with icons and labels to provide a more visual representation of each button's purpose. At the end of the content entry fields there is a high impact filled button for the user to finalize the adding event operation.

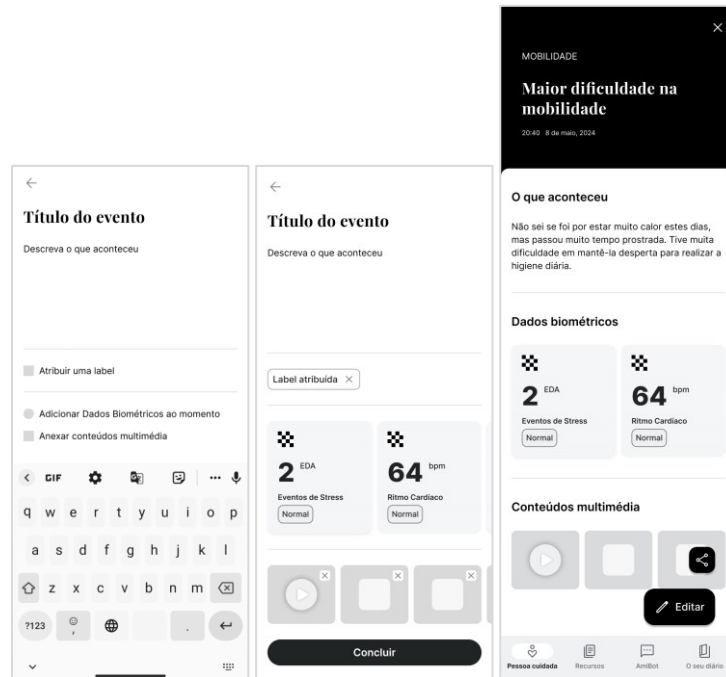


Figure 24: Mid-fidelity: Create new event related to the PLD screens

Once the event is created, the user can visualize its content, edit it if necessary, and share it with third parties. The event details screen is designed to be consistent with other information display screens, ensuring coherence and familiarity. At the top of the screen, we display the label in all caps using a smaller, lightweight font style, followed by the event title in a larger, bolder style with a smaller note indicating the hour and date below. This alignment mirrors the approach used in the cards available on the “View All Events” screen. To highlight this information, we chose a high contrast between the text and a dark background. Next, we present the full description of the event, followed by biometric data cards displayed in a row that can be fully viewed with a side scroll interaction. The preview of the added multimedia content is presented similarly to the biometric data. Low-impact solid lines are placed between these types of information to ensure clear visual distinction of areas. This information group is placed over a lighter shape with rounded corners that covers most of the screen, creating an overlap with the dark background of the first information group. This layering effect emphasizes the importance of the detailed event information and creates a sense of depth. The most important interactions the user can perform on this screen are editing and sharing the event entry. For these actions, we used a FAB button with a label for the edit option and a small FAB for the sharing option. To exit the Event Details screen, we used a close button in the top right corner, differentiating this type of screen from others.

Resources and related areas

The Resources area, as shown in Figure 25, is the second-largest section of our app, providing users with access to a library of relevant and reliable information on various

topics such as types of dementia, managing specific symptoms, finding available support options, and keeping up with the latest news in the field of informal caregiving for PLD. One of our main objectives for this section was to reflect the information gathered during the registration process, ensuring that the most relevant information is presented first. For instance, if the user indicated in the PLD profile that the person was diagnosed with Alzheimer's, content related to Alzheimer's would be prioritized, keeping in line with our Interaction guideline of Conversation.

To achieve this, we structured the main section carefully. At the top bar, following the title, we explain the purpose of this section, like other screens. Immediately below, we present the most relevant information to the user's case, highlighted by directly referencing the user in the subtitle "Practical Guides for You." To emphasize the importance of this information, we created a row of larger cards, fully accessible via side scroll, with high contrast between the card background and the information.

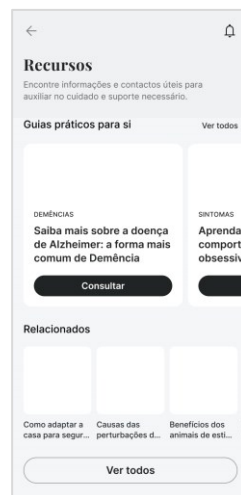


Figure 25: Mid-fidelity: Practical guide's section

The information on these cards follows the same approach as previous designs, featuring a label to indicate the main type of information, followed by the title and a high impact filled button to access the details of the practical guide. Below the main cards, we included a "Related" section, presenting other practical guides that may be of interest. This row of cards is smaller, fitting three fully visible cards on the screen, displayed in a side-scrollable row. Due to their smaller size, the design of each card was adapted to include an image at the top, followed by a preview of the title. This cluster also includes an option to access a screen with the full view of practical guides, using an outlined style, medium-impact button as previously done.

When interacting with the "View All" button, the user accesses a comprehensive screen displaying all practical guides available, as shown in Figure 26. As this screen may contain a large amount of information, potentially creating extensive scrolling, we

grouped the information cards by their labels to facilitate finding the required information. Each set of rows is differentiated by its label, established as a subtitle. Rows of high-priority design cards are fully accessible through side-scrolling or by clicking the "View All" small button situated on the opposite side of the subtitle, which will rearrange the cards into a full vertical list.

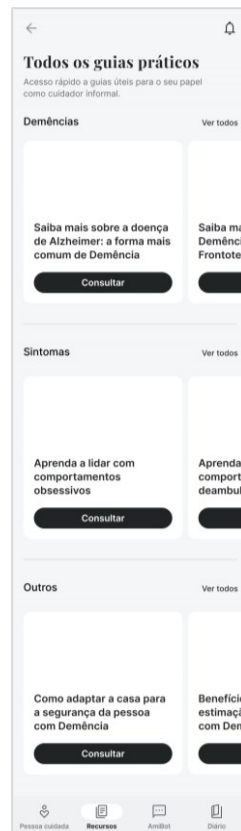


Figure 26: Mid-fidelity: Practical guide's view all screen

When consulting a practical guide, the user will encounter a design structure like that of the Event Details screen. The main changes focus on establishing a clear hierarchy of textual content for easy and quick comprehension, as illustrated in Figure 27. At the top, we present the guide's label to indicate the main theme, followed by the title, an overview of the guide, and the source of the information. Displaying the content source prominently helps foster a continuous sense of trust with the app.

The guide is then broken down into a series of steps. For example, if the guide is about training an informal caregiver to manage a specific behaviour or symptom, it first explains the main causes that can lead to that behaviour or symptom. Then, it provides a step-by-step guide on how the caregiver should address or manage the situation. The first step is to remind the caregiver to seek expert support. Next, it emphasizes that the symptoms or behaviour are beyond the PLD's control. Finally, it presents a set of

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strategies to help the caregiver handle the situation. These three steps are presented in expandable cards, avoiding the need for long scrolling and allowing the user to quickly scan the main content and delve deeper into areas they find most necessary.

Below these steps, we present a set of multimedia contents related to the guide, offering the user various forms of training and helping them learn in the way that suits them best. Providing well-defined content that is factual, relevant, and tailored to the user's context is a key application of our [Conversation guideline](#).

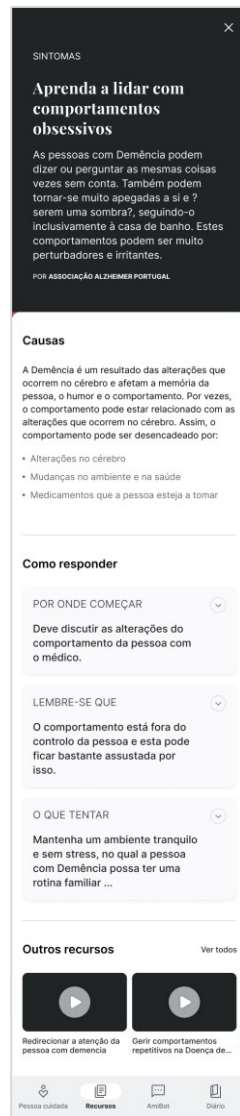


Figure 27: Mid-fidelity: Practical guide details screen

The second section of our Resources main screen is dedicated to presenting the available support options for the user, as shown in Figure 28. To emphasize this, we directly reference the user in the section titled "Support for You." We divided the support options into the most common forms identified in our user research: Associations,

Emotional Support, Social or Practical Support, and Legal Support. To differentiate this section from the previous card designs and enhance its distinctiveness, we used horizontal cards spanning the full column grid, featuring a dark background to contrast with the title, descriptive text, and icon button that allows the user to access the full view of each specific type of support available.



Figure 28: Mid-fidelity: Available support section

Upon entering this comprehensive support screen, as shown in Figure 29, the user encounters the familiar title and description format. Below, there is a high-impact row of cards designed similarly to those on the Guides screen, with the notable addition of the support entity's icon in the top right corner of each card. This section again presents information tailored to the user's specific case by using their home address to display the nearest available support, reinforcing this with the section title, "Support near You". After a dividing line, we provide the user with a set of filtering options to help them sort through the available support services. The filter chips are based on the main types of support we identified during content integration, such as public, online, private, and non-profit. By interacting with these chips, the user can see the vertical row of cards updated to reflect the selected filters. When interacting with the card for a specific support option, the user will again encounter a detail screen like the one previously presented. As depicted in Figure 29, the main changes are focused on adding the full logo of the support service between the label and title of the support on the top section of the screen and in the body the addition of the services available, which were designed as low impact cards and configured in a two column grid that comprise an icon to reinforce the service title and a small description. After a divider we present the full listing of contacts for the support in question, from the phone number, to email, website and address.

Prototype development

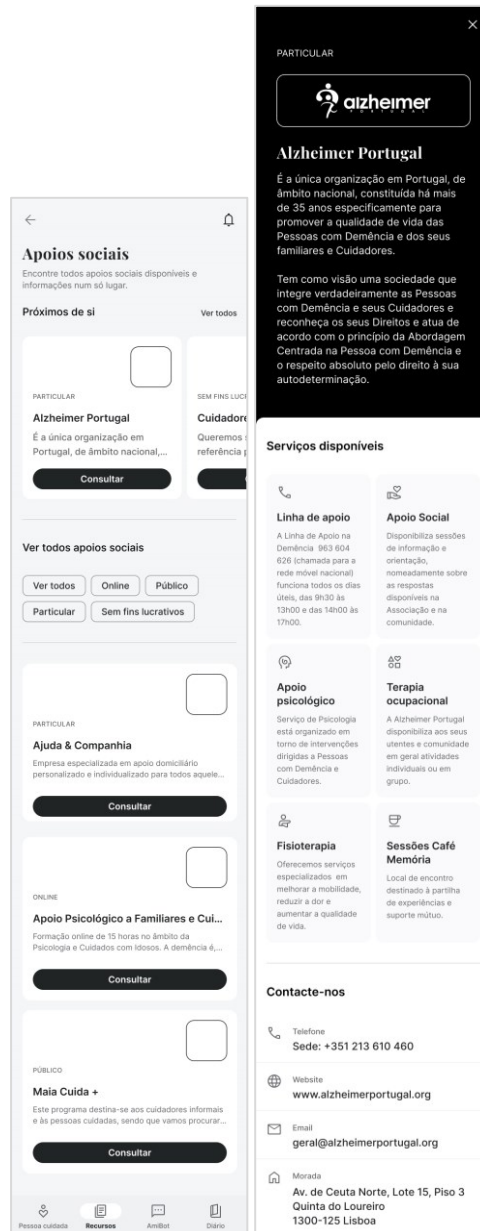


Figure 29: Mid-fidelity: View all “X support” options and details screen

Upon returning to the main Resources screen, the user will find the final section at the bottom as depicted in Figure 30, dedicated to the latest news. This is a low-impact section, so we used a row of small cards with the same design and interaction style as the related practical guides. Following this row, a button like the one used for practical guides allows the user to access the "View All News" screen.

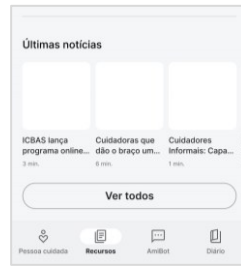


Figure 30: Mid-fidelity: Latest news section

The "View All News" screen as shown in Figure 31, presents a different approach from the previous sections. Given the potential volume of information, we first provide the user with a search option to find the most relevant news. We designed horizontal cards to fit more information on the screen. These cards are based on a three-column grid, featuring an image on the left spanning the full height of the card and covering one-third of its width. The textual content occupies the remaining two-thirds on the right, comprising a label, a preview of the news title, followed by reading time and date. The design of these cards follows the same principles as the event cards.

Users can open the news by tapping the full card, which directs them to the news details screen. This screen has a more editorial approach compared to the others. Drawing inspiration from news applications, we maintained a light, even background, increased the size of the title and headline paragraph, and ensured the source was prominently displayed in bold. We also added images throughout the text, spanning the entire screen with rounded corners. The distinction between paragraphs is maintained by adding space between them, ensuring ample white space to enhance readability, especially for longer articles. To close the details' view, we used the same approach as in other screens, with a close button in the top right corner.

Prototype development

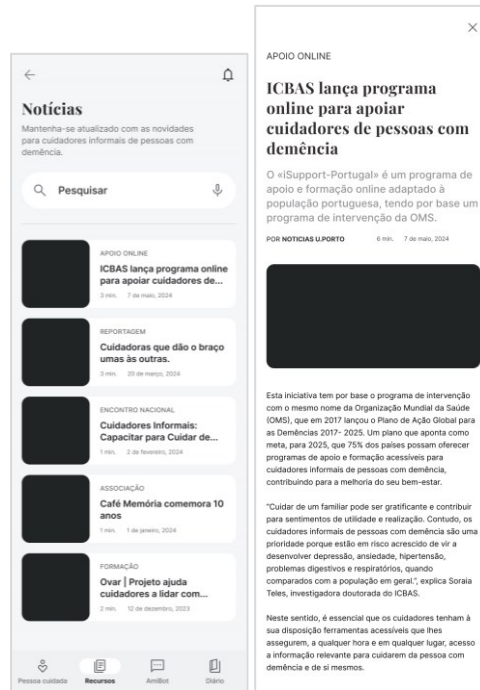


Figure 31: Mid-fidelity: View all news and details screen

Chatbot area

This section of the app behaves distinctly from the others, as illustrated in Figure 32, aiming to foster a conversational interaction. The feature is designed to provide various suggestions to the user, such as activities to undertake with the PLD or ways to enhance the informal caregiver's well-being. We used an aesthetic inspired by chatbot messaging pop-up screens. When selecting this menu option, an integrated pop-up screen appears over the most recently opened screen. The pop-up, designed with rounded corners for a friendly appearance, fits the displayed content in height and uses a dark background to differentiate the interaction planes. The content within the pop-up is placed in rounded light shapes to mimic speech bubbles and ensure adequate contrast.

The initial content displayed includes an icon indicating the app as the first participant, followed by a greeting to adhere to our [Etiquette guidelines](#), and then a title and description asking or suggesting something to the user. When the app poses a question to the user, usually to establish an emotional context, a set of option fields with different answers will be displayed for the user to select, below the main question speech bubble. When the app provides a suggestion based on the user's response, it includes a small illustration to visually reinforce the activity, followed by a title summarizing the suggestion and a description of the activity. It is important to present this content positively, highlighting the potential benefits to encourage the user to engage in the activity.



Figure 32: Mid-fidelity: Chatbot dialog screens

We plan for this bot to activate not only when interacted with but also after a period of inactivity upon the user entering the app. Gathering feedback from the user about these interactions is crucial—whether the suggestions are relevant, whether the bot is activated too frequently, etc.—and using this feedback to tailor the bot's occurrences is essential for maintaining credibility and demonstrating that user feedback is valued and considered for continuous improvement. This section can be closed at any time by pressing the close button in the top right corner.

Informal Caregiver Diary

This is the last main section of our application, tailored to the emotional needs of the informal caregiver. While this section maintains a similar structure and flow of interaction to the PLD event registration as shown in Figure 33, it was important to ensure coherence and familiarity while providing enough differentiation to avoid confusion.

We positioned this section at the furthest point from the PLD dashboard on the menu and labelled it specifically for the informal caregiver, establishing it as a journal rather than an event registration section with the title "O Seu Diário." Upon accessing the main diary screen, the textual information is tailored to focus on the informal caregiver, emphasizing the benefits of journaling for their emotional well-being.

When creating a journal entry, the placeholder text and available options for adding extra content are simplified, leaving only the possibilities to add a label and multimedia content. We have deferred some final decisions regarding further customization of this section to the high-fidelity stage.

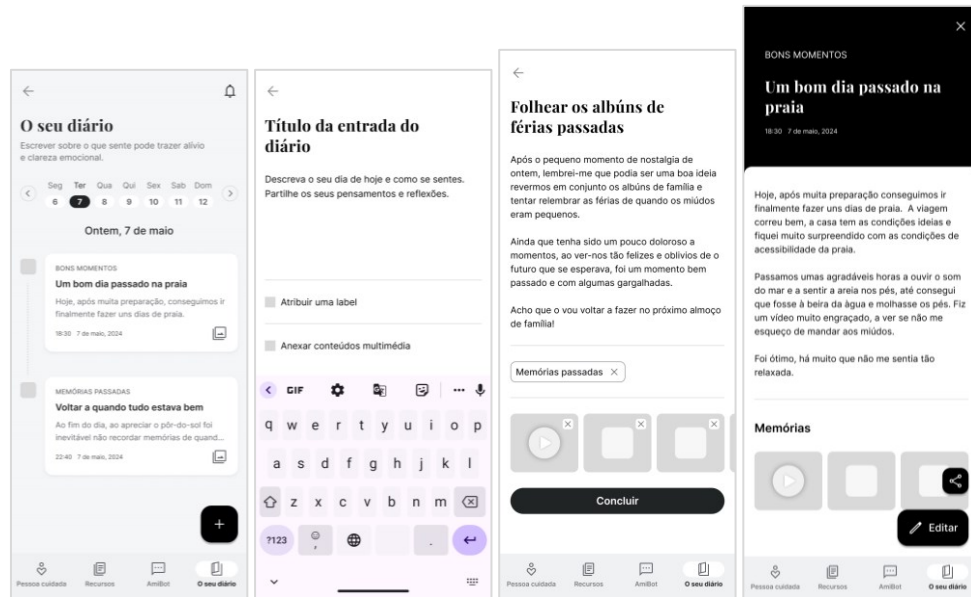


Figure 33: Mid-fidelity: Informal caregiver diary section

Disruption of the vital signs and fall notifications

These two screens function as the main notifications from the application to the user, demanding full attention due to their indication of possible emergency scenarios. Our design decisions aim to instil a higher sense of dominance to effectively guide the user through the information. These notifications cover the entire screen as a pop-up and can only be closed by the user after they have fully scrolled through the event details, as depicted in Figure 34. The pop-up maintains the rounded corners applied to other sections and features a light background.

To enhance the dominance of the text content, we start with a small icon at the top to highlight the type of occurrence, providing a visual cue that complements the event description. This is followed by the word "Attention" in a larger, bolder style to convey urgency, accompanied by a summary description of the event. Smaller, lighter text then guides the user to the next step: checking the biofeedback from the smartband, which includes emotional and practical information. The user can view the current cards from the PLD dashboard for a quick assessment of the physical and stress levels data.

Following this, smaller text indicates the next step, advising the user to evaluate the situation near the PLD and assess their decision options to avoid unnecessary emergency calls. At the end of the pop-up, two buttons are displayed: a primary filled high-impact button to call emergency services, and a low-impact text button below it to close the notification.

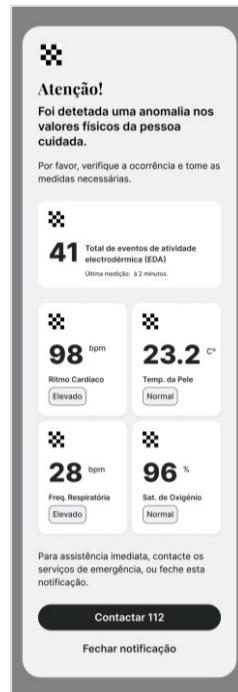


Figure 34: Mid-fidelity: Event notification screen

When these events occur, they are automatically registered in the event section of the PLD dashboard to maintain a record.

Other screens

In addition to the main screens, we designed two more screens, as shown in Figure 35, that we felt were necessary for the prototype of our MVP. The first is the sidebar navigation, which allows the user to access options that are not frequently used, such as the informal caregiver and PLD profiles, smartband and overall application settings and support options. We constructed this screen following the Google Material Design guidelines to ensure the user found this interaction familiar and intuitive.

The second screen is the application notification history. This screen allows the user to consult all types of notifications, from those connected to the PLD to those related to system functionality, such as low battery alerts for the smartband. This screen is based on a cluster of listing items divided by the time of the notification occurrence. Each list item includes an icon to provide a visual cue, along with the title and a small description.

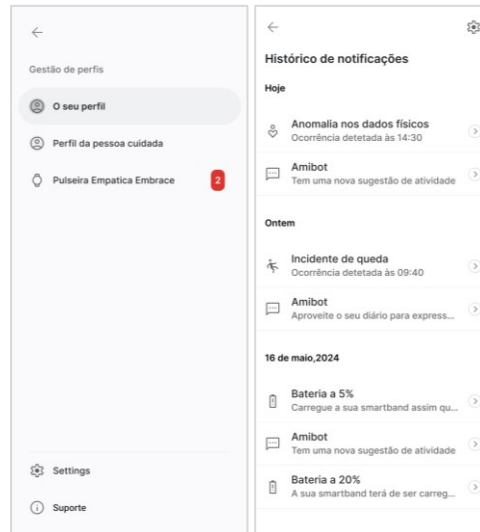


Figure 35: Mid-fidelity: Navigation drawer and system notifications history screens

By adding these screens, we aimed to enhance the overall user experience for our testing sessions and ensure that all necessary functionalities were accessible.

Prototyping

With all our screens structured and the final content applied, we created the prototype connections. Using the Figma tool, we provided the main interactions between screens. This included selecting the type of interaction, such as whether it occurs after a delay, on tap, or on drag, specifying the duration of interactions when applicable, and choosing animation types for screen transitions. This was particularly effective for implementing slide-in or slide-out animations for side navigation and other specific components. Additionally, we configured the scroll behaviour.

Completing this step at this stage of the design was crucial. It allowed us to ensure that we hadn't missed any interaction steps, to test each flow ourselves, and to correct any problems. This process helped us refine the user experience and confirm the seamless functionality of our design.

5.3 High-fidelity and final interactions

After incorporating all necessary screens with the final textual content and structured design, we implemented our final design decisions to transform our medium-fidelity prototype into a high-fidelity one. These decisions focused primarily on establishing our colour profile, making final typography adjustments, and selecting appropriate iconography. We also chose types of images, ranging from illustrations to photographic elements, and defined textures and elevation elements, such as shadows. These components were crucial for reinforcing our previous decisions and establishing the

complete personality of our product. The complete set of high-fidelity screens and the link to the final prototype can be found in [Annex H](#).

Colour

As outlined in our aesthetics guidelines for colour, the association of colours with specific concepts must be handled carefully, as these associations can vary among cultures. Since our focus is on the context of Portugal, we felt comfortable exploring the connections between colours and concepts related to informal caregiving and healthcare within Western culture. This cultural context allows us to make informed decisions that resonate well with our target audience. Through some research, we confirmed assumptions regarding the associations of various colours in the context of healthcare, caregiving and dementia (Color Psychology, 2024; Interaction Design Foundation, 2024d).

Blue is associated with calmness, trust, and reliability, making it a popular choice in visual identities for healthcare products and entities like the World Health Organization (WHO) (Interaction Design Foundation, 2024d). Green is linked to nature, health, and tranquillity and is most recognized through its association with pharmacy symbols and the Portuguese green cross medical service (Interaction Design Foundation, 2024d). Yellow represents positivity, optimism, and energy and is often used in contexts related to mood improvement, vitality, and emotional well-being (Interaction Design Foundation, 2024d). Pink conveys warmth, compassion, and nurturing, evoking feelings of care and support (Interaction Design Foundation, 2024d). Purple is specifically associated with dementia awareness, as seen in the branding of organizations like the Alzheimer's Association. It symbolizes compassion, wisdom, dignity, and respect for those affected by the condition (Interaction Design Foundation, 2024d).

From the initial sketches on paper and our preliminary research into mobile applications for informal caregiving of PLD, we knew we wanted to explore a more creative and distinctive visual approach for this prototype. Therefore, we decided to integrate all the previously mentioned colours, including a new addition—red—instead of opting for just one. This choice, as shown in Figure 36, enabled us to create a dynamic and visually engaging design. However, it also posed some challenges, particularly in achieving a sense of recognition and maintaining a balance between dominant and subtle elements within the app.

Prototype development

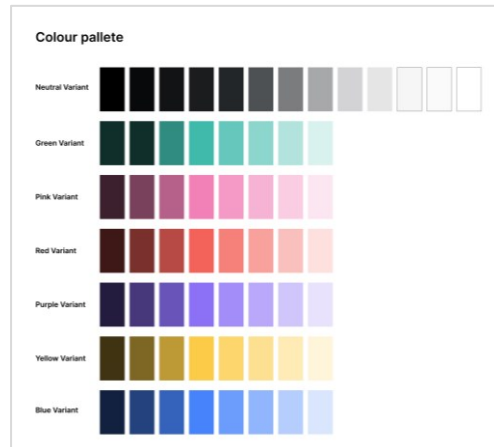


Figure 36: Final colour palette choices

We addressed these challenges by strategically allocating colours to specific components, such as cards, illustrations, and certain icons while maintaining a neutral palette for the rest of the interface. Backgrounds predominantly featured light shades, while buttons and typography varied between black and grey to achieve the desired impact. Despite employing a diverse colour palette, we designated purple and its various shades as our primary accent colour. This hue was predominantly utilized in areas with less content as shown in Figure 37, such as the profile creation, medication addition processes, and the chatbot section. Additionally, we used purple to differentiate the informal caregiver journaling section of the app from the PLD event section.

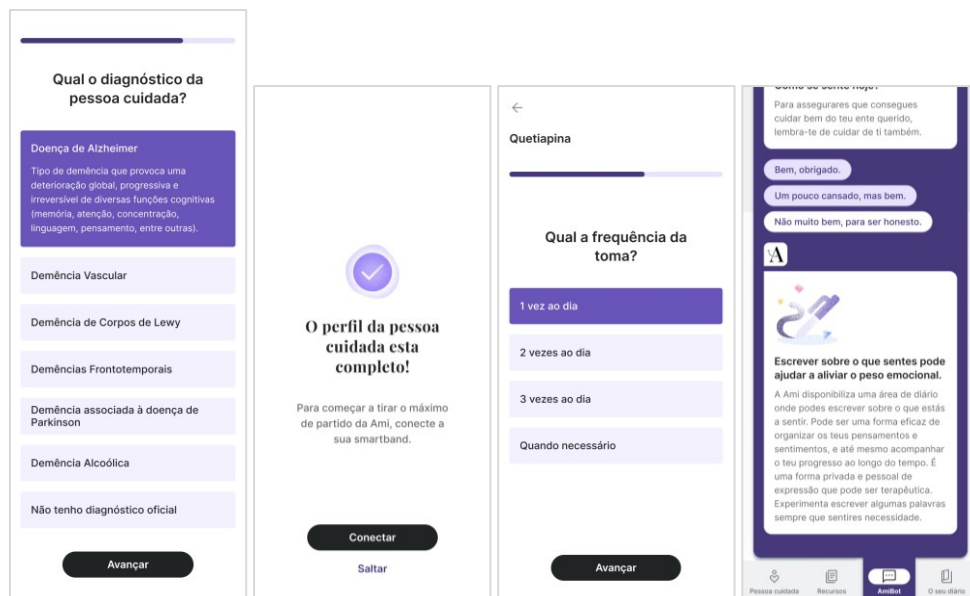


Figure 37: High-fidelity: Screens where purple was used as a predominant colour

Another significant colour-related decision pertained to the biometric information cards, which displayed data from the smartband and were featured across the PLD dashboard and event notifications. To clearly indicate the status of each value, we introduced red to our colour palette. Following an adapted traffic light approach as illustrated in Figure 38, we assigned colours to signify different statuses: green for normal, yellow for slightly elevated, red for elevated, and blue for low.

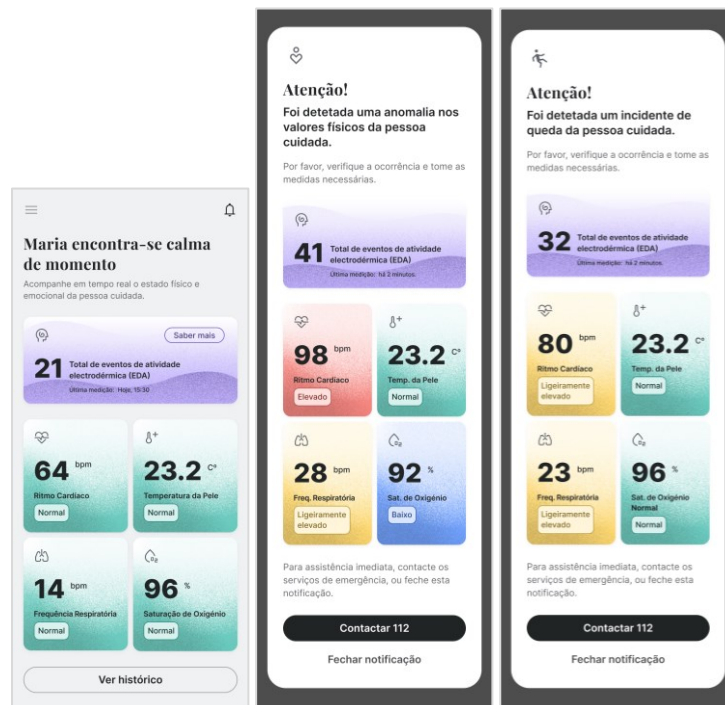


Figure 38: High-fidelity: “Traffic light” colours applied to biometric data cards status

In addition to illustrations, we incorporated colour into some of the icons used throughout the app. While we primarily utilized icons from the Google library, we also adapted and created a small number of icons from scratch, particularly those pertaining to different types of medication. When it came to colouring these icons, we applied colour to those that were primarily intended to reinforce textual concepts and required a high level of impact, as shown in Figure 39. For the more system-related icons, we maintained a neutral palette to ensure consistency and balance.

Prototype development

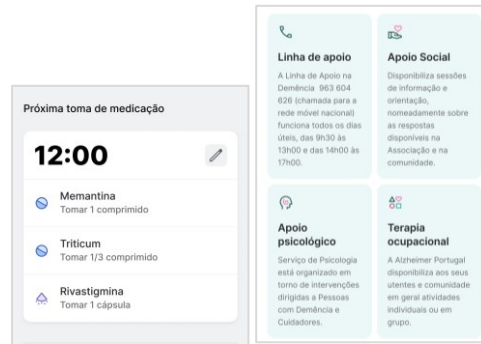


Figure 39: Coloured icons used for reinforcing the textual content

Illustrations and photographic language

We adopted a different approach with our practical guide cards and other informational components to uphold our objective of crafting a distinctive visual style for our prototype. Rather than relying on photographic images, which can perpetuate stereotypes, become repetitive, and pose challenges in ensuring text visibility, we turned to our colour palette. As shown in Figure 40, our focus shifted towards creating a minimalistic set of illustrations infused with vibrant colours and an inspirational vibe. This approach aims to captivate and engage users effectively while maintaining visual appeal and clarity.

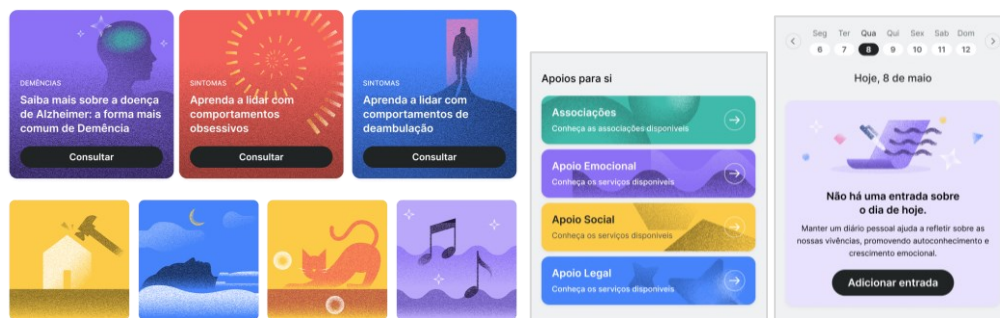


Figure 40: Set of illustrations created to depict the practical guide and support topics

While we cannot entirely avoid using photographic images, especially in our news section where they are commonly employed to bolster the credibility of articles, we can curate these images. Drawing inspiration from the minimalist and inspirational tone of our illustrations, we aimed to use or edit the images from the articles in a manner that aligns with our colour palette and focus on strategic details, avoiding overly crowded and stereotypical images, as depicted in Figure 41.

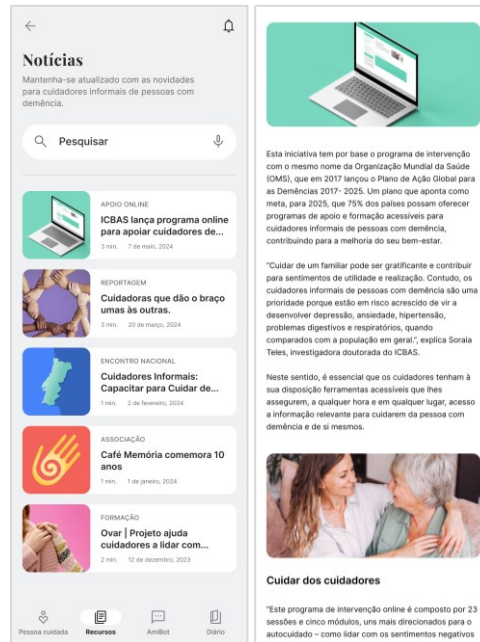


Figure 41: Set of illustrations created to depict the practical guide topics

Textures and elevations

As shown in Figure 42, our use of a grainy texture in several graphic elements, including illustrations within our application, served to add a palpable feeling to our prototype and increase visual interest. This approach entails an added level of proximity and reality between the user and the application, making interactions feel more tactile. Additionally, using this type of texture in coloured backgrounds allowed us to create gradients that imbued these shapes with a sense of movement, directing the user's attention to specific parts of the interface. We believe this approach is particularly effective in creating interfaces that feel more human and less mechanical, enhancing the overall user experience.

Prototype development

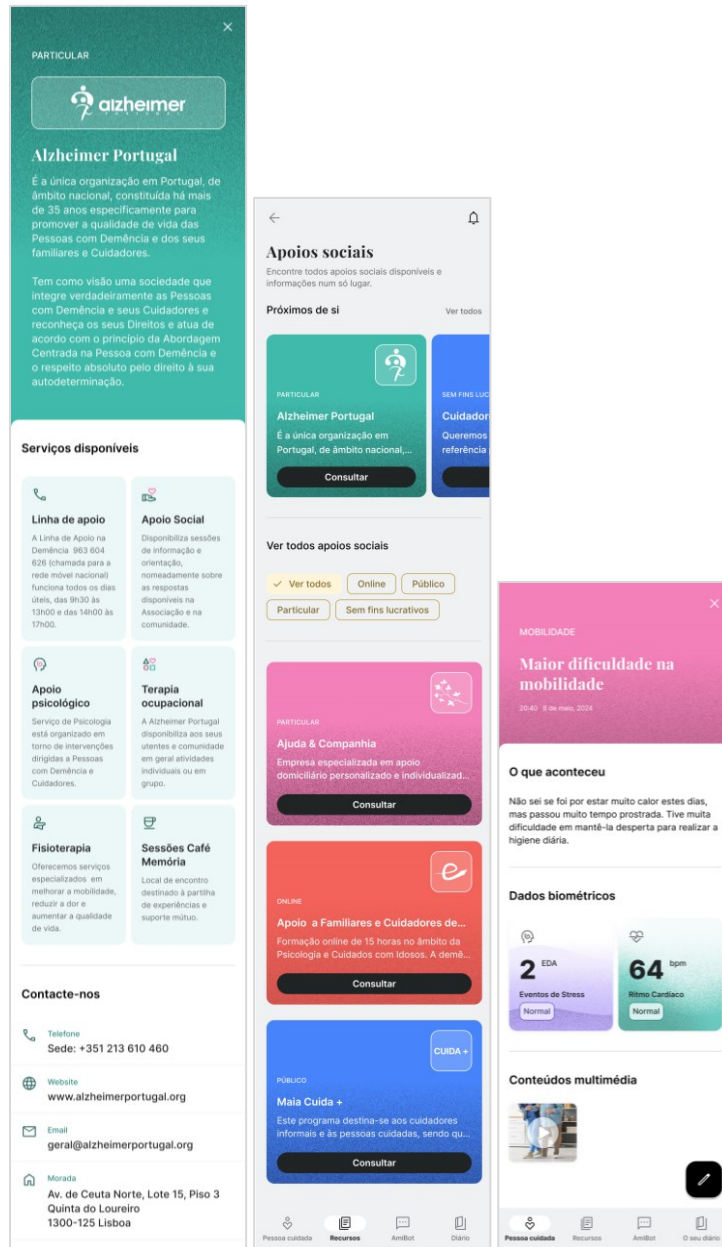


Figure 42: Textured applied to background sections

To enhance the sense of depth and highlight various components against the background, we incorporated an elevation effect with a subtle shadow. This layering technique not only adds the intended tactile quality to the interface but also helps distinguish interactive elements, improving usability. The low-impact shadows provide a gentle contrast that ensures components stand out without overwhelming the overall design, contributing to a cohesive visual experience.

Typography

As previously mentioned, we had already established our prototype typography. However, we felt that we could enhance the visual appeal by pairing our main sans-serif

font with a serif font for specific purposes. Pairing different types of fonts not only adds visual interest but also helps guide the user's eye through the textual content. We decided to emphasize only the headlines of each page and the main titles, as shown in Figure 43. These elements used larger font sizes, so this change wouldn't impact text legibility.

After researching the Google Fonts library, we chose the Playfair Display font in a bold style. This decision was based on its pronounced character shapes and height. This combination aimed to enhance our aesthetic balance and provide a versatile design approach.



Figure 43: Combination of a serif and sans-serif font styles

Branding

Finally, we reached the stage of naming and branding our prototype, a crucial step for the app's presentation, which forms the user's first interaction and impression. We focused on two main decisions, starting with the choice of a name. We decided on a feminine name, aligning with the [Stereotype guideline](#) that products with a feminine personality and voice are perceived as more empathetic and relatable. This approach was particularly beneficial for a product aimed at supporting informal caregivers. The chosen name was "Ami," derived from the word "amigo" in Portuguese, symbolizing friendship and support.

To create the application icon as depicted in Figure 44, we drew inspiration from the "A" shape in our name, as well as our chosen typography, colours, and illustrations. We aimed to imbue the icon with a sense of connection, support, and happiness, reflecting our overall goal of establishing a personality that is friendly yet serious and reliable. This thoughtful design supports our decision to present the app as both approachable and trustworthy, essential qualities for a tool intended to aid informal caregivers.

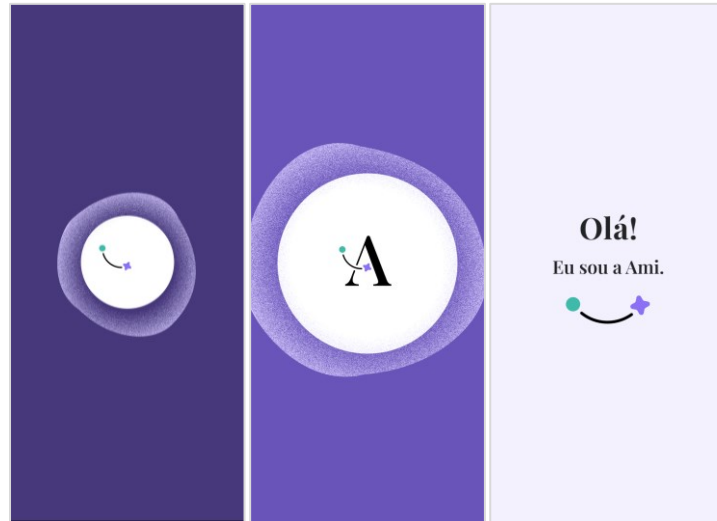


Figure 44: Brand icon and name for the application

Unexplored dimensions

Due to our study limitations and lack of practical knowledge in these fields, this prototype does not explore the dimensions of motion and sound, which are significant components of a comprehensive user experience.

6. Prototype testing and results discussion

In this section, we present the findings from our test plan, designed to evaluate the overall usability and perceived impact of the MVP prototype of the Android app "Ami." These results address our final research question: "Can applying emotional design principles to a Digital Health solution positively impact its user experience and adoption levels?" To answer this, we collected both quantitative data—via task completion metrics—and qualitative data—through the Think Aloud Protocol and questionnaire responses.

We anticipate that the insights from this test plan will serve as a valuable resource for the future design iterations and development of additional Digital Health solutions.

Comprehensive details on the test plan, including location and setup, participant recruitment and characteristics, methodology, moderator role, deliverables such as the task plan, scenario script, questionnaires, and the full results, can be consulted in [Annex I](#).

6.1 Key characteristics of the participant sample

Our testing sessions began with collecting information from each participant. This step aimed to characterize our sample based on the following key aspects: age range, gender, caregiving role, and self-assessed proficiency in smartphone interaction. Due to study limitations, we expanded our participant sample to include both informal caregivers and non-caregivers, and we conducted the tests both in-person and remotely.

We conducted 10 (N=10) testing sessions, four in person and six remotely. The remote sessions involved younger participants who are more proficient and familiar with video conferencing tools. Consequently, we did not encounter any significant issues that

affected the session environment or created different conditions compared to the in-person sessions. Each session lasted approximately 45 minutes to 1 hour.

The participant sample, as shown in Figure 45, was predominantly younger individuals. Five participants were aged 25 to 34, two were aged 35 to 44, and three older participants were aged 65 to 84. In terms of gender, the sample had a slight female predominance, with six female participants and four male participants. These characteristics closely aligned our sample with two of our user personas, José and Laura, each representing the extremes in caregiver demographics.

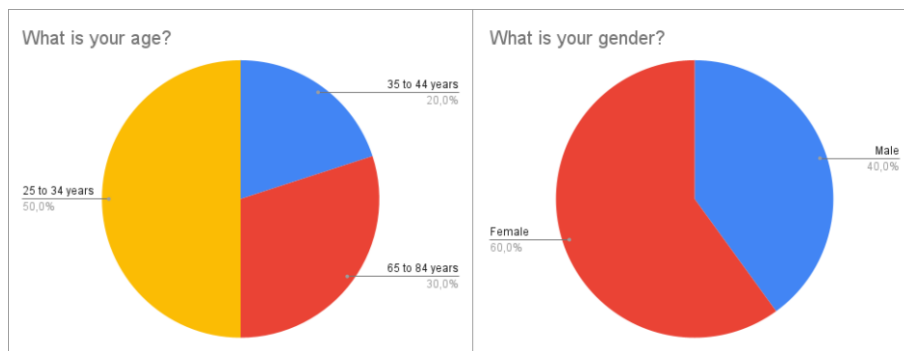


Figure 45: Participant sample demographic characteristics.

Figure 46 presents information regarding the participants' caregiving roles, two are currently informal caregivers for PLD, and two have past experience. The remaining six participants have no prior experience in caregiving for PLD. Concerning the self-assessed level of smartphone expertise, seven participants rated themselves as proficient, while three rated themselves as intermediate.

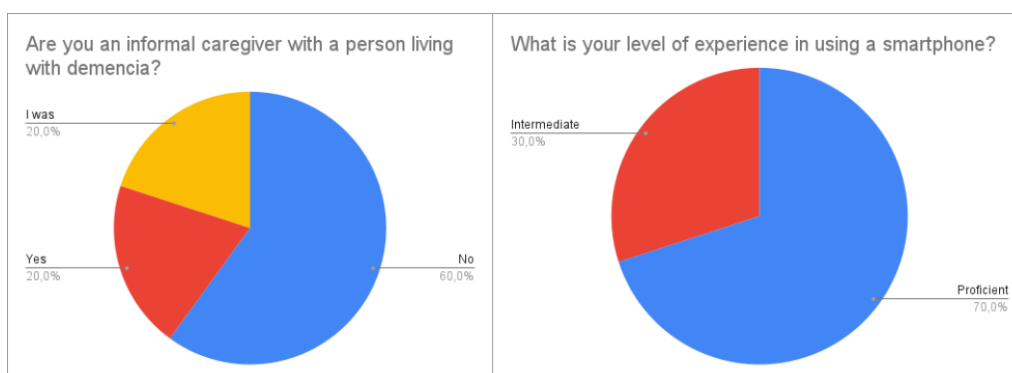


Figure 46: Participant sample caregiving roles and technology proficiency.

6.2 Task completion findings

Our task completion plan, the main focus of our testing sessions, comprised 16 tasks covering the most important features of our prototype. The primary objective of this section was to assess the application's ease of use by measuring the completion rate of each task, both with and without assistance. To achieve this, we utilized three main metrics: the number of errors, assistance, and deviations. The number of errors helps pinpoint specific areas where users encounter problems and understand how accurately users can complete tasks. The assistance helps us understand how users can independently navigate the system and identify complex areas that may require better guidance. Deviations help us understand how users naturally navigate through the system, revealing any deviations from the expected path. Moreover, throughout the session, the moderator took notes pertaining to the practice of the Think Aloud Protocol (Nielsen Norman Group, 2012) to register valuable qualitative insights. This approach aimed to enhance our understanding of the qualitative data and enrich our analysis. Below, we provide the key findings of our task completion, while comprehensive details can be found in [Annex I](#) for further reference.

Table 6: Errors, deviations, assistances, and completion rates by task

Tasks	Errors	Assistances	Deviations	% Completeness (Unassisted tasks)	% Completeness (Assisted tasks)
T.1	0	1	0	90%	10%
T.2	0	3	0	80%	20%
T.3	1	3	1	80%	20%
T.4	0	2	0	80%	20%
T.5	0	2	0	90%	10%
T.6	2	5	5	50%	50%
T.7	0	0	0	100%	0%
T.8	6	7	2	30%	70%
T.9	0	4	0	90%	10%
T.10	0	1	0	90%	10%
T.11	1	7	0	50%	50%

Prototype testing and results discussion

Tasks	Errors	Assistances	Deviations	% Completeness (Unassisted tasks)	% Completeness (Assisted tasks)
T.12	0	1	0	90%	10%
T.13	1	4	1	70%	30%
T.14	0	0	0	100%	0%
T.15	0	1	0	90%	10%
T.16	0	2	0	80%	20%

The task completion section of our test plan provided valuable insights into the performance of our MVP prototype. Firstly, we analysed error metrics, pinpointing tasks 6 and 8 as having the highest error rates. Task 6 involved confirming medication intake. Through moderator notes, we identified two primary issues: the need for an immediate option to mark medication intake within the PLD's medication section without navigating to the editing screen and the insufficient visual prominence of the editing button, causing oversight by some participants. Notably, one older participant failed to associate the visual icon with the concept of editing. Task 8 focused on registering events regarding the PLD. Many users initially navigated to the informal caregiver diary section. However, upon closer examination of the textual content, they realized they were in the wrong section and most returned immediately to the PLD dashboard.

Furthermore, both these tasks exhibited the highest rates of deviations, as confirmed by the information provided in the moderator notes. These deviations stemmed from a need to search further in other sections for solutions.

Next, we examined assistance rates, focusing on tasks 8 and 11, which required the most intervention from the moderator. In task 8, as previously mentioned, participants struggled with differentiating between registering events regarding the PLD and adding diary entries as informal caregivers. The moderator frequently directed participants to carefully review the textual content of the informal caregiver diary section. Following this guidance, all participants promptly realized their error and returned to the PLD dashboard. Task 11 tasked participants with locating the nearest social support options to their location. However, many users overlooked the title of this main section and hastily scrolled further down the screen. Once again, the moderator emphasized the importance of thoroughly reviewing the full textual content. One participant mentioned their expectation of immediately viewing the distance between their location and the presented social services on the information card.

The completion rates further underscore our findings, with tasks 6 and 8 exhibiting higher percentages of assisted completion, at 50% and 70% respectively. In contrast, tasks

7 and 14 achieved 100% unassisted completion rates. Task 7 involves adding a new medication, a straightforward process akin to the initial profile creation task. Task 14 entails accessing the informal caregiver diary, which participants mistakenly attempted during task 8. Interestingly, participants showed no signs of hesitation when addressing this task. Figure 47 presents a summary of the completion rates comparing unassisted versus assisted methods as outlined in our test plan.

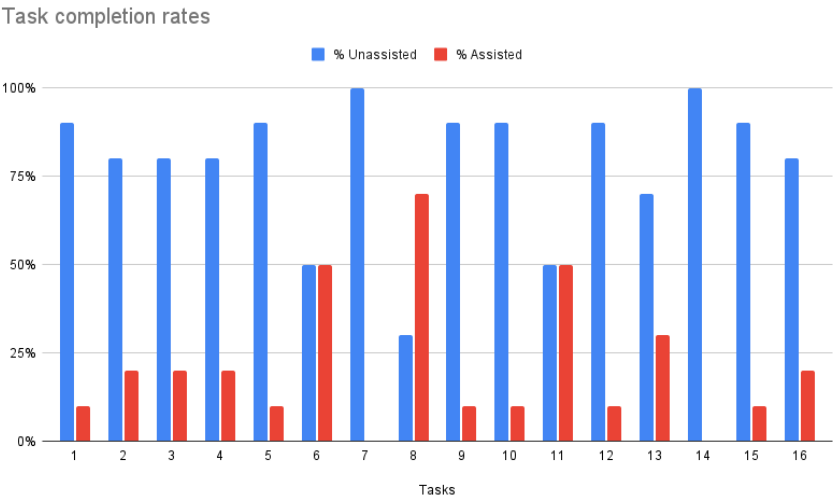


Figure 47: Completion rate with assistance versus unassisted.

In conclusion, our task completion analysis not only identified areas for improvement but also provided valuable insights into user behaviour and preferences. These findings will guide further iterations of our MVP prototype, ensuring a more intuitive and user-friendly experience for our target audience.

6.3 User Experience Questionnaire (UEQ) findings

The User Experience Questionnaire (UEQ) is a fast and reliable tool for measuring the user experience of interactive products. Widely used in the field and in numerous research studies, it is available in over 30 languages and includes supplementary materials that facilitate the analysis of results (Hinderks et al., 2024). The UEQ assesses the user experience across six scales, covering a total of 26 evaluation items: Attractiveness, which evaluates the overall impression of the product; Perspicuity, which measures how easy it is to become familiar with and learn to use the product; Efficiency, which assesses the ability to complete tasks without unnecessary effort; Dependability, which gauges the user's sense of control over the interaction; Stimulation, which looks at the excitement and motivation in using the product; and Novelty, which examines the innovation and creativity of the product, as well as its ability to capture users' interest.

Prototype testing and results discussion

This comprehensive evaluation framework ensures a detailed understanding of a product's user experience across several dimensions.

The UEQ evaluates user experience using six scales without producing an overall score, as this would be difficult to interpret. Instead, the individual scale means are analysed. Values between -0.8 and 0.8 are neutral, above 0.8 are positive, and below -0.8 are negative. The scales range from -3 (horribly bad) to +3 (extremely good), though values typically fall between -2 and +2 due to the averaging of diverse opinions (Hinderks et al., 2024). Below, we present a summary of the most relevant findings provided by the UEQ analysis tool; for more detailed information on the results, refer to the Test Plan report in [Annex I](#).

Figure 48 displays the mean and standard deviation of each evaluation item. Overall, all items received a positive assessment. However, it's notable that item 23 stands out with a negative mean. This discrepancy suggests a potential issue with the interpretation of this item within this context, especially considering that all other items on this scale have highly positive means.

Item	Mean	Variance	Std. Dev.	No.	Left	Right	Scale
1	↑ 2.6	0.7	0.8	10	annoying	enjoyable	Attractiveness
2	↑ 2.4	0.3	0.5	10	not understandable	understandable	Perspicuity
3	↑ 2.7	0.2	0.5	10	creative	dull	Novelty
4	↑ 2.4	1.8	1.3	10	easy to learn	difficult to learn	Perspicuity
5	↑ 2.9	0.1	0.3	10	valuable	inferior	Stimulation
6	↑ 1.3	3.1	1.8	10	boring	exciting	Stimulation
7	↑ 2.7	0.2	0.5	10	not interesting	interesting	Stimulation
8	↑ 1.4	4.3	2.1	10	unpredictable	predictable	Dependability
9	↑ 2.1	1.7	1.3	10	fast	slow	Efficiency
10	↑ 1.8	5.3	2.3	10	inventive	conventional	Novelty
11	↑ 2.2	0.6	0.8	10	obstructive	supportive	Dependability
12	↑ 2.9	0.1	0.3	10	good	bad	Attractiveness
13	↑ 2.0	2.0	1.4	10	complicated	easy	Perspicuity
14	↑ 2.7	0.2	0.5	10	unlikable	pleasing	Attractiveness
15	↑ 2.2	0.8	0.9	10	usual	leading edge	Novelty
16	↑ 2.4	1.2	1.1	10	unpleasant	pleasant	Attractiveness
17	↑ 2.3	0.9	0.9	10	secure	not secure	Dependability
18	↑ 2.6	0.5	0.7	10	motivating	demotivating	Stimulation
19	↑ 2.9	0.1	0.3	10	meets expectations	does not meet expectations	Dependability
20	↑ 2.2	3.5	1.9	10	inefficient	efficient	Efficiency
21	↑ 2.5	0.9	1.0	10	clear	confusing	Perspicuity
22	↑ 2.8	0.2	0.4	10	impractical	practical	Efficiency
23	↓ -2.8	0.2	0.4	10	organized	cluttered	Efficiency
24	↑ 2.9	0.1	0.3	10	attractive	unattractive	Attractiveness
25	↑ 2.8	0.2	0.4	10	friendly	unfriendly	Attractiveness
26	↑ 2.5	0.9	1.0	10	conservative	innovative	Novelty

Figure 48: UEQ mean and standard deviation values per item.

Based on these individual values, the UEQ tool generates results for the aforementioned six scales. As depicted in Figure 49, the Attractiveness scale emerges with the highest positive assessment, supported by a low standard deviation. Following closely are the scales of Stimulation, Perspicuity, and Novelty, although the last two exhibited higher standard deviations. The Efficiency scale, while still rated positively overall, received the lowest score. It's worth noting that item 23, identified as an outlier, is part of this scale, which may have significantly influenced this outcome.

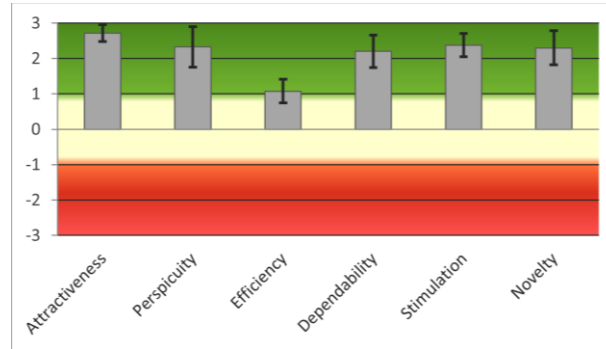


Figure 49: UEQ results per scale

The UEQ scales can be categorized into pragmatic quality (Perspicuity, Efficiency, Dependability) and hedonic quality (Stimulation, Novelty), as shown in Figure 50. Pragmatic quality concerns task-related aspects, while hedonic quality relates to non-task-related aspects. The mean of these three pragmatic and hedonic quality aspects is calculated. In the case of our prototype, while both aspects exhibit positive values, we observe a higher level of hedonic quality than pragmatic quality.

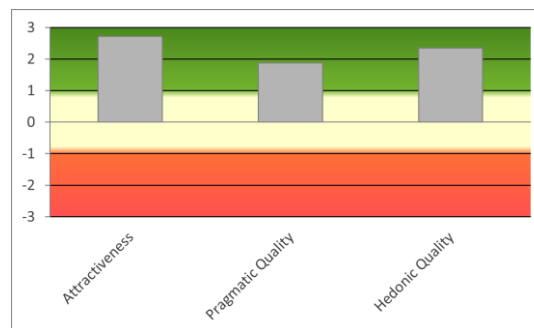


Figure 50: UEQ scales categorized into pragmatic and hedonic qualities

The UEQ analysis tool includes a benchmark option. Scale means are compared to existing values from a benchmark dataset, consisting of data from 21,175 individuals across 468 studies on various products. This enables insights into the relative quality of the evaluated product compared to others. As depicted in Figure 51, our ratings across all scales are above average, with the Attractiveness scale particularly noteworthy.

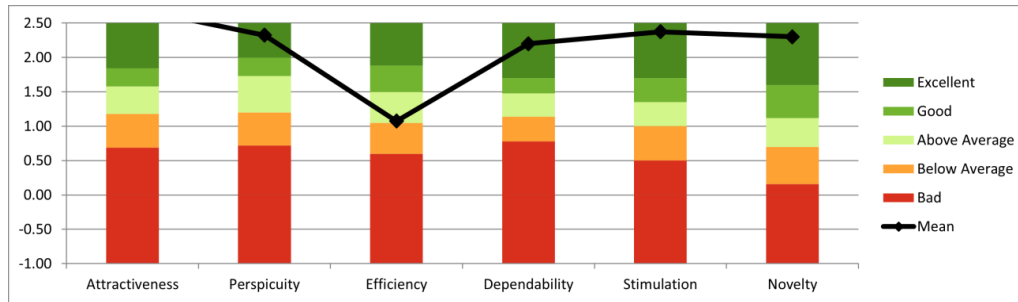


Figure 51: UEQ benchmark analysis

Although our application performed exceptionally well across all UEQ scales and assessments, including the benchmark comparison, it's crucial to acknowledge that we utilized a relatively small sample of participants. To ensure the robustness and relevance of these findings, a larger sample size would be necessary. This would provide a more comprehensive understanding of user experiences and enhance the reliability of our results.

6.4 Custom questionnaire on the impact of emotional design principles

To evaluate the influence of implementing emotional design principles and guidelines in the development and design of the MVP prototype of our Android app, 'Ami,' we designed a custom questionnaire based on our framework for designing for emotion. The questionnaire comprised specific sections: the first four questions aimed to gauge the impact of our Aesthetic principles, followed by four questions addressing our Interaction principles. The ninth question focused on our Commitment principles, and we included a final open-ended question to gather any additional feedback participants wished to share. However, it is important to note that the questionnaire was not validated by the industry nor previously tested, which may affect the reliability and validity of the results.

The questionnaire responses were measured using a Likert scale ranging from 1 to 7, where a score of 1 indicated a negative perception and a score of 7 indicated a positive one. For detailed information on the questionnaire guide and the scales used for each question, please refer to the Test Plan report available in [Annex I](#).

The results were assessed by calculating the mean value and evaluating the standard deviation for each question, as shown in Figure 52. Each question of the questionnaire was analysed individually to discern its correlation with our established principles and guidelines.

Question 1 yielded a positive result, with an average rating of 6.5 and a low standard deviation of 0.5. This indicates that most participants not only found the app's aesthetics appealing but also felt drawn to them, fostering further engagement.

Question 2 assessed the balance between the dominant and submissive qualities of the aesthetic elements, aiming to determine if we achieved the right balance. The results indicate a generally positive response. With a standard deviation of 1.6 and an average rating of 3.9, these values indicate that participants mostly fell in the middle of the scale.

Question 3 sought to determine the success of presenting a predominantly friendly personality. With an average rating of 6.2 and a standard deviation of 1.9, we believe we achieved an appropriate level of friendliness without compromising the necessary reliability and seriousness expected from a healthcare-oriented app.

Question 4, the final question regarding aesthetic principles and guidelines, focused on evaluating the quality and adequacy of the app's aesthetic elements. The results indicated a positive assessment, with an average rating of 6.4 and a standard deviation of 1.9.

Question 5 focused on the perceived complexity of the app's capabilities. The results indicated that participants mostly rated it in the middle of the scale, with an average of 2.9 and a high standard deviation of 2.3. This suggests we may have struck the right balance between perceived simplicity and complexity, aligning with our Interaction principle of power.

Question 6 assessed participants' sense of control over the app. The results showed that most participants felt in control, with one of the highest average ratings at 6.7 and a low standard deviation. This demonstrates the successful implementation of our Interaction principles related to power and status.

Question 7 examined the conversational aspect of our app's textual content. With an average rating of 6.8 and a standard deviation of 0.4, we can confidently state that our app effectively addressed the emotional context of the participants and conveyed a personality that fostered credibility.

Question 8 evaluated the perceived alignment between the app's features and participants' expectations. With an average rating of 6.9 and a standard deviation of 0.3, we can confidently state that participants were highly satisfied with the app's features.

Question 9 assessed whether participants had already established a sense of trust with the app. The results were positive, with an average rating of 6.7 and a standard deviation of 0.4. These findings support our commitment principles, which emphasize that credibility is highly dependent on the successful implementation of both aesthetic and interaction principles.

Prototype testing and results discussion

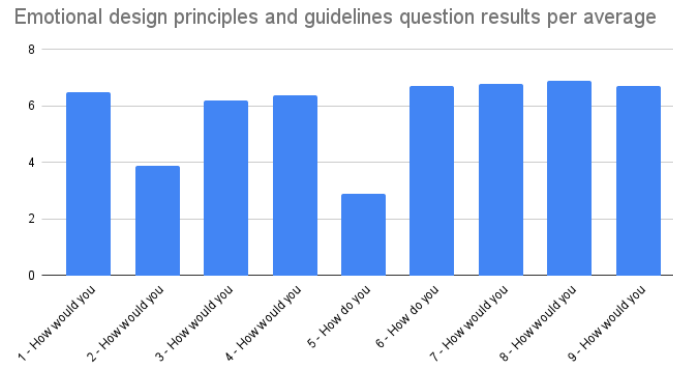


Figure 52: The average results per question

Question 10 allowed participants to share any relevant comments. Eight participants provided additional feedback. Given the limited sample size, we took a descriptive approach to the comments, focusing on areas for improvement and the perceived value of the solution. The selected comments will be presented in English as follows.

“Aesthetically appealing and highly innovative application compared to what is currently available on the market...”

“Inspires positivity and comfort to the user, something very important that allows adding positive elements to caregiver tasks that are often mentally exhausting. Visually appealing, but the use of strong colours like red should consider that it inspires concern in the caregiver, so in more educational contexts, such as resources, other colours may be more appropriate. This app would make all the difference in my life and my father's, who is also a caregiver.”

“Useful, informative, and with the potential to improve the lives of dementia patients as well as their caregivers.”

“I think it would be interesting, as well, to provide access to the information corresponding to the person being cared for to more than one caregiver (in cases where it is deemed useful/practical). This way, in the event of an unforeseen circumstance or absence of the "official" caregiver, another person would have access to the information, ensuring the well-being of the individual for whom we are responsible.”

“... the content and options it provides to the caregiver seem quite comprehensive.”

Overall, the positive responses across all assessed areas indicate that our design framework successfully enhanced the user experience of the 'Ami' app.

6.5 Limitations

Despite the valuable insights gained from our test plan, several limitations should be considered when interpreting the results. The test plan would have benefited from a larger sample size, which would provide a more robust and comprehensive understanding of the findings. Although we aimed to match the main demographic profiles of our user personas, we observed a notably younger participant group, which tends to be more technologically savvy. This skew in demographics may overlook the experiences of older and less proficient users, impacting the perspective of the results. Additionally, the inclusion of non-caregivers in our sample, while relatable in terms of role performance, inevitably affects the consistency and robustness of our findings.

Furthermore, the use of a Figma prototype, while efficient for testing early-stage concepts, does not fully capture the complexity and functionality of a fully developed application. This limitation can influence users' perceptions and task completion rates. Additionally, the use of two types of testing environments, whether in person or remote, although no relevant issues were detected during the sessions, does not exclude the possibility of introducing biases or limitations regarding the interaction with the prototype.

Lastly, we must acknowledge the subjective nature of the qualitative data provided by the Think Aloud Protocol observations and questionnaire responses. Despite efforts to standardize data collection procedures and analysis methods, individual moderator biases or participant interpretations may have influenced the accuracy or reliability of the data.

6.6 Conclusions

In conclusion, our test plan provided valuable insights into the usability and user experience of the MVP prototype of the Android app "Ami," particularly in the context of applying emotional design principles to Digital Health solutions. Despite limitations, our findings suggest that integrating emotional design principles positively impacts user perceptions, engagement, and trust.

Moving forward, iterative prototype refinement based on user feedback and task completion metrics would be crucial to enhance usability and address identified limitations effectively. Additionally, expanding the participant sample to encompass a more diverse demographic range, with a primary focus on informal caregivers of PLD, and conducting longitudinal studies to evaluate long-term user engagement and adoption rates would further strengthen the validity of our findings.

Overall, our study serves as a foundational framework for future research and development efforts in the field of Digital Health, emphasizing the importance of user-

centred design and emotional engagement in enhancing the effectiveness and adoption of healthcare applications.

7. Conclusion and future work

This dissertation aimed to address the significant emotional and practical challenges faced by informal caregivers of People Living with Dementia (PLD) by developing a prototype for a home-based and affordable Digital Health Solution that bridges insights from the fields of Emotional Design and technology.

Our main objectives were to identify the main challenges faced by these caregivers, assess how current digital health solutions address these challenges, and determine what is lacking in existing solutions. Subsequently, we aimed to develop and test a prototype incorporating emotional design principles to evaluate their impact on user satisfaction, connection, and adoption levels.

The key research questions guiding this research included identifying the specific problems and challenges that digital health solutions can address, determining the emotional design principles that may support these challenges, and evaluating the overall impact on the user experience and user level of adoption of applying these principles to the designing of new digital health solutions.

The literature review of this study aimed to provide insights that supported our first two research questions. Structured into two parts, the initial part delved into the subject of dementia and its overarching impact on those providing informal care. We identified several emotional and practical challenges, categorized into three primary dimensions: the absence of information and advice, the lack of practical support and the deficiency in emotional assistance. Furthermore, our investigation affirmed the positive impact of digital health solutions, particularly the vast potential showcased by mobile technology. However, we uncovered significant deficiencies in the current landscape of mobile applications tailored for caregiver support. Among the 38 apps evaluated, we found a limited range of features and a lack of personalization, filtering options, and credible information. Most of these apps were not publicly available and did not function optimally.

Secondly, we investigated the field of emotional design, tracing its evolution from inception to its contemporary perspective. Drawing from the insights of various authors, including the latest ACT model by van Gorp & Adams (2012), we shed light on the overlooked aspect of emotions as active agents in interaction rather than mere by-products. This exploration culminated in the formulation of our own [framework of principles and guidelines for designing for emotion](#), set to guide the future development of our proposed digital health solution prototype. In summary, our literature review revealed a significant gap in the intersection of design, emotion and technology.

Next, we advance to validate and deepen our comprehension of the findings from our literature review concerning the challenges encountered by informal caregivers of PLD and the potential of technology in alleviating these challenges. To accomplish this, we undertook a comprehensive user research process aimed at informing the design instruments crucial to the development of our prototype. Through a combination of questionnaire surveys and semi-structured interviews, valuable insights were gained into the multifaceted experiences of caregivers. The findings underscored emotional challenges, practical difficulties, and societal stigma as prominent themes, reinforcing the conclusions drawn from our literature review. Technology emerged as a promising avenue for support, particularly among younger caregivers. The study emphasizes the need for targeted interventions and enhanced support systems to improve dementia care in Portugal.

With the main challenges faced by Portuguese informal caregivers of PLD identified, along with the opportunities presented by mobile technology and the emotional design principles and guidelines that may address these challenges, we proceed to integrate all the gathered knowledge into the design of a prototype solution. Our aim is to evaluate the perceived impact of applying these emotional design insights by conducting user testing sessions, gathering feedback from participants, and analysing the results to understand how emotional design influences user experience and adoption of the prototype solution.

A Figma prototype was designed and tested. The favourable outcomes of our testing sessions, which included the results of a task completion plan, findings from the industry Usability Experience Questionnaire (UEQ), and insights from a custom questionnaire focused on emotional design principles and guidelines, underscored the positive influence of integrating emotional design principles into the development of a digital health solution. Specifically, these findings highlighted improvements in user perception, engagement, and trust.

The implications of this study are multifaceted. Theoretically, it contributes to the healthcare field by advancing our understanding of the personal narratives of Portuguese informal caregivers of PLD, while also extending the application of emotional design to digital health solutions for caregivers. On a practical level, the study provides a [framework for developing user-centred healthcare applications](#) that cater to both practical

and emotional needs. Moreover, the findings underscore the importance of societal engagement and education in mitigating stigma and enhancing support for caregivers.

Despite the valuable insights, the study presented several limitations. Firstly, the sample size was relatively small, with 40 participants for the questionnaire and 7 participants for the semi-structured interviews. A larger sample size would have provided a more robust and comprehensive understanding of the findings. Additionally, due to time constraints, the data analysis did not include an in-depth exploration of possible correlations between variables, particularly with the data collected from the questionnaire.

The test plan for the prototype testing had several limitations. In addition to the relatively small sample size of only 10 participants, there were other significant concerns. Although we attempted to align our sample with the demographic profiles of our user personas, we observed a noticeably younger participant group; this skewed demographic may have neglected the experiences of older, less tech-savvy users. Furthermore, including non-caregivers in our sample, while relatable in terms of role performance, compromises the consistency and robustness of our findings. The use of a Figma prototype doesn't fully represent the complexity and functionality of a developed application, potentially impacting users' perceptions and task completion rates. Lastly, the qualitative data obtained from Think Aloud Protocol observations and questionnaire responses are subjective, and individual biases or interpretations could influence the accuracy or reliability of the data.

Despite these limitations, the study provides valuable insights into the challenges faced by informal caregivers of People Living with Dementia (PLD) and the potential of technology to address these challenges.

Future research should involve extensive field studies and longitudinal validation of the prototype across a comprehensive population of informal caregivers of PLD. It is necessary to explore the integration of digital solutions within the home context and broader healthcare systems while also enhancing the customization and personalization of these solutions. Addressing societal stigma through educational initiatives and investigating the indirect effects on the well-being of PLD and their caregivers are also critical areas for further study. Additionally, an economic analysis of scaling digital health solutions could provide valuable insights for stakeholders and policymakers.

In conclusion, this dissertation underscores the critical role of Emotional Design in developing effective digital health tools tailored to the needs of informal caregivers of PLD. The research provides a foundation for future work aimed at improving caregiver support through innovative technology solutions. By continuing to explore and refine these approaches, we can enhance the quality of life for both caregivers and individuals living with dementia.

8. References

- Adobe. (2024). *Serif vs Sans Serif Fonts & When to Use Which* | Adobe.
<https://www.adobe.com/creativecloud/design/discover/serif-vs-sans-serif.html>
- Alhejaili, R., & Alomainy, A. (2023). The Use of Wearable Technology in Providing Assistive Solutions for Mental Well-Being. *Sensors*, 23(17).
<https://doi.org/10.3390/S23177378>
- Almutairi, R. R., Nursing Student, in, Zauszniewski, J. A., & Catherine Seibyl Professor, F. (2022). Sleep Disturbance in Informal Caregivers of Persons with Dementia: Systematic Review. In *International Journal of Caring Sciences* (Vol. 15). www.internationaljournalofcaringsciences.org
- Alzheimer's Association. (2022). *What is Dementia? Symptoms, Causes & Treatment* | alz.org. <https://www.alz.org/alzheimers-dementia/what-is-dementia>
- Alzheimer's Association. (2023). *Be a Healthy Caregiver* | Alzheimer's Association.
https://www.alz.org/help-support/caregiving/caregiver-health/be_a_healthy_caregiver
- Alzheimer's Society. (2022, November 18). *Treatments for dementia* | Alzheimer's Society. <https://www.alzheimers.org.uk/about-dementia/treatments>
- Ba, S., & Hu, X. (2023). Measuring emotions in education using wearable devices: A systematic review. *Computers & Education*, 200, 104797.
<https://doi.org/10.1016/J.COMPEDU.2023.104797>
- Bastoni, S., Wrede, C., Cristina, da S., Sanderman, R., Gaggioli, A., Braakman-Jansen, A., & van Gemert-Pijnen, L. (2021). *Factors Influencing Implementation of eHealth Technologies to Support Informal Dementia Care: Umbrella Review*.
- Brave, S., & Nas, C. (2002). *Emotion in Human-Computer Interaction*.
- Brown, E. L., Ruggiano, N., Li, J., Clarke, P. J., Kay, E. S., & Hristidis, V. (2019). Smartphone-Based Health Technologies for Dementia Care: Opportunities, Challenges, and Current Practices. *Journal of Applied Gerontology*, 38(1), 73–91.
https://doi.org/10.1177/0733464817723088/ASSET/IMAGES/LARGE/10.1177_0733464817723088-FIG1.JPEG
- Bruner, J. (1990). *Acts of meaning*. Harvard University Press.
- Centers for Disease Control and Prevention. (2022, November 14). *What Is Dementia?* | CDC. <https://www.cdc.gov/aging/dementia/index.html>
- Christie, H. L., Bartels, S. L., Boots, L. M. M., Tange, H. J., Verhey, F. J. J., & de Vugt, M. E. (2018). A systematic review on the implementation of eHealth interventions for informal caregivers of people with dementia. *Internet Interventions*, 13, 51–59.
<https://doi.org/10.1016/J.INVENT.2018.07.002>
- Color Psychology. (2024). *Color Psychology: A Guide for Designers, Marketers & Students*. <https://www.colorpsychology.org/>
- Cooper, A. (2004). *The inmates are running the asylum*. Sams.
- Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience*.
- Damásio, A. (2011). *Descartes' Error*.
- Desmet, P. M. A. (2002). *Designing emotions*.

- Dogusoy, B., Cicek, F., & Cagiltay, K. (2016). How serif and sans serif typefaces influence reading on screen: An eye tracking study. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 9747, 578–586. https://doi.org/10.1007/978-3-319-40355-7_55
- Ducharme, F., Kergoat, M. J., Coulombe, R., Lvesque, L., Antoine, P., & Pasquier, F. (2014). Unmet support needs of early-onset dementia family caregivers: A mixed-design study. *BMC Nursing*, 13(1). <https://doi.org/10.1186/S12912-014-0049-3>
- Gerboni, G., Comunale, G., Chen, W., Lever Taylor, J., Migliorini, M., Picard, R., Cruz, M., & Regalia, G. (2023). Prospective clinical validation of the Empatica EmbracePlus wristband as a reflective pulse oximeter. *Frontiers in Digital Health*, 5. <https://doi.org/10.3389/FDGTH.2023.1258915>
- Ghahramani, F., & Wang, J. (2021). Intention to Adopt mHealth Apps Among Informal Caregivers: Cross-Sectional Study. *JMIR MHealth and UHealth*, 9(3). <https://doi.org/10.2196/24755>
- Gitlin, L. N., Bouranis, N., Kern, V., Koeuth, S., Marx, K. A., McClure, L. A., Lyketsos, C. G., & Kales, H. C. (2022). WeCareAdvisor, an Online Platform to Help Family Caregivers Manage Dementia-Related Behavioral Symptoms: an Efficacy Trial in the Time of COVID-19. *Journal of Technology in Behavioral Science*, 7(1), 33. <https://doi.org/10.1007/S41347-021-00204-8>
- Google. (2024a). *FAB – Material Design 3*. <https://m3.material.io/components/floating-action-button/overview>
- Google. (2024b). *Material Design*. <https://m3.material.io/>
- Google. (2024c). *Material Symbols & Icons - Google Fonts*. <https://fonts.google.com/icons>
- Guessi Margarido, M., Shah, A., & Seto, E. (2022). Smartphone applications for informal caregivers of chronically ill patients: a scoping review. *NPJ Digital Medicine*, 5(1). <https://doi.org/10.1038/S41746-022-00567-Z>
- Harvard Medical School. (2022, November 16). *Is it dementia or depression? - Harvard Health*. <https://www.health.harvard.edu/mind-and-mood/is-it-dementia-or-depression>
- Hinderks, A., Schrepp, M., & Thomaschewski, J. (2024). *User Experience Questionnaire (UEQ)*. <https://www.ueq-online.org/>
- Interaction Design Foundation. (n.d.). *What is Visual Hierarchy? — updated 2024 | IxDF*. Retrieved June 8, 2024, from <https://www.interaction-design.org/literature/topics/visual-hierarchy>
- Interaction Design Foundation. (2022a, October 26). *What is Emotional Design? | IxDF*. <https://www.interaction-design.org/literature/topics/emotional-design>
- Interaction Design Foundation. (2022b, December 7). *What is User Centered Design? | IxDF*. <https://www.interaction-design.org/literature/topics/user-centered-design>
- Interaction Design Foundation. (2024a). *Personas – A Simple Introduction | IxDF*. <https://www.interaction-design.org/literature/article/personas-why-and-how-you-should-use-them>
- Interaction Design Foundation. (2024b). *What Are User Stories? — updated 2024 | IxDF*. https://www.interaction-design.org/literature/topics/user-stories#what_are_user_stories?-0
- Interaction Design Foundation. (2024c). *What is a Sitemap in UX Design? | IxDF*. <https://www.interaction-design.org/literature/article/ux-sitemap>

References

- Interaction Design Foundation. (2024d). *What is Color Symbolism? — updated 2024* | IxDF. <https://www.interaction-design.org/literature/topics/color-symbolism>
- Interaction Design Foundation. (2024e). *What is Task Analysis?* | IxDF. <https://www.interaction-design.org/literature/topics/task-analysis>
- ISO. (2010, December 7). *ISO 9241-210:2010(en), Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems*. <https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-1:v1:en>
- Jeon, M. (2017). *Emotions and affect in human factors and human-computer interaction*.
- Jordan, P. W. (2000). *Designing pleasurable products*.
- Kang, E., & Hwang, H.-J. (2023). *The Importance of Anonymity and Confidentiality for Conducting Survey Research*. <https://doi.org/10.15722/jrpe.4.1.202303.1>
- Møller Jensen, J., Hageman, M., Bang Løyeche Lausen, P., Kalsgaard Møller, A., & Löchtefeld, M. (2019). *Informing Informal Caregivers About Dementia Through an Experience-Based Virtual Reality Game*. 125–132. https://doi.org/10.1007/978-3-319-92022-1_11/FIGURES/4
- Nielsen, L. (2013). *Human-Computer Interaction Series Personas-User Focused Design*. <http://www.springer.com/series/6033>
- Nielsen Norman Group. (2012, December 18). *Thinking Aloud: The #1 Usability Tool*. <https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/>
- Norman, D. A. (2005). *Emotional Design*.
- Peters, R., Ee, N., Peters, J., Booth, A., Mudway, I., & Anstey, K. J. (2019). Air Pollution and Dementia: A Systematic Review. *Journal of Alzheimer's Disease : JAD*, 70(s1), S145–S163. <https://doi.org/10.3233/JAD-180631>
- Sala-González, M., Pérez-Jover, V., Guilabert, M., & Mira, J. J. (2021). Mobile apps for helping informal caregivers: A systematic review. *International Journal of Environmental Research and Public Health*, 18(4), 1–17. <https://doi.org/10.3390/IJERPH18041702>
- Sanders, E. B.-N. (1992). CONVERGING PERSPECTIVES: Product Development Research for the 1990s. *Design Management Journal (Former Series)*, 3(4), 49–54. <https://doi.org/10.1111/J.1948-7169.1992.TB00604.X>
- Schaller, S., Marinova-Schmidt, V., Gobin, J., Criegee-Rieck, M., Griebel, L., Engel, S., Stein, V., Graessel, E., & Kolominsky-Rabas, P. L. (2015). Tailored e-Health services for the dementia care setting: A pilot study of “eHealthMonitor.” *BMC Medical Informatics and Decision Making*, 15(1). <https://doi.org/10.1186/S12911-015-0182-2>
- Triberti, S., Chirico, A., Rocca, G. La, & Riva, G. (2017). Developing Emotional Design: Emotions as Cognitive Processes and their Role in the Design of Interactive Technologies. *Frontiers in Psychology* | *Www.Frontiersin.Org*, 8, 1773. <https://doi.org/10.3389/fpsyg.2017.01773>
- Understanding Graphics. (2024). *The Visual Language of Dashed Lines*. <https://understandinggraphics.com/brainy/the-visual-language-of-dashed-lines/>
- van Gorp, T., & Adams, E. (2012). Design for Emotion. *Design for Emotion*. <https://doi.org/10.1016/C2010-0-67661-9>
- Wang, S., & Yuan, H. (2019). Deeper user experience - Emotional design. *Advances in Intelligent Systems and Computing*, 774, 188–195. https://doi.org/10.1007/978-3-319-94944-4_21

- Werner, N. E., Brown, J. C., Loganathar, P., & Holden, R. J. (2022). Quality of Mobile Apps for Care Partners of People With Alzheimer Disease and Related Dementias: Mobile App Rating Scale Evaluation. *JMIR MHealth and UHealth*, 10(3).
<https://doi.org/10.2196/33863>
- World Health Organization. (2021). Global status report on the public health response to dementia. *Geneva: World Health Organization*, 251.
<https://digitalcommons.fiu.edu/cgi/viewcontent.cgi?article=1962&context=srhreports>
- World Health Organization. (2022a). *Dementia*. <https://www.who.int/news-room/fact-sheets/detail/dementia>
- World Health Organization. (2022b, October 1). *Ageing and health*.
<https://www.who.int/news-room/fact-sheets/detail/ageing-and-health>
- Zwaanswijk, M., Peeters, J. M., van Beek, A. P. A., Meerveld, J. H. C. M., & Francke, A. L. (2013). Informal Caregivers of People with Dementia: Problems, Needs and Support in the Initial Stage and in Subsequent Stages of Dementia: A Questionnaire Survey. *The Open Nursing Journal*, 7, 6.
<https://doi.org/10.2174/1874434601307010006>

Annex A – Questionnaire and Interview guides

This annex contains the complete scripts of the questionnaire and semi-structured interview used in the study.

Questionnaire guide

Introduction

Hello, my name is Jessica Teixeira, and I am an informal caregiver for a person living with dementia—my mother. Motivated by my personal experience, I decided to develop my master's dissertation in this context.

As such, I would like to introduce you to my research project entitled, "Bridging Emotional Design with Mobile Technology: towards the needs of dementia informal caregivers," as part of the Master's in Multimedia at the Faculty of Engineering of Porto. This research stems from an interest in gaining a deep understanding of the main practical and emotional challenges that these informal caregivers face in their daily lives, with the aim of developing a technological solution that addresses the identified needs.

All the data you submit is collected anonymously and will be used exclusively for academic purposes.

Information related to the informal caregivers

1 - What is your age?

Options: 18 to 24 years; 25 to 34 years; 35 to 44 years; 45 to 64 years; 65 to 84 years; More than 84 years old

2 - What is your gender?

Options: Female; Male; Other

3 - What is your relationship with the person living with dementia?

Options: Spouse; Daughter/Son; Granddaughter/Grandson

4 - Do you share a residence with the person with dementia?

Options: Yes; No

5 - How long have you been providing care for the person with dementia?

Options: Less than 1 year; 1 to 5 years; 6 to 8 years; More than 10 years

6 - What is the frequency with which you provide care for the person with dementia?

Options: Daily; 3 to 6 times per week; 1 to 2 times per week; Less than once a week

7 - Do you share your responsibilities as an informal caregiver?

Options: Yes, No

Information related to the person with dementia

8 - What is the age of the person with dementia?

Options: Less than 44 years; 45 to 64 years; 65 to 84 years; More than 84 years

9 - What is the gender of the person with dementia?

Options: Female; Male; Other

10 - What is the level of dependency of the person with dementia?

Options: Total; Severe; Moderate; Mild

Information about your knowledge of dementia and your ability to handle the challenges of this disease as an informal caregiver.

11 - Did you feel that at the time of the dementia diagnosis of the person you care for, you were provided with all the necessary information to handle the situation?

Options: Yes, No

12 - Have you ever felt the need to seek information about the dementia diagnosis and related topics?

Options: Yes, No

Search for information about dementia (If answered Yes on the previous question)

13 - Through which channels did you conduct this search?

Options: Contact with healthcare professionals; Contact with organisations or helplines in the field of dementia; Contact with other informal caregivers; Internet/Websites; Other

14 - What type of information about dementia did you search for?

Options: Information about what dementia is, the progression of the disease, and its symptoms; Information about medication and clinical studies for the person with dementia; Information on how to deal with behavioral changes in the person with dementia; Information about nursing homes or day centers for the person with dementia in my region; Information about helplines and support groups for informal caregivers of dementia

Self-perception of your knowledge about dementia and your ability to handle the challenges of the disease

15 - Do you currently feel adequately informed about dementia?

Options: Yes, No

16 - Do you currently feel adequately equipped to handle the person with dementia?

Options: Yes, No

Information about the challenges you face in your daily life as an informal caregiver of a person with dementia

17 - Please list the main practical challenges you face in your day-to-day life as an informal caregiver.

Open field text

18 - Please list the main emotional challenges you face in your day-to-day life as an informal caregiver.

Information about your familiarity with technology

Evaluate your daily use of the smartphone for the following situations:

19 - Do you use your smartphone to obtain information about various topics?

Options: Yes, No

20 - Do you use your smartphone to send and receive emails?

Options: Yes, No

21 - Do you download applications to install on your smartphone?

Options: Yes, No

22 - Do you own other types of technology such as tablets, smartwatches, home assistants, etc.?

Options: Yes, No

Thank you for your contribution.

Please enter your email contact if you are interested in continuing your participation in this study.

Interview guide

Introduction

Hello. Before we begin the interview, I would like to provide an overview of the context, the main topics we will discuss, and the confidentiality aspects involved. If you have any doubts or questions at any time, please feel free to ask.

The motivation for this research comes from my personal experience as an informal caregiver for my mother, who suffers from dementia. Through this experience, I noticed a significant lack of solutions and support from both the health and social systems for providing practical and emotional assistance to caregivers.

With my background in communication design and my interest in applying this knowledge to develop assistive technologies for healthcare, I decided to pursue this research as part of my master's degree. My goal is to propose a technological solution that incorporates the principles of emotional design to enhance the user experience. Emotional design is a user-centred design philosophy that emphasizes the importance of understanding users' needs deeply to create effective solutions.

This interview is a tool that will allow me to understand your experience as an informal caregiver for a person with dementia. Your insights will be extremely valuable in defining the functionalities that this technological solution should offer.

The interview is structured into three parts. The first part aims to learn about your background and how this chapter of your life began. The second part will explore your daily life, the biggest challenges you face, and how you cope with these challenges.

Lastly, I would like to understand the role that technology plays in your daily routine. Before we proceed with the interview, I need your consent to use the collected data, should you agree to participate. I would like to remind you that all data will be treated anonymously and used exclusively for academic purposes. If you have any questions, please feel free to ask.

Demographic information

- Name:
- Age:

- Occupation:
- Name of the person with dementia:
- Age of the person with dementia:
- Relationship with the person with dementia:
- What is the diagnosis (dementia condition) of the person with dementia?
- Do you share your responsibilities as an informal caregiver?

Questions related to information about the onset of the disease and its diagnosis

- When was the diagnosis given?
- What situations made you realize that something was wrong?
- When you were informed of the diagnosis, what type of information were you given to help manage the situation?
 - Examples:
 - Information about the condition of dementia and the progression of the disease
 - Strategies for managing the various symptoms of the disease
 - Local support network
- What were the main difficulties you faced during the initial stage of the disease?
- In terms of the person's behavioural changes with dementia, what were the most challenging situations you encountered? Please provide examples of how you dealt with these situations.
- At any point, did you fear that the person's behaviour with dementia would cause dangerous situations at home? Please provide examples.
- Can you describe your current daily routine as an informal caregiver?
- Do you feel that your role as an informal caregiver impacts your mental health? Please provide examples.
- Do you feel that you need more professional support to manage the person with dementia? Please provide examples of situations where you feel this would be necessary.
- And to manage your mental health?
- How do you cope with the ongoing grief of caring for the person?

Questions related to the use of technological tools in daily life

- Do you use a smartphone? Do you own a computer and have an internet connection?
- Do you use any applications or technological tools to help manage your daily tasks as an informal caregiver?
- Do you use any medication management tools? Surveillance cameras?
 - Sub-question: What led you to seek out this solution?
- What do you use to note down relevant information to share during consultations with professionals?

Annex B – Code Book Analysis framework

This annex includes the code book analysis framework, detailing the keywords used for analysing both the questionnaire and interview data in the study.

Table 7: Code book analysis framework for questionnaire and semi-structured interview

<i>Analysis Categories</i>	<i>Keywords (Questionnaire)</i>	<i>Keywords (Semi-structured Interviews)</i>
Lack of Information and/or Advice		
Lack of information regarding about the symptoms and progression of dementia.	"falta de informação" "omissão de informação" "desconhecimento sobre o futuro" "não ter conhecimento" "não saber" / "não sei" "não compreender" "progressão da demência" "conseguir responder de forma adequada" "sintomas da demência"	"falta de informação" "omissão de informação" "desconhecimento sobre o futuro" "não ter conhecimento" "não saber" / "não sei" "não compreender" "progressão da demência" "conseguir responder de forma adequada" "formação" "sintomas da demência"
Lack of information on how to deal with the changes in behaviour. Lack of information on what to do when the person with dementia is afraid, angry, confused or even in apathy.	"saber lidar com alterações de comportamento" "estar alterado" "estar confuso"/"estado de confusão" "difícil de lidar com" "é complicado lidar com" "mudanças de humor" "necessidade de antecipar situações destabilizadoras" "não saber como reagir" "comportamentos obsessivos" "comportamentos repetitivos" "gerir as mudanças/alterações súbitas" "redirecionar a atenção/comportamento" "saber lidar com agressividade" "estado de apatia"	"saber lidar com alterações de comportamento" "estar alterado" "estar confuso"/"estado de confusão" "difícil de lidar com" "é complicado lidar com" "mudanças de humor" "necessidade de antecipar situações destabilizadoras" "não saber como reagir" "comportamentos obsessivos" "comportamentos repetitivos" "gerir as mudanças/alterações súbitas" "redirecionar a atenção/comportamento" "saber lidar com agressividade" "estado de apatia"

Annex B – Code Book Analysis framework

<i>Analysis Categories</i>	<i>Keywords (Questionnaire)</i>	<i>Keywords (Semi-structured Interviews)</i>
	"medo" "manter a estabilidade"	"medo" "manter a estabilidade"
Lack of information on how to deal with the aggression of the person with dementia.	"conseguir defender-me" "conseguir acalmar a pessoa com demência" "manter-me calmo/a (o cuidador)" "medo" "lidar com agressividade / agressão" "comportamentos violentos" "evitar que a pessoa com demência se magoe" "proteger-me"	"conseguir defender-me" "conseguir acalmar a pessoa com demência" "manter-me calmo/a" "medo" "lidar com agressividade / agressão" "comportamentos violentos" "evitar que a pessoa com demência se magoe" "proteger-me"
Lack of information on how to undertake activities with the person with dementia.	"perceber que atividades despertam interesse" "saber os limites da pessoa com demência" "manter a motivação" "manter atenção" "necessidade de socialização" "saber que tipo de atividades lúdicas são adequadas" "atividades em conjunto" "como promover a interação"	"perceber que atividades despertam interesse" "saber os limites da pessoa com demência" "manter a motivação" "manter atenção" "necessidade de socialização" "saber que tipo de atividades lúdicas são adequadas" "atividades em conjunto" "como promover a interação"
Lack of information on how to adapt the home to provide better care.	"dificuldade em movimentar-se/mobilidade da pessoa com demência" "mobilidade na própria casa" "adaptar a casa" "limitar o acesso" "equipamentos de apoio" "transporte especializado para deslocamentos" "mecanismos de segurança" "adaptar a casa de banho" "adaptar o quarto"	"dificuldade em movimentar-se/mobilidade da pessoa com demência" "mobilidade na própria casa" "adaptar a casa" "limitar o acesso" "equipamentos de apoio" "transporte especializado para deslocamentos" "mecanismos de segurança" "adaptar a casa de banho" "adaptar o quarto"
Lack of information about legal regulations and how to apply for financial support.	"estatuto do cuidador informal" "subsídios" "quantidade de burocracia" "apoios sociais" "apoios financeiros"	"estatuto do cuidador informal" "subsídios" "quantidade de burocracia" "apoios sociais" "apoios financeiros"
Lack of Practical Support		
Needs assistance with the housekeeping (e.g.	"manutenção da casa" "tratamento/limpeza da roupa"	"manutenção da casa" "tratamento/limpeza da roupa"

<i>Analysis Categories</i>	<i>Keywords (Questionnaire)</i>	<i>Keywords (Semi-structured Interviews)</i>
cleaning, repairs, garden, etc).	"preparação de refeições" "limpeza da casa" "tratar do jardim" "reparações na casa" "casa"	"preparação de refeições" "limpeza da casa" "tratar do jardim" "reparações na casa" "casa"
Needs assistance to undertake physically demanding activities (e.g. bathing, dressing, hygiene routine, etc).	"higiene diária" "higiene oral" "manter a mobilidade" "idade do cuidador" "saúde do cuidador" "necessidade de assistência/ajuda" "tratar/cuidar de" "dar de comer" "refeições diárias/alimentação adaptada" "dar banho" "ter força física" "levantar a pessoa com demência" "deitar a pessoa com demência" "esforço(s) físico" "dar a medicação" "horas para todas as tarefas" "outras doenças inerentes / chagas/ úlceras de pressão" "cuidar o corpo" "assistência para operar/usar a sonda" "manter a rotina" "organizar a rotina/tarefas" "falta de tempo" "cansaço" "esgotado fisicamente" "dependência/dependente"	"higiene diária" "higiene oral" "manter a mobilidade" "idade do cuidador" "saúde do cuidador" "necessidade de assistência/ajuda" "tratar/cuidar de" "dar de comer" "refeições diárias/alimentação adaptada" "dar banho" "ter força física" "levantar a pessoa com demência" "deitar a pessoa com demência" "esforço(s) físico" "dar a medicação" "horas para todas as tarefas" "outras doenças inerentes / chagas/ úlceras de pressão" "cuidar o corpo" "assistência para operar/usar a sonda" "manter a rotina" "organizar a rotina/tarefas" "falta de tempo" "cansaço" "esgotado fisicamente" "dependência/dependente"
Needs someone to look after the person with dementia now and then.	"centro de dia" "descanso do cuidador" "férias" "partilhar a responsabilidades" "vigilância" "segurança" "alguém para tomar conta" "não pode estar sozinho/a" "ausência do cuidador"	"centro de dia" "descanso do cuidador" "férias" "partilhar a responsabilidades" "vigilância" "segurança" "alguém para tomar conta" "não pode estar sozinho/a" "ausência do cuidador"

Annex B – Code Book Analysis framework

<i>Analysis Categories</i>	<i>Keywords (Questionnaire)</i>	<i>Keywords (Semi-structured Interviews)</i>
Lack of Emotional Support		
Finds it difficult to balance work-life with being an informal caregiver.	"conciliar o emprego com cuidados" "vida profissional" "abandonar a profissão" "manter/organizar horários" "responsabilidade" "compreensão por parte da entidade patronal" "dificuldades financeiras" "proteção legal / desemprego" "gerir a vida familiar" "conjuguar a vida profissional com a pessoal"	"conciliar o emprego com cuidados" "vida profissional" "abandonar a profissão" "manter/organizar horários" "responsabilidade" "compreensão por parte da entidade patronal" "dificuldades financeiras" "proteção legal / desemprego" "gerir a vida familiar" "conjuguar a vida profissional com a pessoal"
Loneliness.	"tratar/cuidar de mim" "tempo para mim" "exclusão social" "desânimo" "tristeza" "depressão" "problemas em dormir" "falta de privacidade" "vontade de abandonar tudo" "sentimento de incapacidade" "apoio psicológico" "grupos/associações de apoio" "preocupação(o/a) constante"	"tratar/cuidar de mim" "tempo para mim" "exclusão social" "desânimo" "tristeza" "depressão" "problemas em dormir" "falta de privacidade" "vontade de abandonar tudo" "sentimento de incapacidade" "apoio psicológico" "grupos/associações de apoio" "preocupação(o/a) constante"
Feels emotionally overwhelmed.	"dificuldade em gerir muitos sentimentos" "dificuldade em aceitar a situação" "turbilhão de emoções" "falta de privacidade" "exaustão emocional/psicológica" "aflição" "burnout/stress" "medo de errar" "revolta com a situação" "desespero" "angústia" "frustração" "desgastante" "ansiedade" "pensamentos negativos" "sentimentos de injustiça" "manter a calma"	"dificuldade em gerir muitos sentimentos" "dificuldade em aceitar a situação" "turbilhão de emoções" "falta de privacidade" "exaustão emocional/psicológica" "aflição" "burnout/stress" "medo de errar" "revolta com a situação" "desespero" "angústia" "frustração" "desgastante" "ansiedade" "raiva" "pensamentos negativos" "sentimentos de injustiça" "manter a calma"

<i>Analysis Categories</i>	<i>Keywords (Questionnaire)</i>	<i>Keywords (Semi-structured Interviews)</i>
	"cuidar da própria saúde mental" "cansaço psicológico" "estar à altura do desafio" "resiliência" "conforto" "carinho" "amor e dedicação" "perceber que a pessoa com demência está doente e que os seus comportamentos não são propositados" "sentimento de culpa"	"cuidar da própria saúde mental" "cansaço psicológico" "estar à altura do desafio" "resiliência" "conforto" "carinho" "amor e dedicação" "perceber que a pessoa com demência está doente e que os seus comportamentos não são propositados" "sentimento de culpa"
Constant worrying that the behaviour of the person with dementia may cause unsafe situations around the house.	"quedas" "evitar acidentes" "deixar a água/o gás/etc ligado" "necessidade de constante monitorização" "evitar que a pessoa com demência se magoe" "fugir/sair de casa sozinha" "deixar de conduzir" "trancar portas"	"quedas" "evitar acidentes" "deixar a água/o gás/etc ligado" "necessidade de constante monitorização" "evitar que a pessoa com demência se magoe" "fugir/sair de casa sozinha" "perder" "deixar de conduzir" "trancar portas"
Constant worrying that health problems may occur due to the persons with dementia difficulty in communicating physical ailments.	"dificuldade em comunicar com a pessoa com demência" "estar constantemente atento a alterações físicas" "conhecer/perceber os sinais de desconforto físicos" "constante preocupação" "manter o bem estar da pessoa com demência"	"dificuldade em comunicar com a pessoa com demência" "estar constantemente atento a alterações físicas" "conhecer/perceber os sinais de desconforto físicos" "constante preocupação" "manter o bem estar da pessoa com demência"
Cannot adequately cope with the grief over the deteriorating situation of the person with dementia.	"perda da personalidade" "distinguir a pessoa da doença" "sofrimento constante" "perda do futuro idealizado" "não conseguir prever o futuro/medo do futuro" "estado de grande sensibilidade" "ocultar a dor" "sensação de impotência em relação à situação" "aceitar a situação" "degradação da pessoa amada" "tentar viver no presente" "não ser reconhecido"	"perda da personalidade" "distinguir a pessoa da doença" "sofrimento constante" "perda do futuro idealizado" "não conseguir prever o futuro/medo do futuro" "estado de grande sensibilidade" "ocultar a dor" "sensação de impotência em relação à situação" "aceitar a situação" "degradação da pessoa amada" "tentar viver no presente" "não ser reconhecido"

Annex B – Code Book Analysis framework

<i>Analysis Categories</i>	<i>Keywords (Questionnaire)</i>	<i>Keywords (Semi-structured Interviews)</i>
	"(não) reconhecer a pessoa amada" "manter a coragem" "saudade" "sentimento de perda contante"	"(não) reconhecer a pessoa amada" "manter a coragem" "saudade" "sentimento de perda contante"
Stigmatization		
Feels stigma from society.	"falta de empatia por parte das instituições e dos seus colaboradores" "mudar mentalidades" "desistência por parte das entidades de saúde" "atitudes humanizadas" "mobilidade urbana" "exclusão social" "educar a sociedade para esta doença" "apoios/serviços governamentais" "desrespeito"	"falta de empatia por parte das instituições e dos seus colaboradores" "mudar mentalidades" "desistência por parte das entidades de saúde" "atitudes humanizadas" "mobilidade urbana" "comunidade" "exclusão social" "educar a sociedade para esta doença" "apoios/serviços governamentais" "desrespeito"

Annex C – User research

Questionnaire findings

This annex includes detailed findings from the questionnaire conducted during the user research stage of this study.

Table 8: Characteristics of the participating informal caregivers

<i>Characteristics of the participating informal caregivers</i>	<i>Results (in absolute values)</i>
Age	
18 to 24 years old	2
25 to 34 years old	3
35 to 44 years old	3
45 to 64 years old	20
More than 84 years old	11
Gender	
Female	26
Male	13
Relationship with the person living with dementia	
Spouse	8
Daughter/Son	28
Grandchild	1
Other	2
Do you share residence with the person with dementia?	
Yes	29
No	10
How long have you been caring for the person with dementia?	

Annex C – User research Questionnaire findings

<i>Characteristics of the participating informal caregivers</i>	<i>Results (in absolute values)</i>
1 to 5 years	19
6 to 8 years	12
More than 10 years	8
How often do you provide care to the person living with dementia?	
Daily	35
1 to 2 times per week	3
Less than 1 time per week	1
Do you share your responsibilities as an informal caregiver?	
Yes	25
No	14

Table 9: Characteristics of the people living with dementia cared for by the informal caregiver participants

<i>Characteristics of the people living with dementia</i>	<i>Results (in absolute values)</i>
Age	
45 to 64 years old	6
65 to 84 years old	21
More than 84 years old	12
Gender	
Female	30
Male	9
What is the dependency level of the person living with dementia?	
Mild	3
Moderate	9
Severe	10
Total	17

Table 10: Information regarding the informal caregivers self-perceived knowledge of dementia and ability to deal with the challenges of this disease

<i>Self-perceived knowledge of dementia</i>	<i>Results (in absolute values)</i>
Do you feel that, at the time of the diagnosis of dementia of the person you care for, you were provided with all the information necessary to deal with the situation?	
Yes	7
No	32
Have you ever felt the need to look for information about the diagnosis of dementia and related topics?	
Yes	36
No	3
Through which channels did you carry out this research? (multiple choice)	
Information about what dementia is, its progression and its symptoms	29
Information about medication and clinical studies for the person with dementia	15
Information on how to deal with the behavioural changes of the person with dementia	28
Information about homes or day centres for people with dementia in your region	16
Information about informal dementia caregiver support lines and groups	18
Others	3
Do you currently feel adequately informed about dementia?	
Yes	19
No	20
At this moment, do you feel adequately qualified to deal with the person with dementia?	
Yes	17
No	22

Table 11: Information on the informal caregiver's familiarity with technology

<i>Familiarity with technology</i>	<i>Results (in absolute values)</i>
Own a smartphone?	
Yes	35
No	4
Do you use your smartphone to obtain information about various topics?	
Yes	34
No	1
Do you use your smartphone to send and receive emails?	
Yes	33
No	2
Do you download applications to install on your smartphone?	
Yes	32
No	3
Do you own other types of technology such as tablets, smartwatches, home assistant, etc.	
Yes	27
No	8

Table 12: Information about the challenges you face in your daily life as an informal caregiver of a person with dementia (qualitative analysis)

<i>Main challenges you face in your day-to-day life as an informal caregiver (open answer)</i>	<i>Negative Reference</i>	<i>Positive Reference</i>
Lack of information and advice		
Lack of information regarding about the symptoms and progression of dementia	12	N/A
Lack of information on how to deal with the changes in behaviour	14	N/A
Lack of information on how to deal with the aggression of the person with dementia	7	N/A
Lack of information on how to undertake activities with the person with dementia	8	N/A

<i>Main challenges you face in your day-to-day life as an informal caregiver (open answer)</i>	<i>Negative Reference</i>	<i>Positive Reference</i>
Lack of information on how to adapt the home to provide better care	7	N/A
Lack of information about legal regulations and how to apply for financial support	1	N/A
Total	49	N/A
Practical challenges		
Needs assistance with the housekeeping (e.g. cleaning, repairs, garden, etc)	1	N/A
Needs assistance to undertake physically demanding activities (e.g. bathing, dressing, hygiene routine, etc)	46	N/A
Needs someone to look after the person with dementia now and then	5	1
Total	52	1
Emotional challenges		
Finds it difficult to balance work-life with being an informal caregiver	17	N/A
Loneliness	20	N/A
Feels emotionally overwhelmed	32	7
Constant worrying that the behaviour of the person with dementia may cause unsafe situations around the house	4	N/A
Constant worrying that health problems may occur due to the persons with dementia difficulty in communicating physical ailments	5	N/A
Cannot adequately cope with the grief over the deteriorating situation of the person with dementia.	23	2
Total	101	9
Stigmatization		
Feels stigma from society	5	N/A
Total	5	N/A

Annex D – User personas profiles

This annex presents additional profiles of the user personas developed in this study.

Bridging Emotional Design with mobile technology: Towards the needs of dementia informal caregivers

User Research
Persona

2024



Laura | 32 Years old

Laura is 32 years old and recently married to Tiago. Laura is an accountant with her own practice that specializes in helping other freelance workers with their finances and Tiago works as a software engineer for a fintech company. They live in Lisbon, a city as busy as Laura's life. In her spare time, Laura is an avid reader of poetry and enjoys sunday afternoons of cake baking and long walks in the park. As an only child, Laura's dream is to have a large family with several children of her own.

EMOTIONAL PROFILE

Laura was initially deeply shocked by the prospect of becoming her mother's caregiver. She needed time to accept this new role, and only when her mother's symptoms worsened did she fully grasp the seriousness of the situation. Her life was disrupted, necessitating a reduction in her work hours, which brought added financial strain and a sense of professional loss. She found herself devoid of time for her personal life and social activities, almost losing sight of her dream of motherhood. Laura has experienced burnout, due to the overarching situation and, most acutely, due to the burden of guilt for not dedicating enough time to her husband and for questioning her competence as her mother's caregiver. These feelings tend to resurface from time to time.

RELATION TO FOCUS AREA

Laura has been the sole caregiver of his mother Alice who was diagnosed with early onset Alzheimer, four years ago.

THE INTIAL STAGE

Laura resides in close proximity to her mother, and they routinely share lunches at least twice a week. The initial signs that something was amiss became evident when her mother began to muddle their lunch schedules, misplace her belongings, and experienced fatigue and despondency. Initially attributed to her age, the initial diagnosis was depression. However, a turning point occurred when Laura received a panicked call from her mother, who was disoriented and couldn't find her way back home from the bakery. With the subsequent diagnosis of early-onset Alzheimer's, the early symptoms became increasingly pronounced, evolving into compulsive behavior related to food and cleaning, repetitive speech, and a notable lack of enthusiasm for recreational activities. This progression was further exacerbated by the necessity of Laura's mother to retire prematurely.

THE ADVANCED STAGE

Feeling unprepared for her mother's dementia diagnosis, Laura sought guidance online. She found the Alzheimer Association and promptly enrolled in their course for caregivers of individuals with dementia. She also joined Café Memória online with her mother, who by that time had started to refuse to leave her house. This was crucial to help Laura feel that she was making the right decisions when dealing and redirecting her mother's obsessive and repetitive behavior. Together, they participated in online dance and yoga classes tailored for individuals living with dementia and their caregivers. Through the Association, Laura accessed affordable home services for her mother, including occupational and physical therapy, as well as psychological support for herself. These resources enabled Laura to manage her caregiving responsibilities while maintaining a balance between her personal life and career.

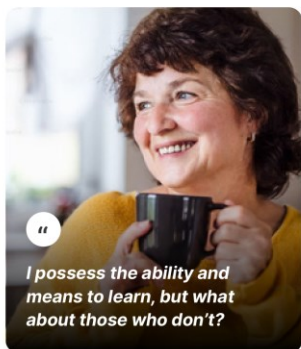
MEDIA USAGE

Laura is a savvy technology user. She uses her phone and other devices to help her keep up with her busy routine and schedules. She has an app to manage her mother's medication and uses Alexa to set several types of reminders. It's mainly through her computer that she looks for reliable information and training directly from globally certified associations and health organizations to help her deal with her caregiving role, she also interacts with social groups for informal caregivers that promote several activities through videoconference. Moreover, she not only relies on a wearable device to monitor her physical activity and receive notifications when her phone is out of reach, but she has also acquired a wearable device developed by the Red Cross for her mother, which aids in tracking her mother's location in case of emergency.

INFLUENCERS

Laura experienced the loss of her father at a young age, and being an only child, her immediate family is limited to her fully supportive husband. Embracing her caregiving responsibilities, she regrettably drifted apart from some of her long-time and close friends. However, in this process, she has forged new connections within the associations and support groups she occasionally attends, and she believes that these newfound relationships have enriched her life more than the ones she left behind.

Figure 53: Full description of the user persona “Laura”



"
I possess the ability and means to learn, but what about those who don't?"

Fernanda | 56 Years old

Fernanda is 56 years old, she is married to Augusto who is twelve years older than her. Together, they have a daughter living in Germany and a son residing in Coimbra. They currently inhabit a small flat in the city center of Lisbon. Fernanda and Augusto are both retired, she worked as a high school History teacher, her dream job since an early age, while he used to be a lawyer with his own practice. Fernanda is an avid reader and writer, firmly believing that the secret to staying young is to keep learning and experiencing new things throughout life.

EMOTIONAL PROFILE

Fernanda characterizes herself as a go-getter. Confronted with the unknown or new challenges, she consistently summons the determination to understand what lies ahead. In her view, knowledge is power, and she embraces change and adaptation fearlessly. Right from the start, she adopted a proactive stance, delving into learning about the disease affecting her husband. While the severity of the situations could be overwhelming, she always endeavored to rationalize them and glean lessons from the aftermath. However, this proactive approach doesn't imply immunity to the emotional toll. On the contrary, she grapples with lingering feelings and occasional depressive states. The necessity to retire early and relocate to a different city, resulting in the loss of some of her social network, further intensifies these emotional states.

RELATION TO FOCUS AREA

Four years ago, Augusto was diagnosed with Alzheimer's, and Fernanda has been the primary caregiver for her husband ever since.

THE INITIAL STAGE

Fernanda's husband's diagnosis was obtained quite rapidly and accurately. Symptoms initially caught the attention of Augusto's coworkers when he experienced difficulties using the computer, a skill he had excelled at. At home, he struggled with simple electronics like the microwave. During a car ride with Fernanda, he couldn't navigate to the familiar supermarket they had frequented throughout their married life. Having lived in Coimbra since their marriage and having close friends who were doctors, Fernanda promptly sought the necessary support to secure the correct diagnosis. Given Augusto's career as a lawyer, he had to retire immediately. As a naturally independent person, he found it challenging to accept the sudden changes brought about by his diagnosis. Depression set in, exacerbating symptoms, including delusional states and occasional aggressive behavior. There was a critical incident when Fernanda had to call emergency services due to Augusto's erratic and aggressive behavior toward her. After explaining the situation, the emergency personnel concluded that hospitalization wasn't immediately necessary and departed. Fernanda was left to fend for herself, marking a significant turning point in both their lives.

THE ADVANCED STAGE

After the incident, Fernanda recognized the need for a support system beyond a good hospital and doctors, a resource lacking in Coimbra. Opting for early retirement, she relocated to Lisbon. Promptly reaching out to the Alzheimer association, Fernanda enrolled in a training course to navigate this new chapter in their lives. Simultaneously, she enrolled Augusto in a day center where he could engage in activities tailored to his evolving needs. With the association's assistance, Fernanda gained more affordable access to a network of services, aiding her in managing practical challenges like personal hygiene, feeding, and dressing. These significant changes prompted Fernanda to seek psychological support for her mental well-being. She grappled with the difficulty of acknowledging that her husband's occasional aggressive behavior toward her was a product of his condition and the persistent grief stemming from the inability to communicate effectively with her lifelong partner.



Annex D – User personas profiles

Bridging Emotional Design with mobile technology: Towards the needs of dementia informal caregivers

User Reaserch
Persona

2024

📺 MEDIA USAGE

Having previously worked extensively with a computer for her job, Fernanda possesses a solid knowledge of technology. She favors using the computer for information research, typically initiating with a broad Google search and then selecting resources from reliable sources such as the WHO or content provided by renowned associations. As a hobby, Fernanda maintains a digital diary, frequently jotting down thoughts in a collection of Word documents. She is actively engaged in social media, participating in groups related to informal caregiving to share stories and tips. In addition to her computer use, Fernanda owns a smartphone, primarily utilizing it for video calls with her children, sending emails, and sharing video information with health services practitioners.

👥 INFLUENCERS

Despite having two children, the geographical distance poses a considerable challenge for Fernanda. They make a point to call her every day and utilize the majority of their vacation time to be more present and provide support. Fernanda, in turn, is mindful not to overly disrupt their lives, recognizing that they are in a phase of constructing their own paths. Additionally, Fernanda stays connected with some of her lifelong friends from Coimbra through phone calls and social media. In Lisbon, she has cultivated new relationships, primarily with other caregivers who also participate in Alzheimer association training courses and activities.



2/2

Figure 54: Full description of the user persona “Fernanda”

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Annex E – Situations, goals and scenarios

This annex presents the complete situations, scenarios, and goals for each persona developed in this study.

Table 13: Situations, goals and scenarios by persona

<i>Situations</i>	<i>Goals</i>	<i>Scenarios</i>
José 70 Years old		
Felt uninformed about dementia and the primary symptoms exhibited by his wife.	Easy access to reliable information on the key aspects of dementia, tailored to the specific case of his wife.	José and his wife are at the neurologist's office following a referral from their family doctor, who suspects Maria's condition is more than just depression. After several examinations, the neurologist diagnoses Maria with probable frontotemporal dementia. Overwhelmed, José listens as the doctor prescribes a medication regimen and schedules the next appointment. They leave the office without asking any questions or being asked any. Almost a day later, after informing their daughters of the diagnosis, José realizes he knows nothing about dementia or what to expect. After a Facebook video call with his daughters, he searches for "demencia" on his phone's Google browser. He opens the top result and begins reading, hoping to find insights relevant to their situation.
Manage a rigorous medication schedule.	Access an effective and shareable medication management system to ensure adherence to the prescribed routine.	After receiving his wife's diagnosis, José goes to the pharmacy to pick up her prescribed medication. The pharmacist prints a note detailing the medication schedule, including the times and dosages. José soon misplaces the note but relies on his memory to manage the regimen. One day, while his daughter is visiting, she calls José for instructions on which medication to give at lunch. Realizing the need for a reliable system, José decides to keep an updated medication schedule on the fridge for easy reference. Since Maria refuses to take her medication, José discreetly mixes it into her food, ensuring she takes it with meals and rarely forgets.
Manage extreme behavioural changes (e.g., hallucinations).	Access to expert and reliable information and training on managing behavioural changes.	José's wife becomes erratic, resisting his attempt to dress her in a jacket and fleeing the house in distress. José, trying to calm her, inadvertently restrains her, leading to feelings of guilt afterward. Realizing the need for help, José plans to discuss the incident with the doctor but feels overwhelmed by the lack of immediate support. Turning to Google for guidance, he searches without refining his keywords, becoming frustrated by the overwhelming amount of information without finding practical solutions tailored to his situation.
Entered a state of mental burnout, finding it increasingly	Access to psychological services to obtain	José, exhausted from daily struggles with his wife's extreme behaviour changes, reached out to his daughter for help. She advised him to contact the family doctor, who scheduled a

Annex E – Situations, goals and scenarios

<i>Situations</i>	<i>Goals</i>	<i>Scenarios</i>
challenging to maintain patience and control over his emotions.	information and training on wellbeing and self-care practices.	psychological consultation due to limited support services in their area. Feeling uncomfortable with sharing his feelings, José sought relief from the practical day-to-day routine to find physical rest and dedicate time to himself.
Falls resulting from declining mobility and spatial perception challenges.	Ensure continuous monitoring of the PLD to prevent falls and other unsafe situations.	Over time, Maria's mobility challenges increased, particularly with navigating stairs, leading to two falls, one requiring hospitalization. Concerned for her safety, José began closely monitoring her and limiting her movements when he couldn't be present. To alleviate his worries, his daughters provided a camera system, allowing remote monitoring via smartphone app, granting José some relief and enabling brief periods of absence when needed.
Experienced persistent physical exhaustion.	Access to information and direct connection to respite services within its geographical area.	José, now solely responsible for caring for his wife's physical needs at 70 years old, maintains a strict routine of dressing, walking assistance, feeding, bathing, and hygiene, which, while organized, proves physically demanding without respite. With minimal assistance from his daughters, José seeks practical support from social services, enduring a bureaucratic process to apply for caregiver benefits, ultimately resulting in no services provided. In the meantime, he arranges for additional help with household chores to ease his burden.
Continuous health monitoring to identify any underlying health issues.	Real-time access to basic health measurements, incident notifications, and direct connections to medical services.	As Jose's wife's condition worsened, she lost the ability to communicate effectively and became unresponsive at times. Concerned for her health, Jose took her to the emergency room twice, where she was diagnosed with a urinary infection and later with COVID-19. Since then, Jose monitors her temperature and blood pressure regularly and becomes anxious at any sign of potential health issues, often rushing to the emergency room.
Sought out cost-effective technological solutions to alleviate practical tasks and emotional worries.	Access news and advice on current technology or solutions that can address both practical and emotional needs.	At the urging of his daughters, José has embraced various technological solutions to assist with practical tasks and provide peace of mind. These range from practical aids like an automatic toilet and support for his wife during meals to cameras and smartphone apps enabling remote monitoring. José typically seeks solutions in response to specific incidents or prolonged behavioural challenges.
At times, experiences feelings of inadequacy in his role as an informal caregiver.	Access to affordable psychological services and support groups located near his residential area.	Jose frequently experiences feelings of failure in his caregiving role during stressful or severe events, but these feelings often dissipate over time. As he becomes more comfortable, he increasingly shares his feelings with his daughters.
Laura 32 Years old		
Struggling to accept the diagnosis.	Access to expert psychological support services both locally and online, along with information and training on wellbeing and self-care practices.	Upon receiving her mother's diagnosis of early-onset Alzheimer's, Laura initially struggled to comprehend the severity of the situation, believing that it would not significantly disrupt their lives. However, as her mother's behaviour became increasingly erratic, Laura found herself thrust into the role of primary caregiver, leading to a reversal of their mother-daughter dynamic. Overwhelmed by her new responsibilities and the uncertainty of the future, Laura experienced emotional distress, culminating in a panic attack. Recognizing the need for support, she sought help from her family doctor for a psychological consultation and turned to

<i>Situations</i>	<i>Goals</i>	<i>Scenarios</i>
		mindfulness exercises through a mobile app to help manage her emotions.
Experienced burnout.	Information and training on wellbeing and self-care practices and facilitating connections to caregiver social support groups both locally and online.	After nearly a year since her mother's diagnosis, Laura began to experience constant exhaustion, struggling to balance her newfound caregiving responsibilities with her job and maintaining a semblance of her own life. Despite her fatigue, she found it difficult to sleep properly and had been neglecting her psychology appointments and personal activities. Upon cancelling yet another appointment, her doctor suggested online consultations, prescribed sleep medication, and encouraged her to seek assistance to alleviate her burden temporarily.
Struggling to cope with significant disruptions in her personal life, including loss of income, social time and future dreams.	Information on affordable in-home social support services, guidance on applying for financial assistance, and understanding legal regulations pertinent to caregiving.	Laura had to adjust her work hours to accommodate her mother's increasing dependence, attempting to work from her mother's house but facing constant interruptions. She sought solutions to occupy her mother and alleviate the need for constant presence, initially trying a day centre but facing resistance from her mother. To maintain her full-time work, Laura considered hiring help, but the cost was prohibitive. She and her husband sought financial support by researching options online, consulting their family doctor, and contacting the Alzheimer's Association.
Struggling with feelings of guilt and inadequacy regarding caregiving, including also concerns about not dedicating sufficient time to both the PLD and her husband.	Direct connections to caregiver social support groups.	During an online psychology session, Laura expressed her feelings of inadequacy in caring for her mother, citing instances of impatience and frustration. She also lamented feeling disconnected from her husband due to their limited quality time together. Her doctor reassured her that such feelings were common and urged her to remember her humanity, emphasizing the importance of self-care to effectively care for others.
Managing the PLD's compulsive and repetitive behaviour.	Information and training on managing compulsive and repetitive behaviour, as well as direct access to expert healthcare respite services and professional advice.	Laura and her mother had just finished lunch when her mother began insisting that she needed to eat. Despite Laura's explanations that they had already eaten, her mother persisted and even went to the kitchen to prepare another meal. Concerned for her safety, Laura tried to prevent her from cooking, but her mother's persistence led to a heated confrontation, causing Laura to lose her temper and intervene forcefully.
Addressing the PLD's depression, characterized by a lack of motivation to perform basic daily tasks or engage in recreational activities.	Expert information on in-home activities tailored to their specific situation, and grant access to online promoted activities and social groups.	Following her diagnosis, Laura's mother had to opt for early retirement, which, coupled with dementia, plunged her into a state of depression, worsening her symptoms. To combat this, Laura sought in-home activities to keep her mother active and uplift her mood. Discovering online classes tailored for individuals with dementia, such as yoga and dance, through the Alzheimer's Association website, they began attending together. Laura observed a notable improvement in both her mother's mood and her own. Encouraged by the positive outcomes, Laura also joined online sessions for informal caregivers, accompanied by her mother.
Sought information and training on	Access to reliable information on the key aspects of	After a distressing incident with her mother, leaving Laura feeling saddened and ashamed of her reaction, she realized the need for a better approach to handling such situations.

Annex E – Situations, goals and scenarios

<i>Situations</i>	<i>Goals</i>	<i>Scenarios</i>
informal caregiving practices.	dementia, personalized to their specific needs.	Determined not to forget, she quickly set a reminder on her phone to discuss this with her mother's doctor at the next appointment. As she walked home, contemplating the event, Laura turned to Google for guidance, searching "how to manage repetitive behaviours in dementia." The top result, a How-to Guide from the Global Alzheimer Association, provided several tips for managing such behaviours, offering Laura a newfound sense of hope and direction.
Managing medication.	Access to medication management system, including setting notifications and ensuring adherence to the prescribed regimen.	Initially, Laura's mother was still capable of understanding the need for medication and collaborated in setting up the weekly medication box. Laura supplemented this by setting reminders on Alexa to prompt her mother to take the medication. However, as her mother's condition progressed, Laura took on the responsibility entirely, managing the medication through an app on her phone. This app allowed her to input medication details, set reminders, track adherence, and manage refills, ensuring her mother's medication regimen was followed consistently.
Experiencing a loss of social connections and personal time.	Access to support services and helplines to alleviate the burden of informal caregiving.	Amidst her caregiving responsibilities, Laura found herself increasingly isolated from her social circle, as her focus shifted entirely to caring for her mother. Many of her closest connections gradually faded away, unable to comprehend the extent of her struggles and the changes in her life. However, upon discovering the Portuguese Alzheimer Association, Laura reached out to their helpline and immediately found solace in speaking with someone who understood her experiences. This initial contact led her to engage in various activities, both online and in person, offered by the association, such as Café Memória, where she connected with other informal caregivers and forged new relationships.
Fernanda 56 Years old		
Addressing delusional and aggressive behaviour.	Manage delusional and aggressive behaviour, including strategies to protect informal caregivers in the event of violence.	Fernanda's husband exhibited agitated behaviour, accusing her of betrayal and making unfounded accusations. Fearing for her safety, she called emergency services. Reflecting on the incident, Fernanda sought information online on managing aggressive behaviour and self-protection strategies.
Relocated to another city due to insufficient accessible support services in her area.	Access information on nearby support services within reach.	Following an aggressive incident with her husband, Fernanda sought guidance from her doctor regarding dementia symptoms and available support services. Disappointed by the lack of local resources, she pursued assistance from social services but found limited practical support. After months of effort, Fernanda made the decision to relocate to Lisbon in search of more accessible and affordable expert assistance.
Managing the depression of the PLD.	Access to expert psychological support services, both locally and online, for comprehensive assistance.	Fernanda noticed her husband's deepening depression after retirement, which worsened his symptoms. Despite her efforts to engage him in activities, he resisted and even became aggressive. Seeking professional help, they consulted a psychologist who recommended enrolling him in a nearby day centre. With the centre's assistance, he participated in activities like colouring, which significantly improved his mood and engagement.

<i>Situations</i>	<i>Goals</i>	<i>Scenarios</i>
Actively sought out expert training and information on caregiving.	Access to accurate and tailored information about dementia, customized to the specific needs of her husband.	After relocating to Lisbon, Fernanda was determined to enhance her caregiving skills and face the challenges ahead. Together with her children, she actively participated in workshops offered by the Portugal Alzheimer Association, which included both theoretical and practical aspects and varied in duration. While Fernanda attended on-site sessions, her daughter, residing in Germany, joined some online workshops offered by the association.
Explored cost-effective support services such as physical therapy, physically demanding activities, and day centres.	Knowledge on accessing financial aid and understanding legal guidelines, alongside information about respite services available in his local area.	Fernanda was deeply grateful for the opportunity to relocate to Lisbon, where she promptly became a member of the Portugal Alzheimer Association. Through her membership, Fernanda gained access to a range of support services at affordable rates, enabling her to enrol her husband in a nearby day centre for tailored activities and arrange in-home physiotherapy sessions to maintain his mobility. As her caregiving responsibilities increased, Fernanda also hired a professional caregiver to assist with her husband's daily hygiene routine. Thanks to her stable financial situation and support from her children, Fernanda was able to access these essential services, facilitated by the Alzheimer Association's network of contacts.
Experienced loss of employment and social connections.	Access to online social support groups and activities, for informal caregivers.	After her husband's diagnosis, Fernanda chose to retire early to become his full-time caregiver, a decision that led her to leave behind her longstanding friendships and family connections in Coimbra when she moved to Lisbon. While she initially maintained regular visits, her husband's declining condition made travel increasingly difficult. Despite staying connected through phone calls and social media, Fernanda finds solace in online caregiver groups, though she occasionally encounters judgmental attitudes. To counter this, she values in-person interactions at events hosted by the Portugal Alzheimer Association, where she can share experiences with fellow caregivers more openly.
Sought psychological support to address her own needs and well-being.	Access to expert psychological support and training on self-care practices.	After her husband's diagnosis, Fernanda's spirits waned, and her children, noticing her change in demeanour, encouraged her to seek professional help. Reluctantly, Fernanda agreed, and after connecting well with her psychologist, she continued online sessions even after relocating to Lisbon, finding solace and support in their discussions, sometimes even involving her family.
Struggling to cope with feelings of grief and acceptance of the situation.	Access to grief counselling sessions, and guidance on coping activities to navigate through the grieving process.	As her husband's condition worsens, Fernanda grapples with a sense of constant loss, compounded by the difficulty of communication and the inevitable changes in their relationship. This sorrow extends to her children, adding to her emotional burden. Seeking solace, Fernanda turns to writing, keeping a journal of her experiences and emotions, a practice recommended by her psychologist. In an effort to support her children, she suggests they attend grief counselling sessions together, providing them with a platform to express their feelings and write letters to Fernanda's husband.
Maintaining communication and exchanging information with both their children and	Efficiently store written notes, photos, and videos documenting various situations, and seamlessly share this	Between appointments spaced several months apart, Fernanda meticulously notes down any questions or concerns she wants to address with her husband's healthcare team. As a member of the Alzheimer's Association, she gained access to various respite services, streamlining communication by capturing photos and videos on her phone to share with them. Embracing

Annex E – Situations, goals and scenarios

<i>Situations</i>	<i>Goals</i>	<i>Scenarios</i>
healthcare professionals.	information with peers and healthcare professionals.	technology, Fernanda also shares moments of joy and humour with her children through images and videos of her husband's leisure activities and amusing moments.

Annex F – User stories and task analysis

This annex presents the detailed user stories and corresponding task analysis developed in this study.

Table 14: Task analysis for User Stories addressing the Lack of Information and Advice

User Stories	Task Analysis
Training Guides	
“As an informal caregiver, I want access to reliable and easy to understand information about the type of dementia diagnosed to my wife so that I can gain a better understanding of her condition, feel more informed and better equipped to support her throughout this journey.”	1. Open the app and see the home screen 2. On the home screen the user will select the menu: "Information and training guides section" 3. The user will see a section called: "Information and training for you" with several options of information guides (these guides were selected based on the set-up questionnaire when created) 4. The user selects the guide referring to the (diagnose, specific symptoms, behaviour changes or other) of the person he cares for 5. The app presents the result" Or 3. The user selects the search option 4. The app suggests filtering options 5. The user selects filter X 6. The app presents results 7. The user selects result X 8. The app presents the result details
“As an informal caregiver, I want reliable and easy to understand information and training on how to effectively deal with the behaviour changes of my wife so that I can enhance the well-being of my wife and myself.”	
“As an informal caregiver, I want expert information and training on how to effectively handle the compulsive and repetitive behaviour of my mother through the app so that I can equip myself with the knowledge and skills necessary to provide the best possible care without stressing myself out.”	
“As an informal caregiver, I want easy access to expert information on in-home activities specifically designed to address the feelings of depression in the PLD through the app so that I can create a supportive environment with activities that cater to my mother needs and preferences, fostering our relationship and well-being.”	
“As an informal caregiver, I seek strategies to defend myself in case of violent behaviour towards me through the app so that I can prioritize my safety while providing care and support to my husband.”	
Information and Useful Contacts	
“As an informal caregiver, I want a direct connection to expert healthcare respite services and professional advice, within my residential area if possible, so that I can access immediate support and guidance in managing these challenging situations.”	1. Open the app and see the home screen 2. Enter the Information and Training section 3. Scroll down to "Get support near you" 4. Select the most convenient option: respite services, psychological services,

Annex F – User stories and task analysis

User Stories	Task Analysis
“As an informal caregiver, I want accessible information on affordable in-home social support services through the app so that I can explore practical solutions to occupy and care for my mother, alleviating the constant need for my presence.”	associations and support groups, financial and legal support - The app presents all results - The user selects result X - The app presents the result details
“As an informal caregiver, I want access to affordable psychological services and support groups that are either close to my residential area or available online through the app so that I can connect with others facing similar challenges, enhance my emotional well-being and feel more confident and supported in my role as a caregiver.”	
“As an informal caregiver, I want access to grief counselling sessions, whether online or in person, through the app so that I can receive professional guidance and support to navigate through my emotions and work towards acceptance.”	
“As an informal caregiver, I want a direct connection to caregiver social support groups, such as associations, within my residential area and/or online so that I can have a platform for sharing my experiences and find mutual support.”	
“As an informal caregiver, I want convenient access to online promoted activities and social groups that I can engage in with my mother through the app so that I can offer her opportunities for interaction, potentially alleviating feelings of isolation associated with depression and creating a more positive and stimulating daily experience for her.”	
“As an informal caregiver, I want guidance on how to apply for financial support and understand legal regulations related to informal caregiving so that I can empower myself with the necessary resources, that enables me to maintain a balance between caregiving responsibilities and work commitments.”	
News	
"As an informal caregiver, I want easy access to news updates and advice on current legal and social regulations through the app so that I can stay informed about evolving policies and guidelines affecting caregiving responsibilities."	- Open the app and see the home screen - Enter the Information and Training section - Scroll down to the Latest news section - The user sees the most recent news - The user selects one of the results to view the details
“As an informal caregiver, I want easy access to news, and advice on current technology or practical solutions through the app so that I can stay informed about innovative tools and resources that can effectively address both practical and emotional aspects of my needs.”	Or - The user selects the view all news option - The user selects the search option - The app suggests some filtering options - The user selects filter X - The app presents results - The user selects result X - The app presents the result details

Table 15: Task analysis for User Stories addressing the Lack of Practical Support

User Stories	Task Analysis
Medication	
“As an informal caregiver, I want to easily define and organize the medication routine, specifying dosage and timing so that I can efficiently manage the medication prescribed to my wife.”	1. Open the app and see the Dashboard of the Person Living with Dementia 2. Scroll down to the Medication section and select it 3. The app presents a section to edit the current medication prescription 4. The user will add a new medication intake, by entering the following information: Name of the medicine, dosage and time of intake. 5. The app will automatically set up an alarm for the new medication entry. And 1. The app will notify the user that it is time to take a medication 2. The user will check the notification and confirm the medication intake. If not, the notification will be highlighted at the top bar of the app until the user confirms it. 3. This notification will be stored in the notification’s history. And 1. Open the app and see the Dashboard of the Person Living with Dementia 2. Scroll down to the Medication section and select it 3. Select the option Share medication schedule 4. The app opens the native share option of the android system (email, WhatsApp, drive, etc)
“As an informal caregiver, I want the app to provide reminders and confirmations, ensuring that the correct medications are taken at the designated times so that I can ensure adherence to the prescribed routine”	
“As an informal caregiver, I want the option to share my medication schedule with trusted individuals, such as family members or caregivers so that I can keep them informed and involved in supporting the health journey of my wife.”	
Monitoring	
“As an informal caregiver, I want the ability to constantly monitor my wife location and physical integrity so that I can actively work to prevent falls and ensure her safety in different situations.”	1. Open the app and see the Dashboard of the Person Living with Dementia 2. The user sees the dashboard overview with the current location of the PLD and status of the major health parameters And 1. The user gets a notification on the phone 2. The user opens the notification to see the details (presents the current location and current health measure status). If not, the notification will be highlighted at the top bar of the app until the user opens it. 3. The app suggests the necessity to follow up with your family doctor or call the emergency services in the case of high severity incident
“As an informal caregiver, I want access to real-time information on her basic health measurements, including body temperature, stress levels, heart rate, and oxygen saturation, through the app so that I can stay informed about her well-being and potential underlying health issues.”	
“As an informal caregiver], I want timely notifications when a fall occurs, or a major disruption is detected in her health parameters so that I can have a quick and appropriate responses to any health issues detected.”	
“As a informal caregiver, I want in the event of a fall or a major disruption in health parameters occurs, to have the option to	

Annex F – User stories and task analysis

<i>User Stories</i>	<i>Task Analysis</i>
establish a direct connection with our family doctor and/or emergency services through the app so that I can ensure immediate help and minimize any potential impact on my wife's well-being.”	And - Open the app and see the Dashboard of the Person Living with Dementia - The user sees the dashboard overview with the current health measures - The user sees a button to access the full history for health measures - The user sees the details for all measure by week and month with latest relevant events highlighted - The user selects the option share full health history - The app opens the native share option of the android system
“As an informal caregiver, I want the ability to track my wife medical history within the app for comprehensive health management so that I can share this information with trusted individuals, such as family members, the family doctor and other health practitioners.”	
Documenting	
"As an informal caregiver, I want the ability to record real-time notes about my wife behavioural changes as they occur through the app so that I can accurately document and track these occurrences, providing valuable information for her healthcare provider.”	- Open the app and see the Dashboard of the Person Living with Dementia - Scroll down to the PLD Journal section - The user will add a new entry to the Journal and attach photos and a video And - Open the app and see the Dashboard of the Person Living with Dementia - Scroll down to the PLD Journal section - Views the latest one entries of the journal and selects one - In the details of the entry selects the option share entry The app opens the native share option of the android system (email, WhatsApp, drive, etc)
“As an informal caregiver, I want an easy way to document information, including written notes, photos, and videos, about various situations through the app so that I can keep a comprehensive record of important events and updates regarding my husband health and well-being.”	
“As an informal caregiver, I want an easy and quick way to share the documented information with peers and health practitioners through the app so that I can facilitate effective communication and collaboration among all parties involved in the care process, ensuring that everyone stays informed and can provide the necessary support and assistance.”	

Table 16: Task analysis for User Stories addressing the Lack of Emotional Support

<i>User Stories</i>	<i>Task Analysis</i>
Companion Bot	
“As an informal caregiver, I want suggestions on wellbeing and self-care practices through the app so that I can learn effective strategies to manage stress, prioritize self-care, and promote my overall mental and emotional well-being.”	1. Open the app and see the Dashboard of the Person Living with Dementia 2. The app will show the companion menu bot message with a daily suggestion or reminder of a wellbeing or self-care practice. 3. The companion should suggest to the user that he uses the informal caregiver journaling feature
“As an informal caregiver, I want suggestions on activities to undertake with the PLD to foster communication and enhance our relationship through the app so that I can incorporate meaningful and engaging activities into our daily routine, promoting communication and strengthening our bond while also prioritizing my own mental and emotional well-being.”	

<i>User Stories</i>	<i>Task Analysis</i>
	And 1. Open the app and see the Dashboard of the Person Living with Dementia 2. The app will show the companion menu bot message asking the user if he wants a suggestion about an activity to undertake with the PLD. 3. If the user selects the Yes option, the app presents the activity, if the user selects No, the bot will ask if the user wants to receive this suggestion with a different frequency
Journaling	
“As an informal caregiver, I want suggestions about activities that can help me deal with grief through the app so that I can have practical tools and coping strategies to process my grief in a healthy and constructive manner.”	1. Open the app and see the Dashboard of the Person Living with Dementia 2. Access the Informal Caregiver Journaling Menu 3. The user will add a new entry to the Journal

Annex G – Prototype paper sketches

This annex presents the full paper sketches of the prototype developed in this study.



Figure 55: Paper sketch: App presentation and profile creation flow

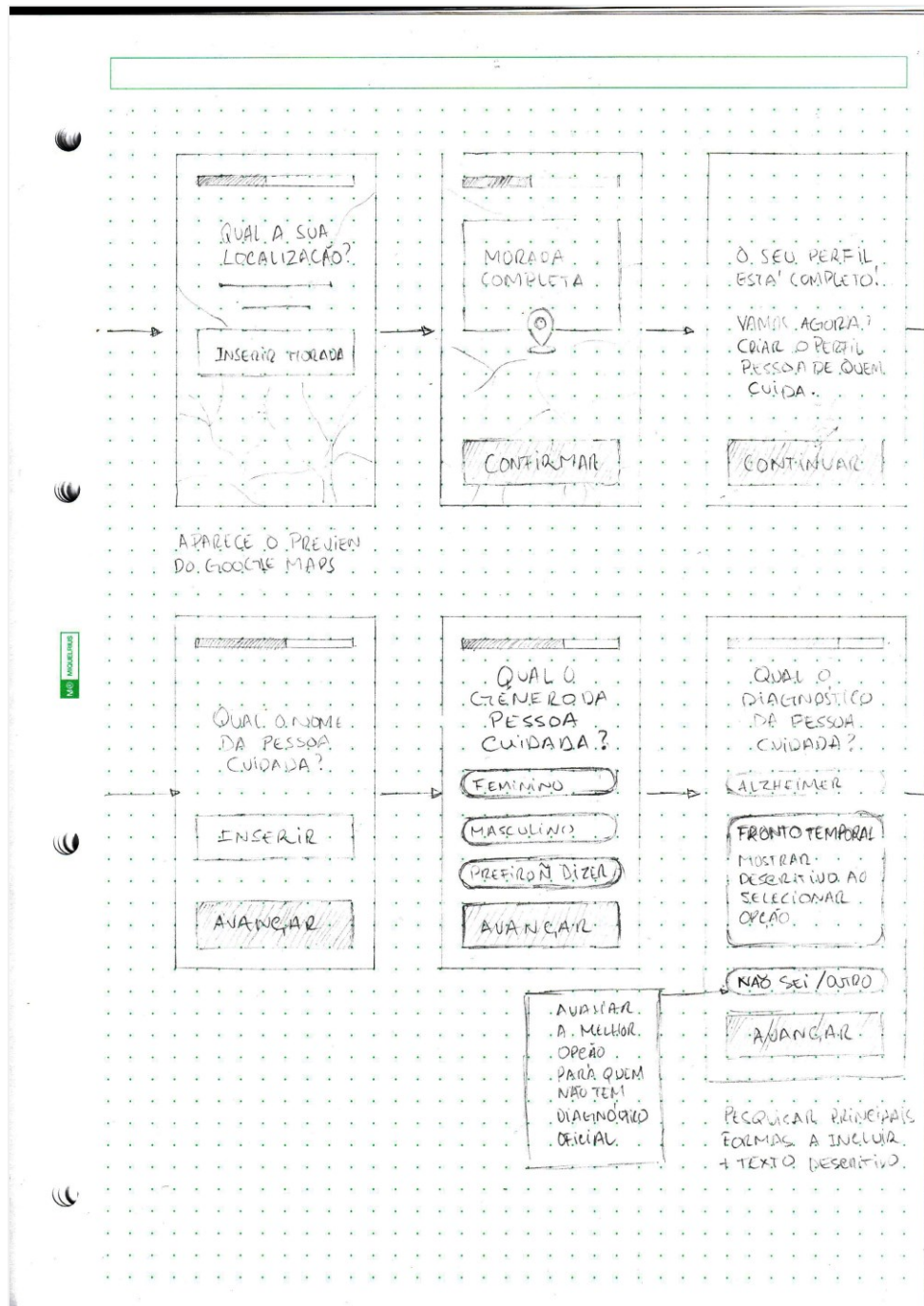


Figure 56: Paper sketch: Profile creation flow for informal caregiver and PLD

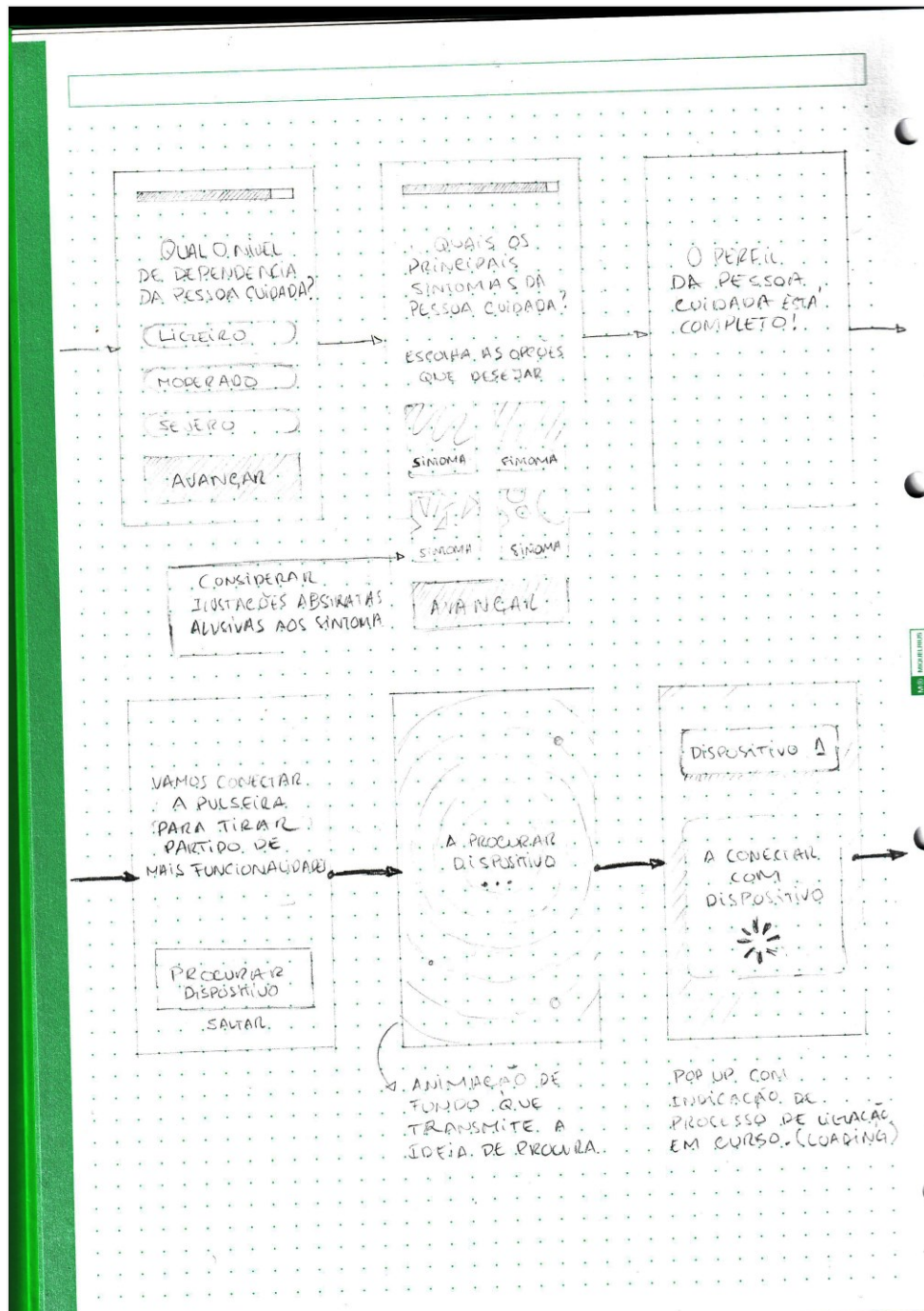


Figure 57: Paper sketch: Connecting smartband flow

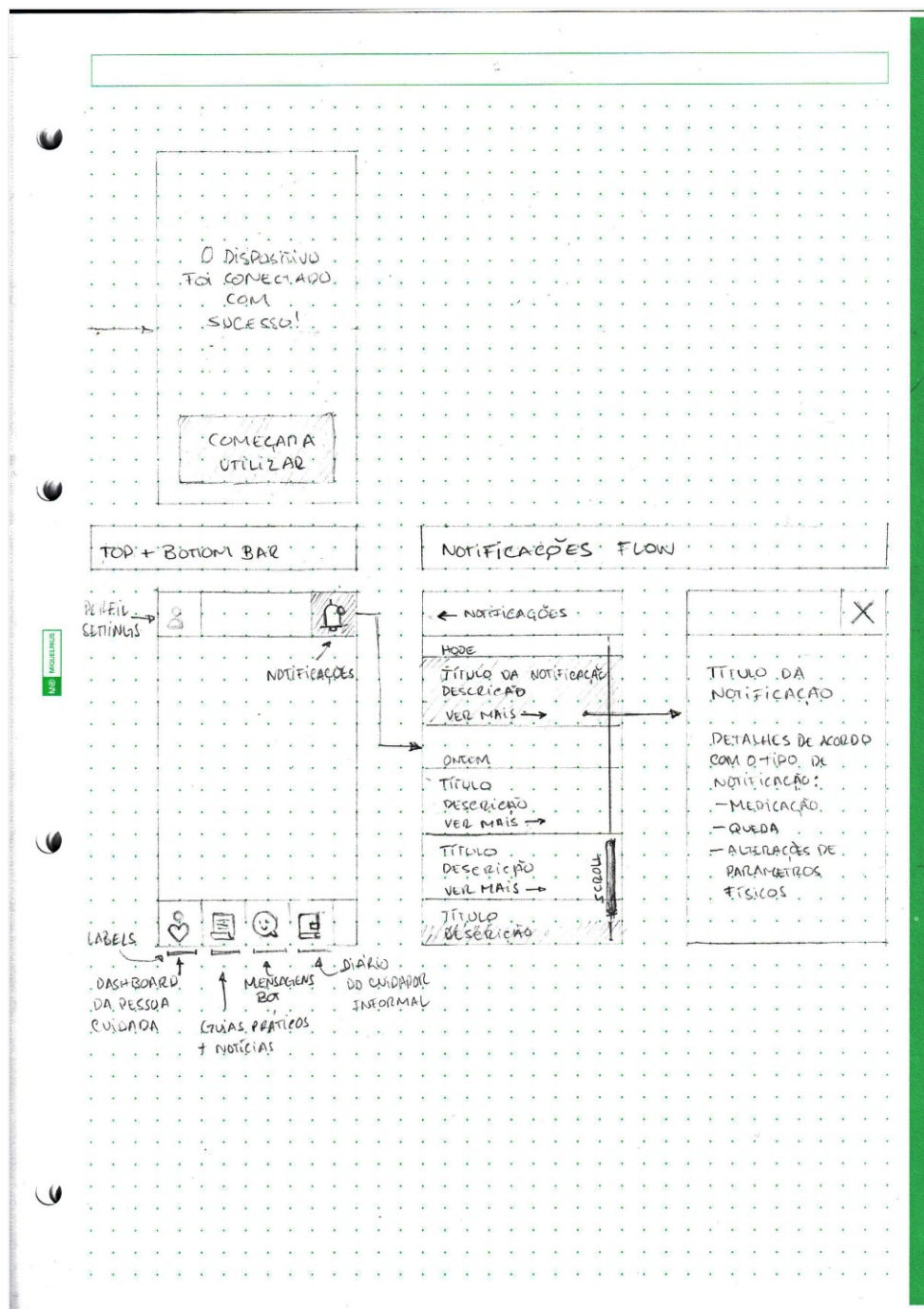


Figure 58: Paper sketch: Bottom menu bar options and notifications screen

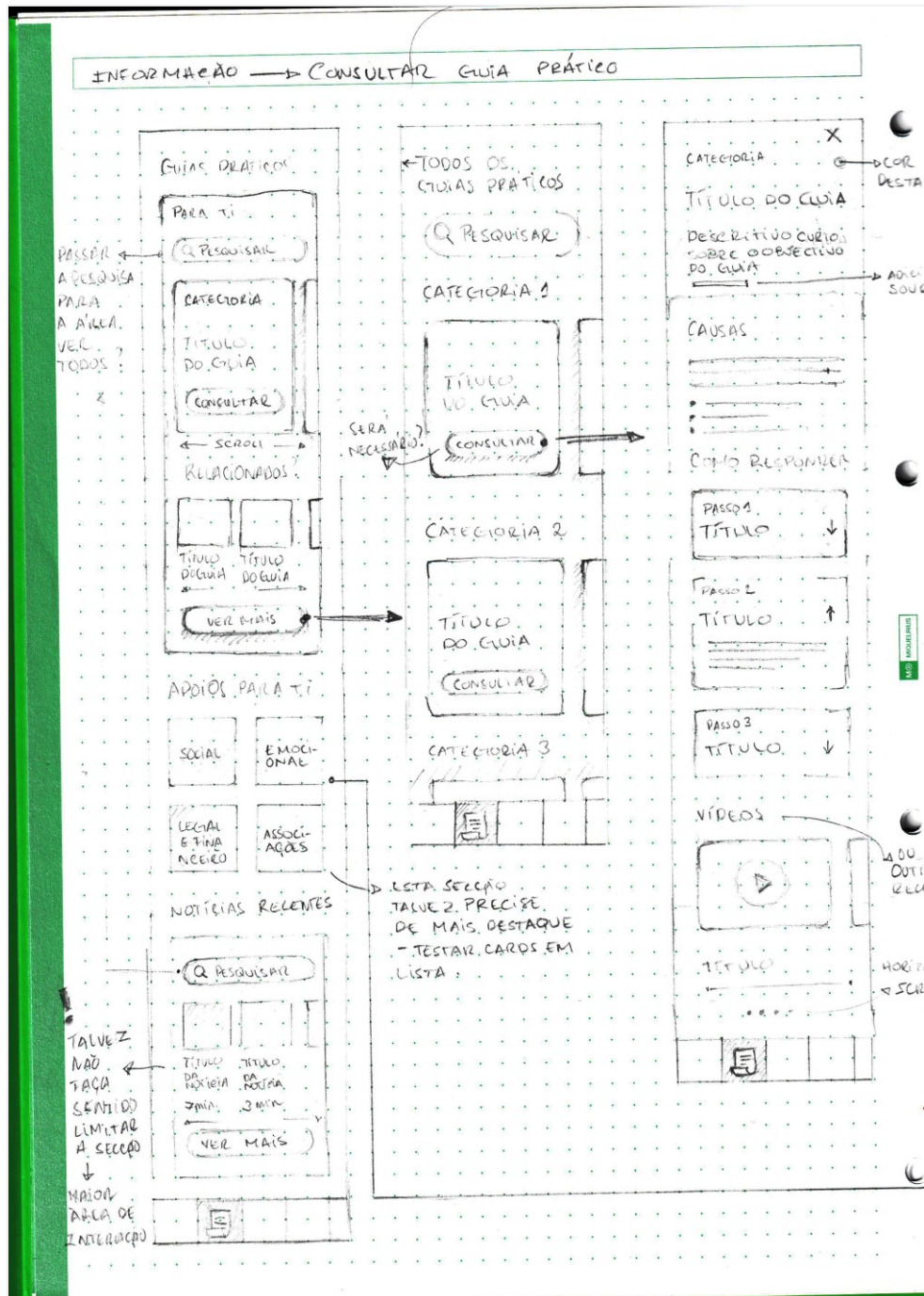


Figure 59: Paper sketch: Resources and consulting practical guide screens

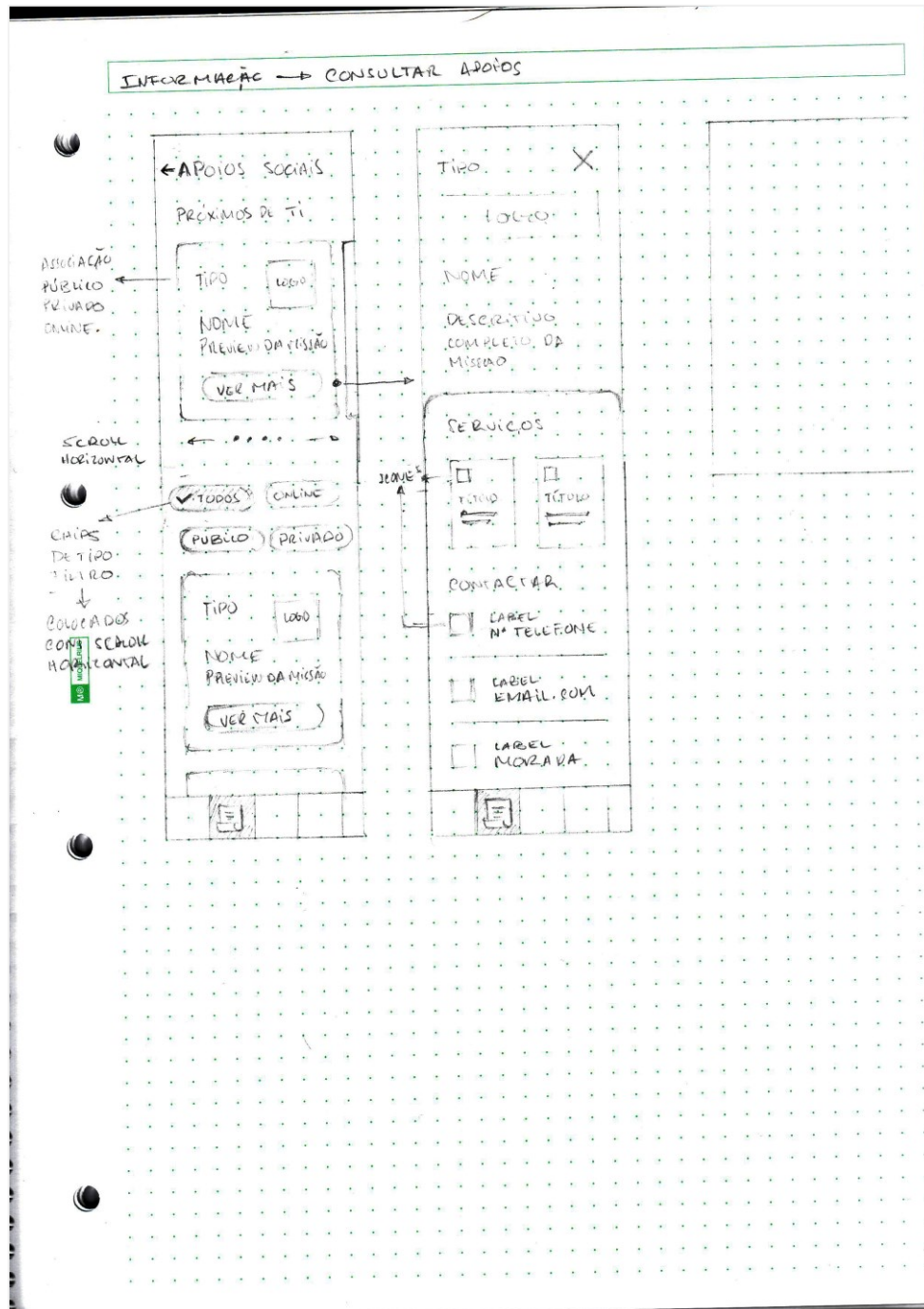


Figure 60: Paper sketch: Consulting support details screens

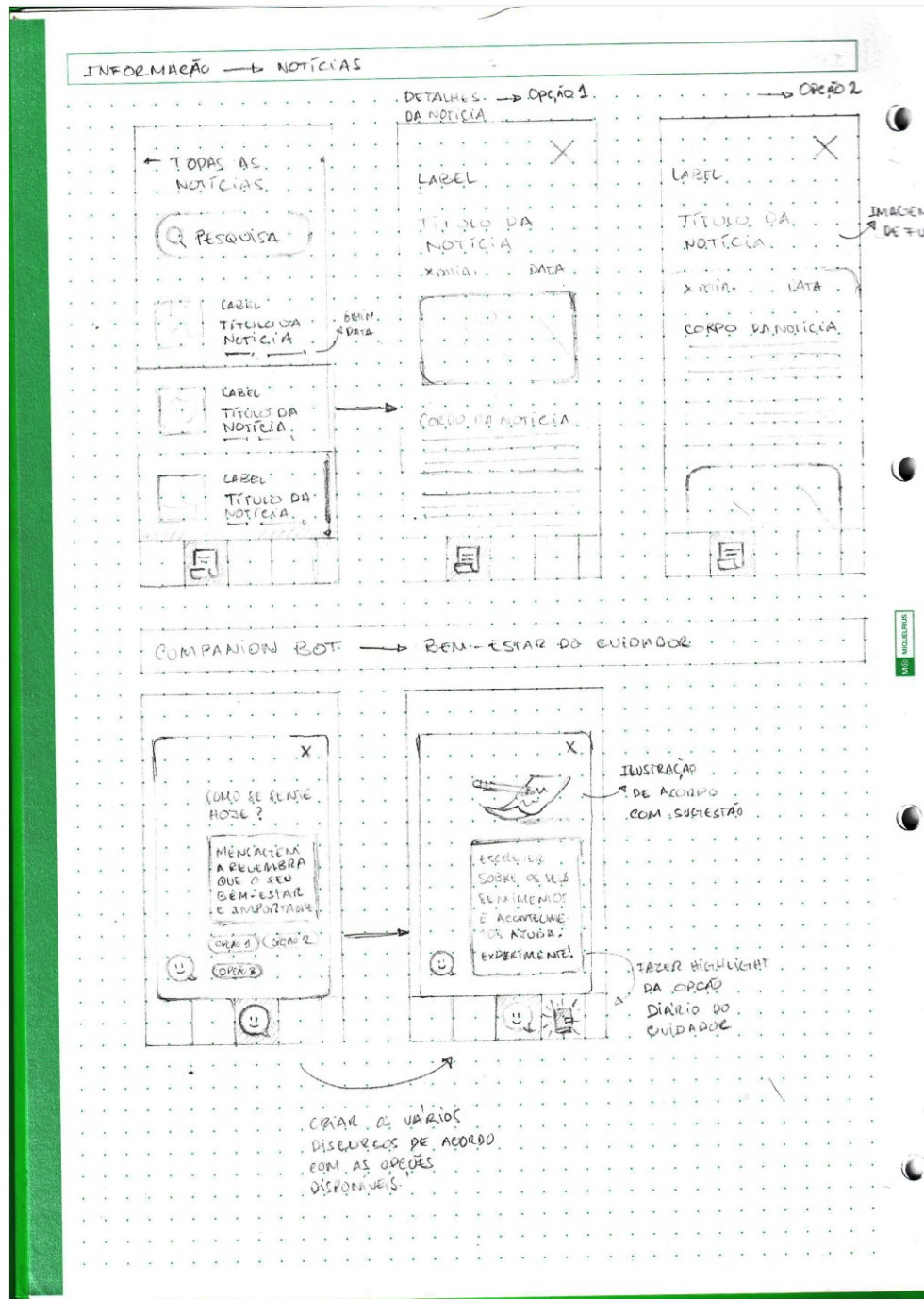


Figure 61: Paper sketch: News and chatbot dialog screens

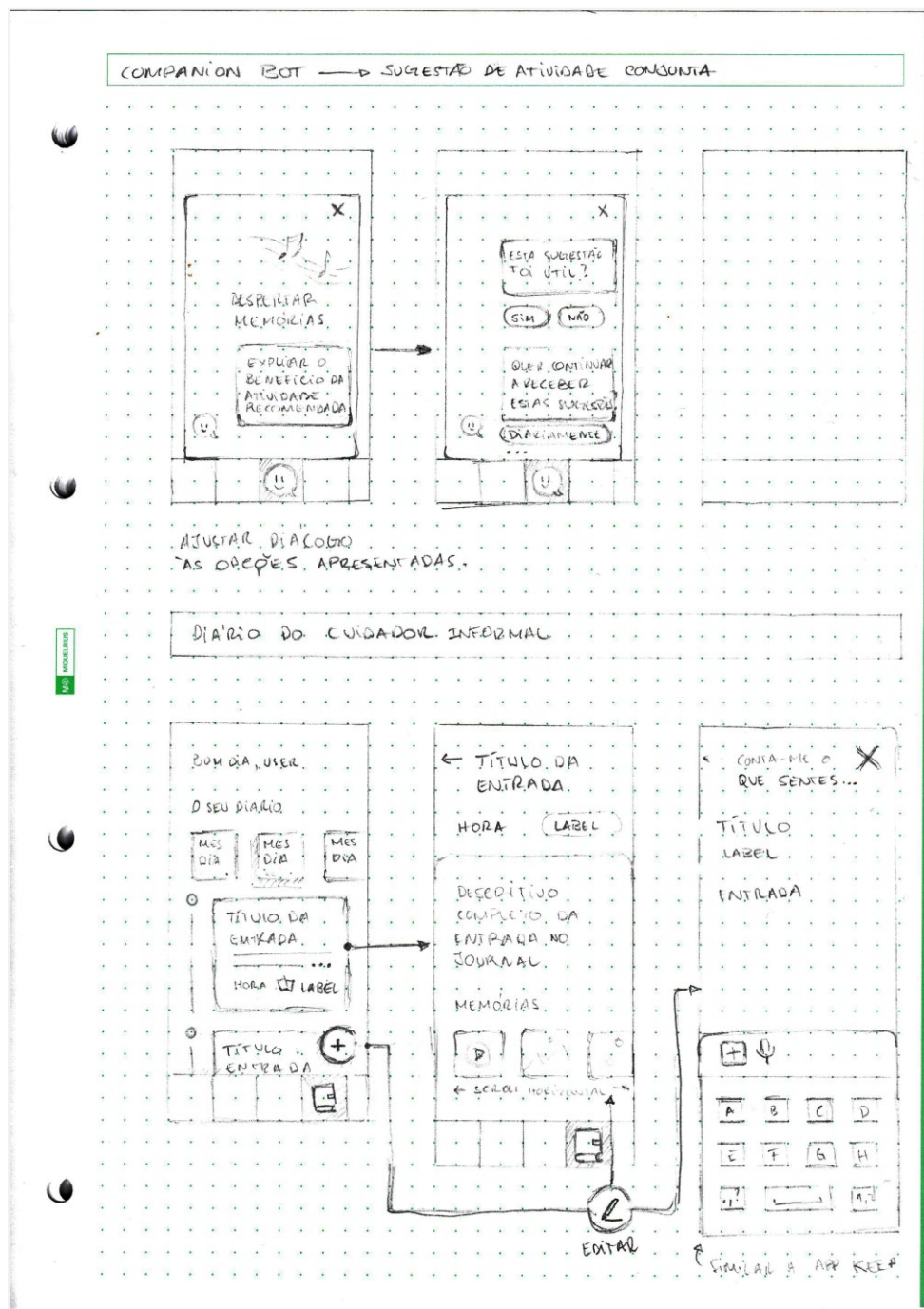


Figure 62: Paper sketch: Informal caregiver diary screens

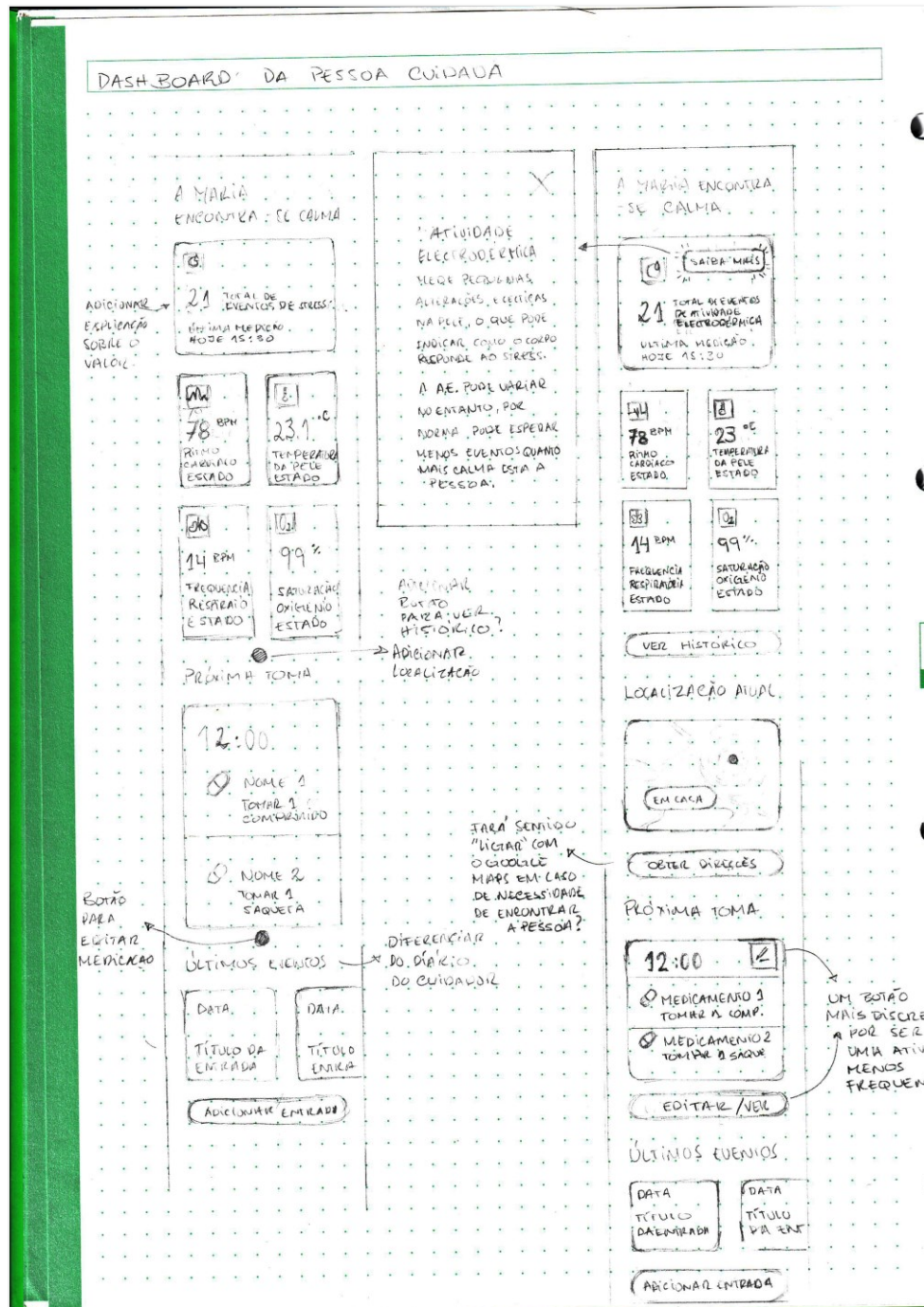


Figure 63: Paper sketch: Dashboard for the Person Living with Dementia

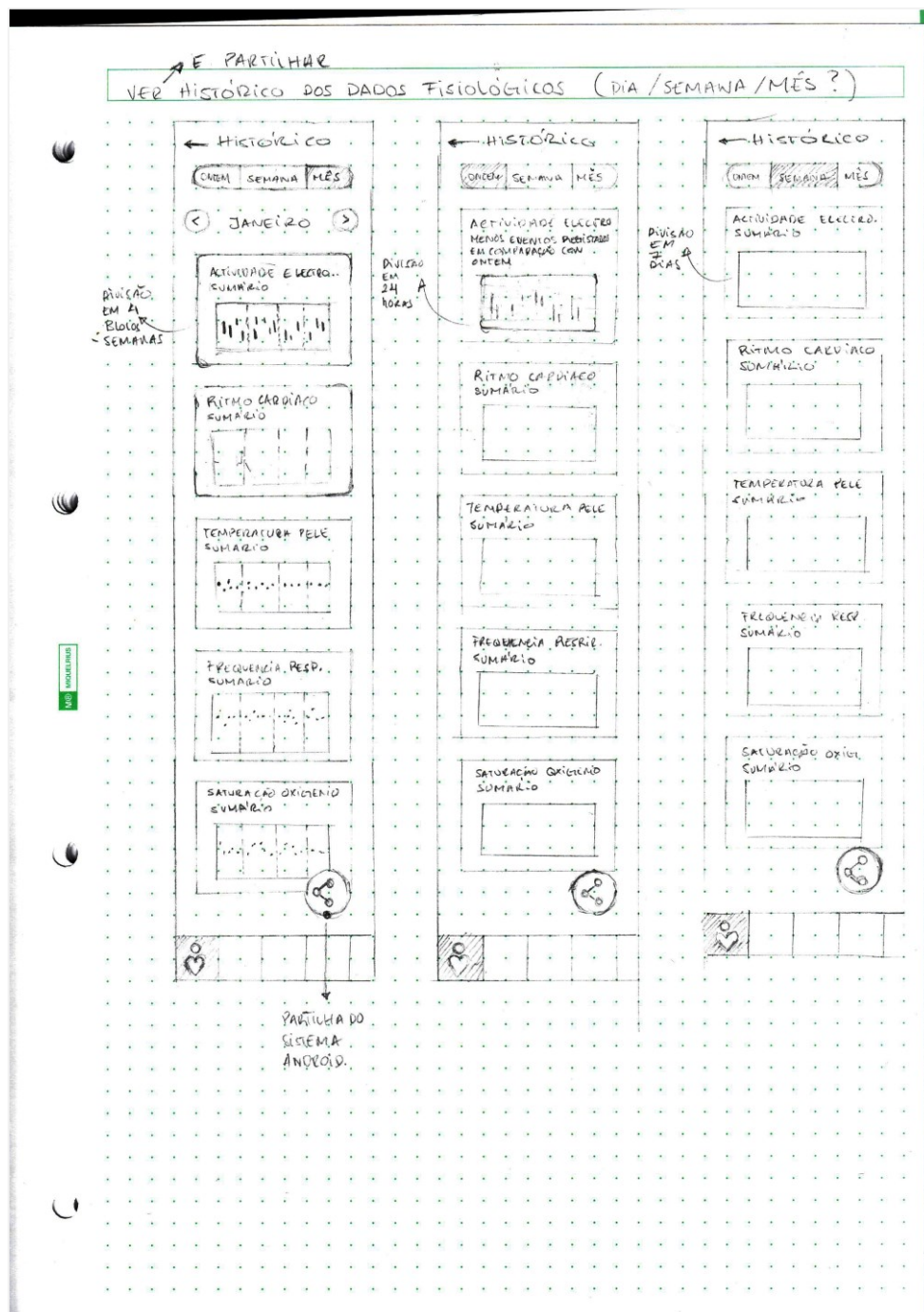


Figure 64: Paper sketch: Historic overview of biometric data screens

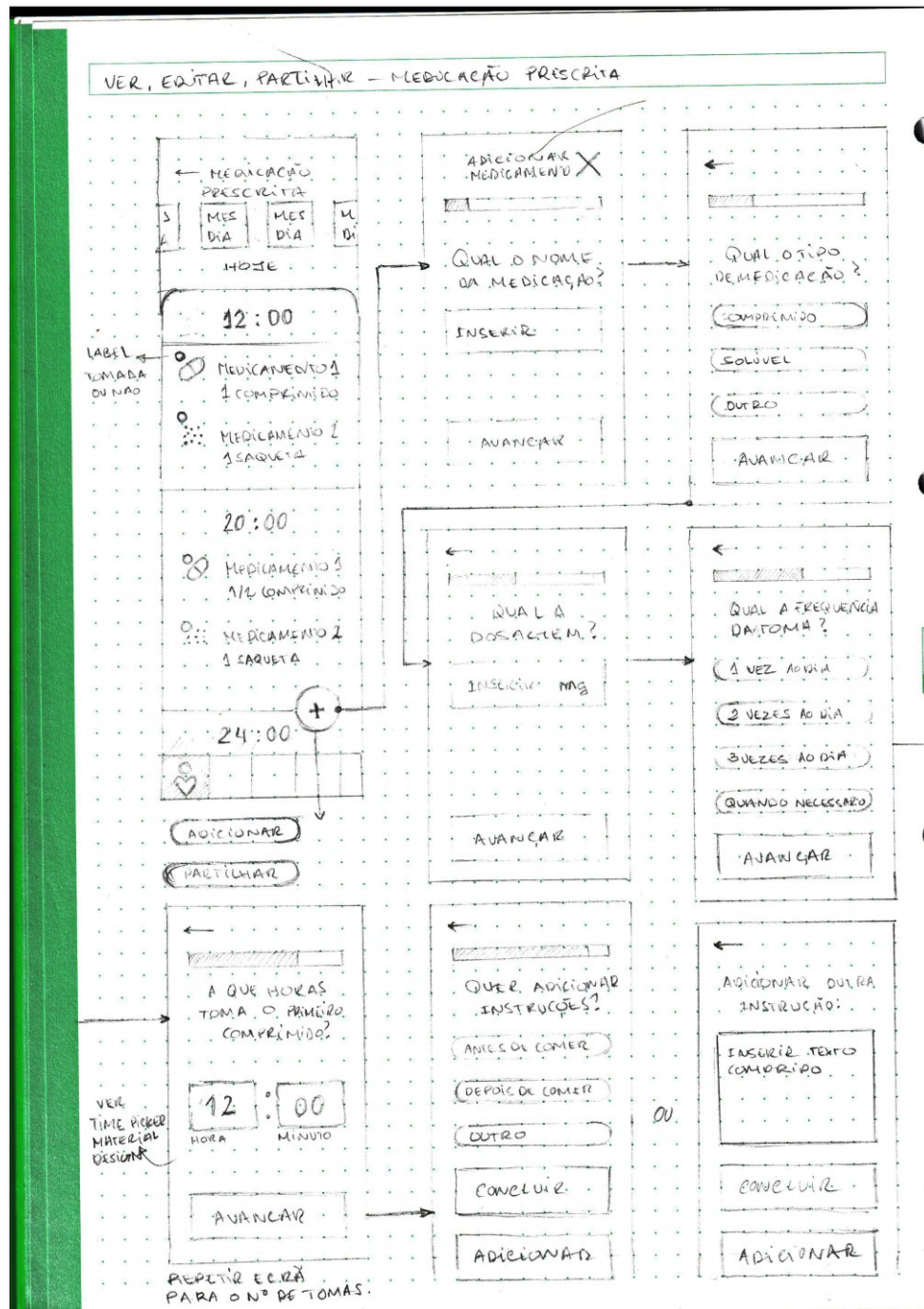


Figure 65: Paper sketch: Medication prescription schedule screens

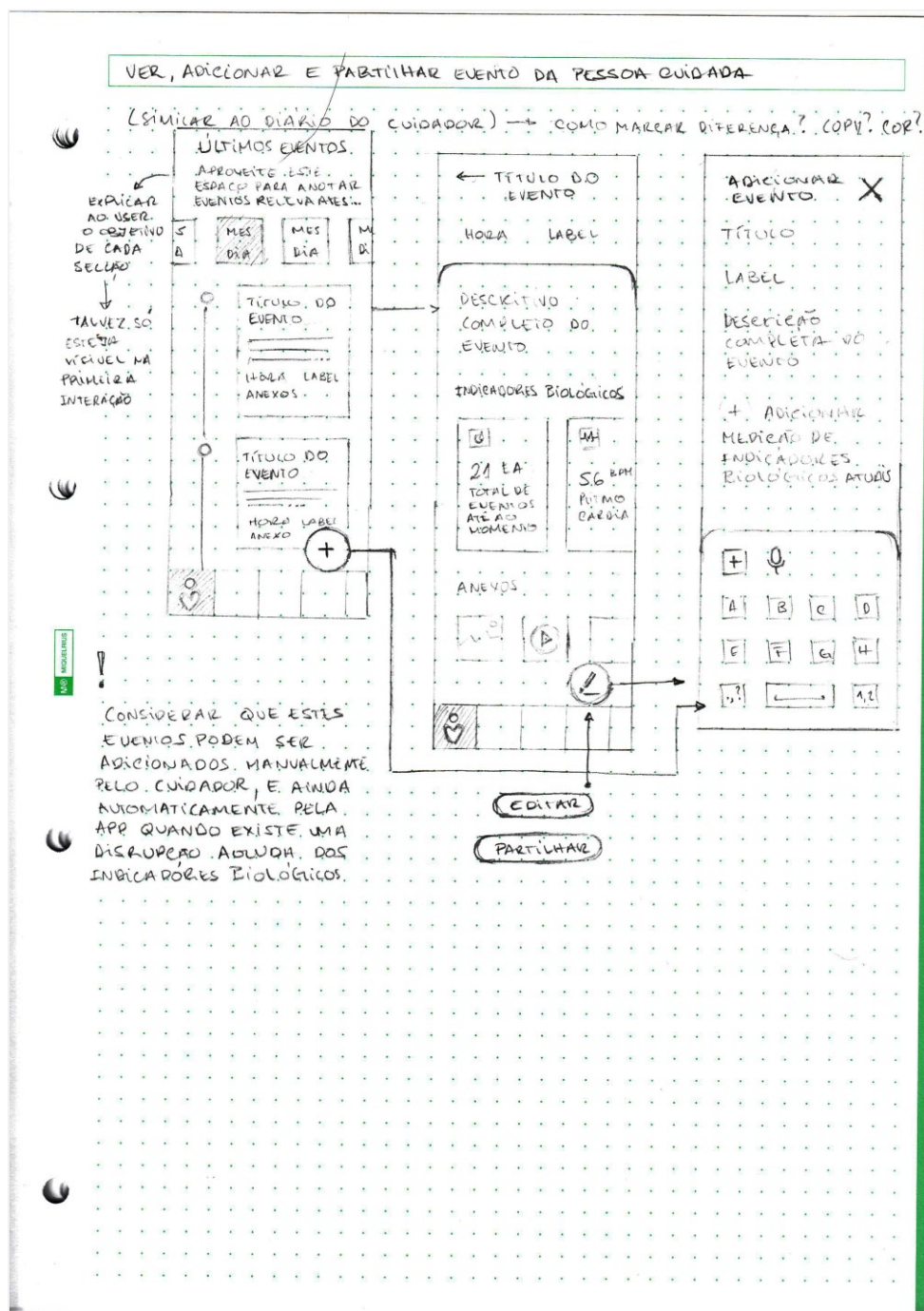


Figure 66: Paper sketch: Registering events for the PLD screens

Annex H – Prototype high-fidelity sketches

This annex showcases the comprehensive high-fidelity screens of the prototype developed in this study and provides links to the Figma project, the interactive prototype, and the prototype video.

Figma project: <https://bit.ly/3L6C8ro>

Figma prototype: <https://bit.ly/45Nxto3>

Video of the prototype: <https://bit.ly/3W2gYRv>

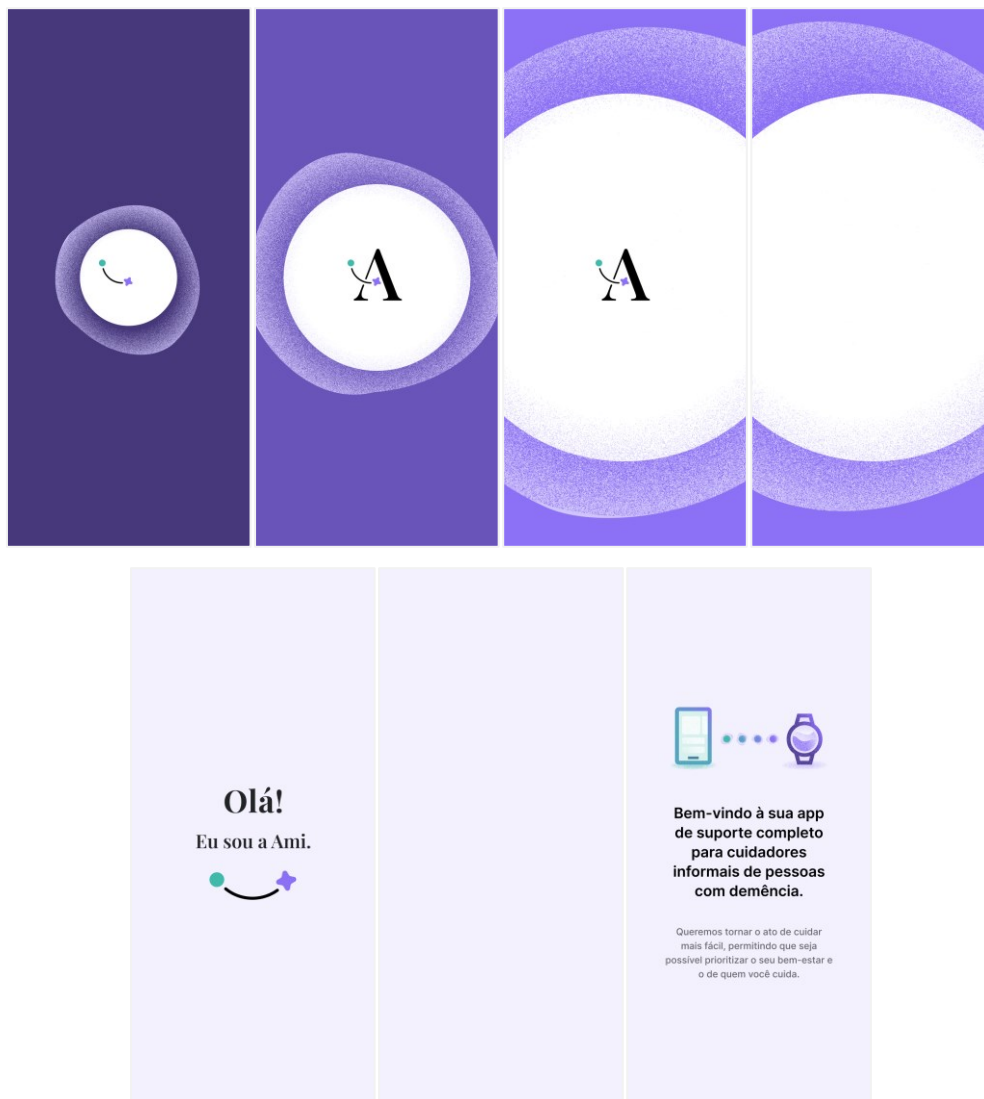


Figure 67: High-fidelity: App presentation animation flow

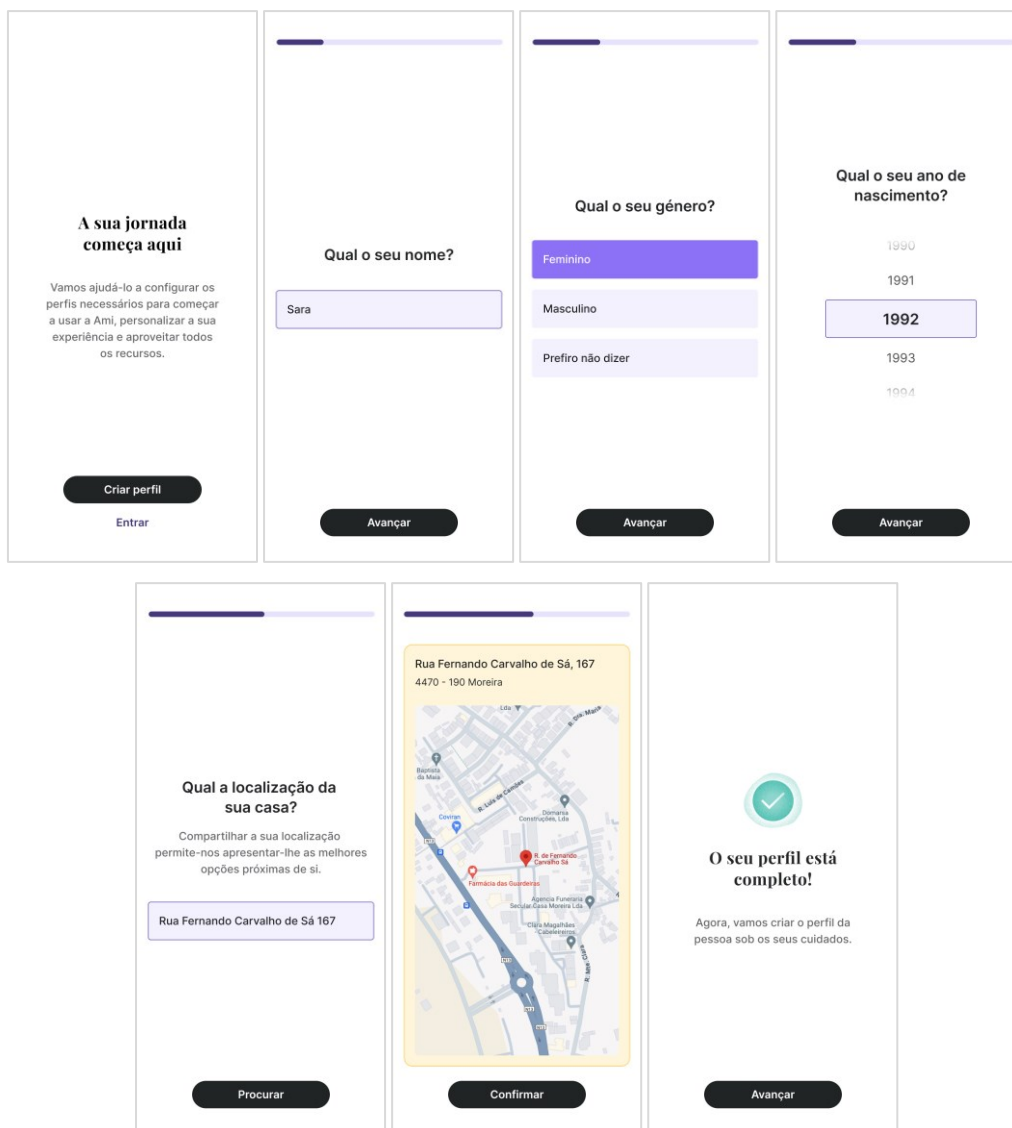


Figure 68: High-fidelity: Profile creation for informal caregiver flow

Annex H – Prototype high-fidelity sketches

Qual o nome da pessoa cuidada?

Maria Clara

Avançar

Qual o género da pessoa cuidada?

Feminino

Masculino

Prefiro não dizer

Avançar

Qual o diagnóstico da pessoa cuidada?

Doença de Alzheimer
Tipo de demência que provoca uma deterioração global, progressiva e irreversível de diversas funções cognitivas (memória, atenção, concentração, linguagem, pensamento, entre outras).

Demência Vascular

Demência de Corpos de Lewy

Demências Frontotemporais

Demência associada à doença de Parkinson

Demência Alcoólica

Não tenho diagnóstico oficial

Avançar

Quais os principais sintomas que a pessoa cuidada apresenta?

Escolha as opções que desejar.

Perda de memória

Perda de Autonomia

Apatia e depressão

Descontrolo emocional

Alucinações

Comportamentos obsessivos

Avançar



O perfil da pessoa cuidada está completo!

Para começar a tirar o máximo de partido da Ami, conecte a sua smartband.

Conectar

Saltar

Mantenha a smartband próxima deste dispositivo.

A procurar...

Mantenha a smartband próxima deste dispositivo.

A procurar...

Dispositivo encontrado

Ami Smartband

Modelo

Conectar dispositivo

Com dificuldades? Ver ajuda



Dispositivo conectado

 Smartband: Ligada
Sincronização ativa

 Bateria: 80%
Capacidade adequada

 Em utilização
Mantenha no pulso

 Aplicação: Ativa
A correr de fundo

 Internet: Ligada
Última sincronização: à 15s.

Começar a usar

Figure 69: High-fidelity: Profile creation for PLD and smartband connection flow

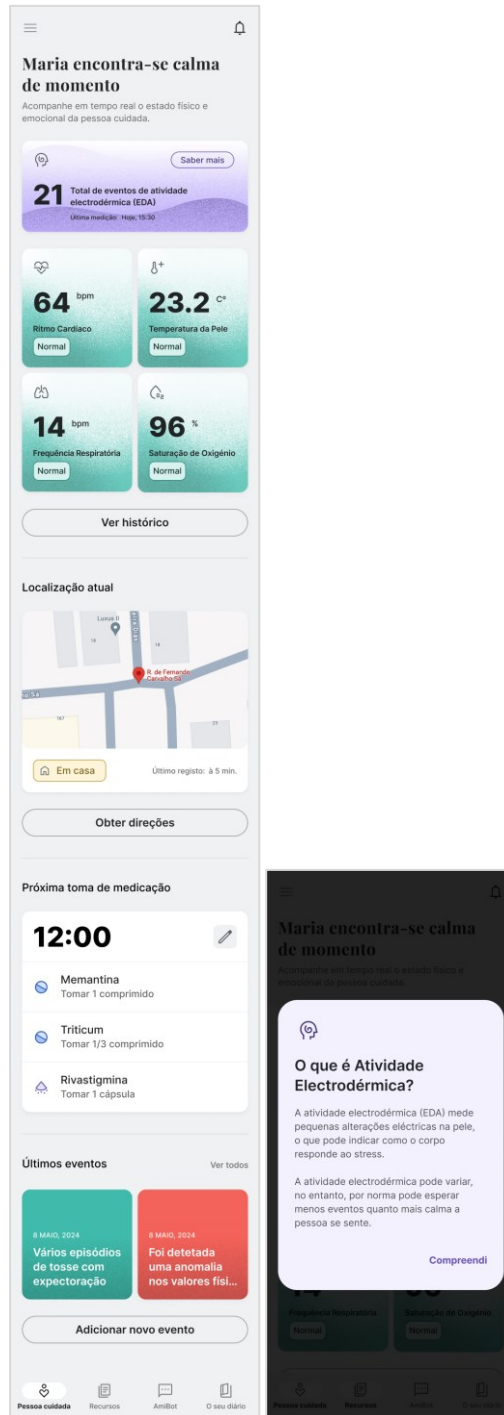


Figure 70: High-fidelity: Dashboard for the PLD know more about EDA pop up

Annex H – Prototype high-fidelity sketches

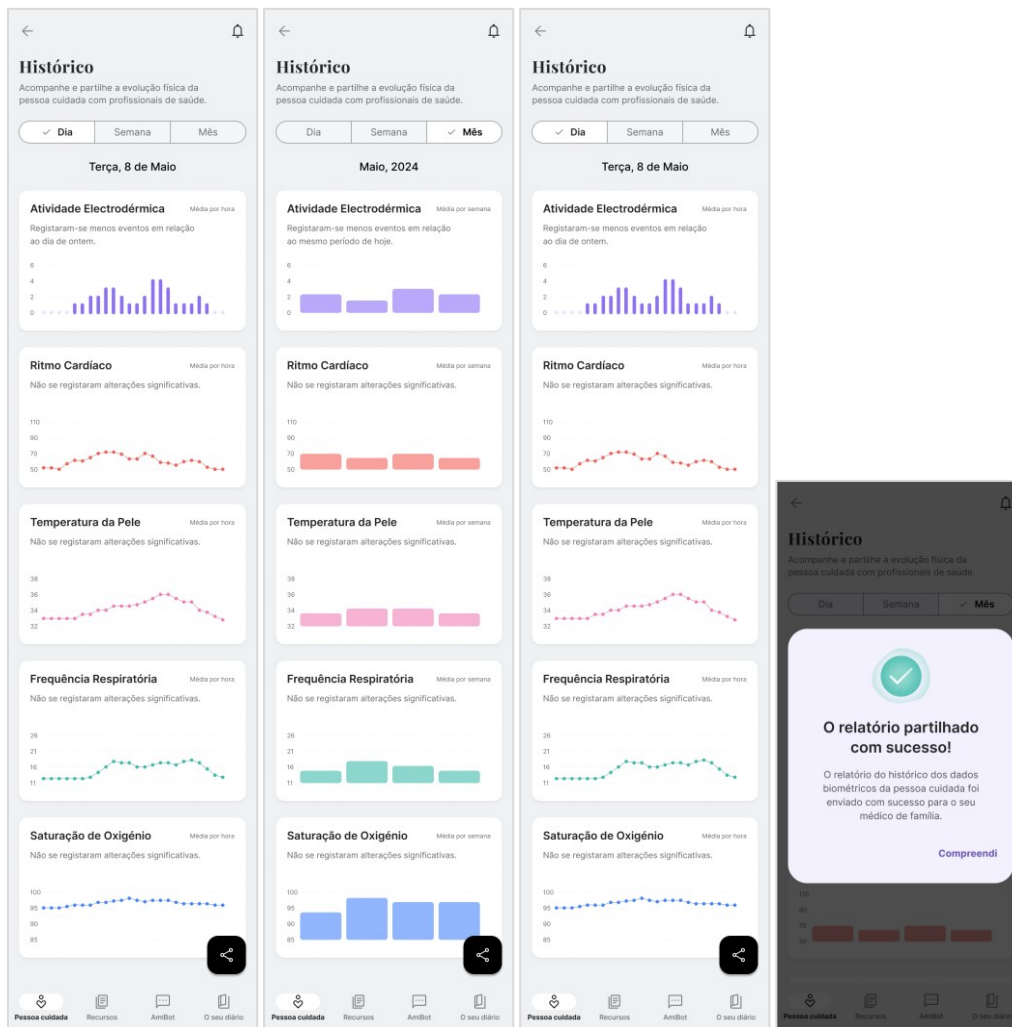


Figure 71: High-fidelity: Historic overview of biometric data screens and success message for sharing report

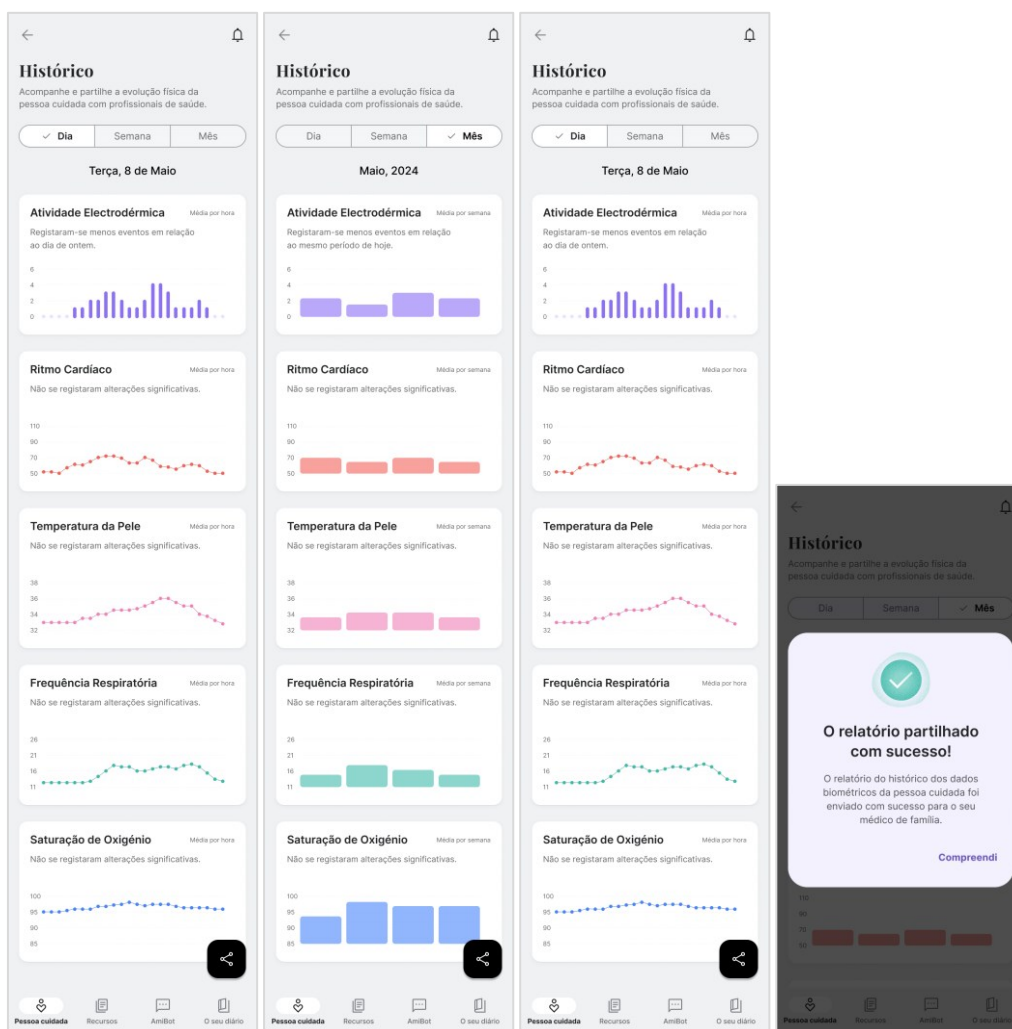


Figure 72: High-fidelity: Historic overview of biometric data screens and success message for sharing report

Annex H – Prototype high-fidelity sketches

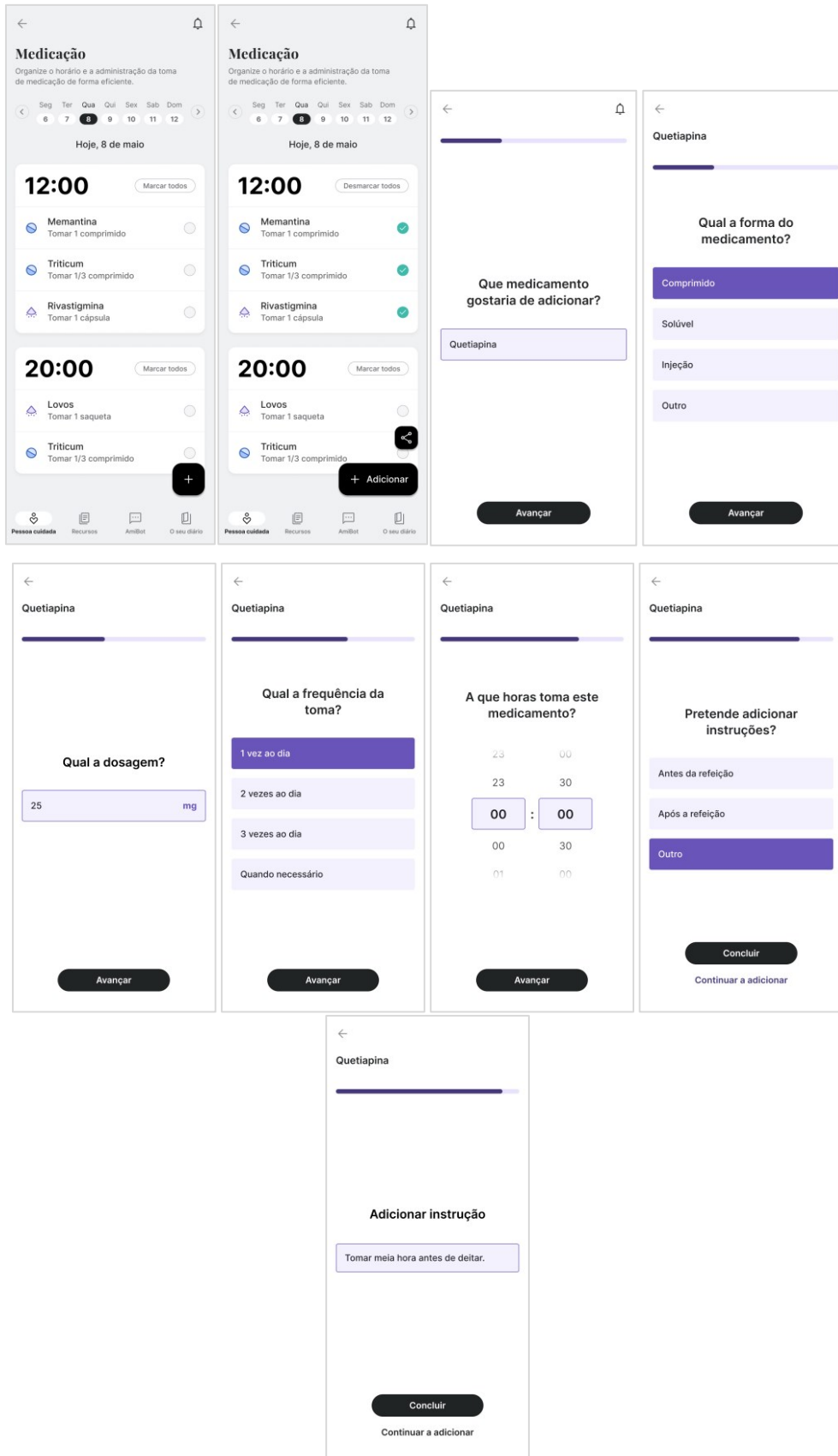


Figure 73: High-fidelity: Medication prescription schedule and new medication flow

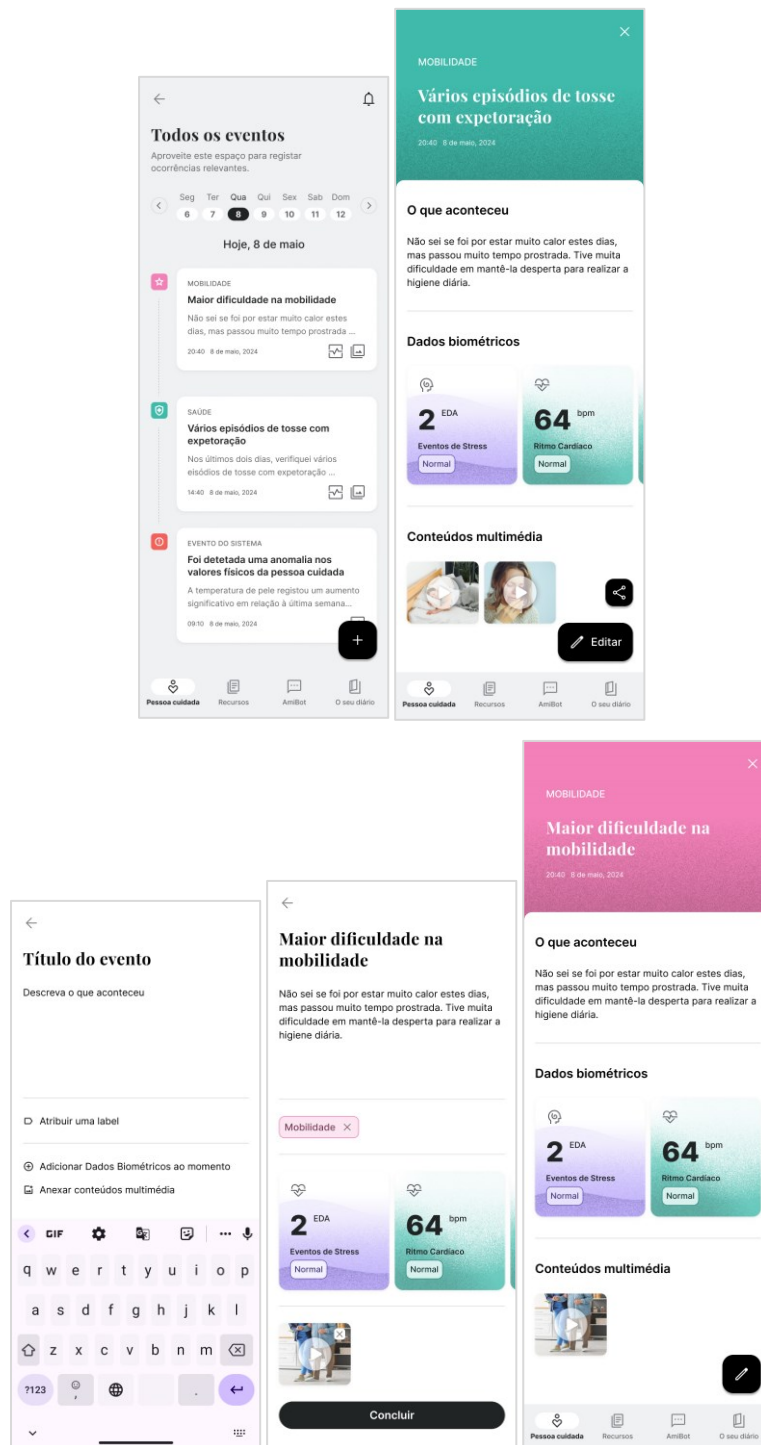


Figure 74: High-fidelity: Register events regarding the PLD screens

Annex H – Prototype high-fidelity sketches

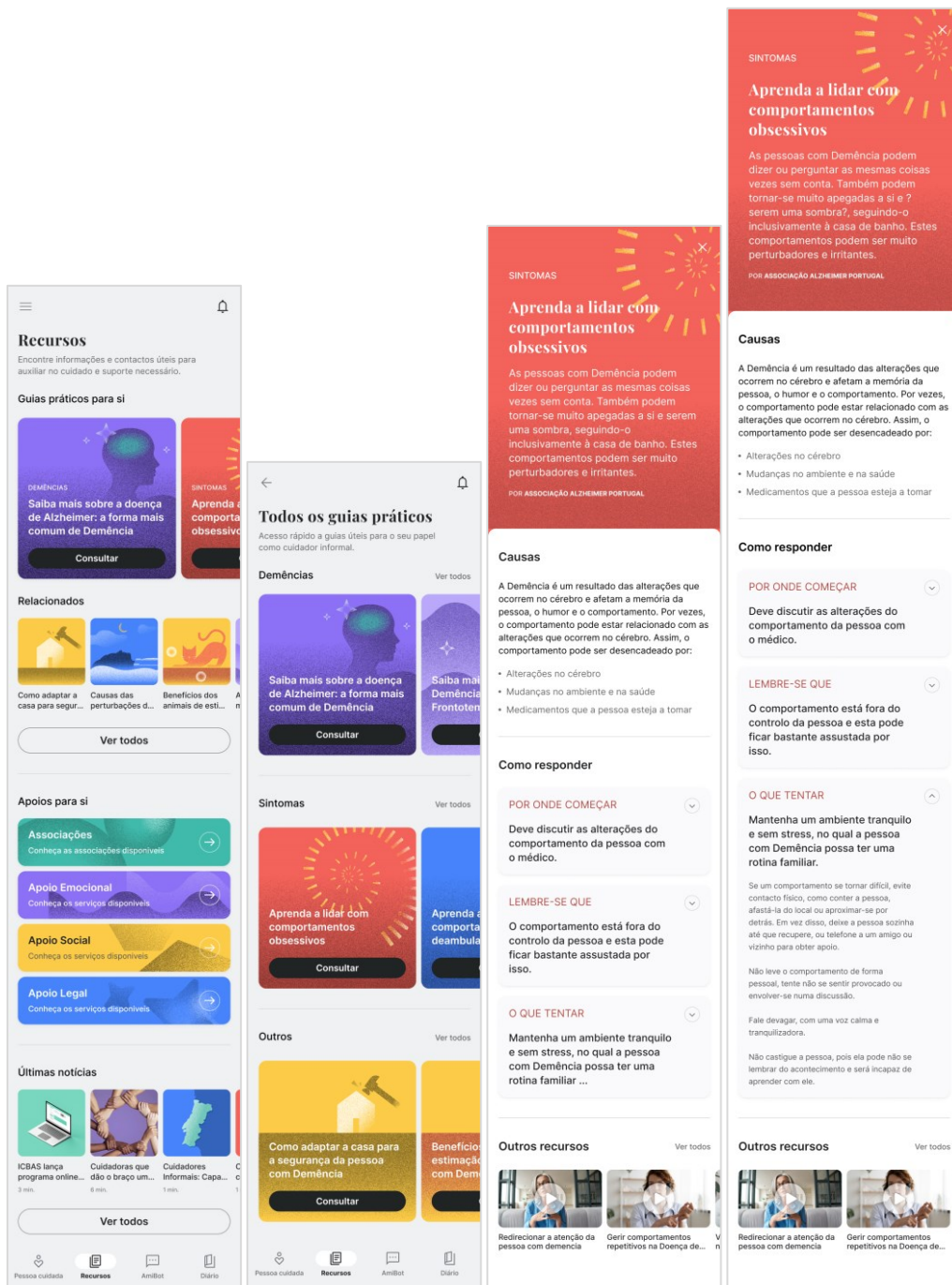


Figure 75: High-fidelity: Resources and practical guide details screen

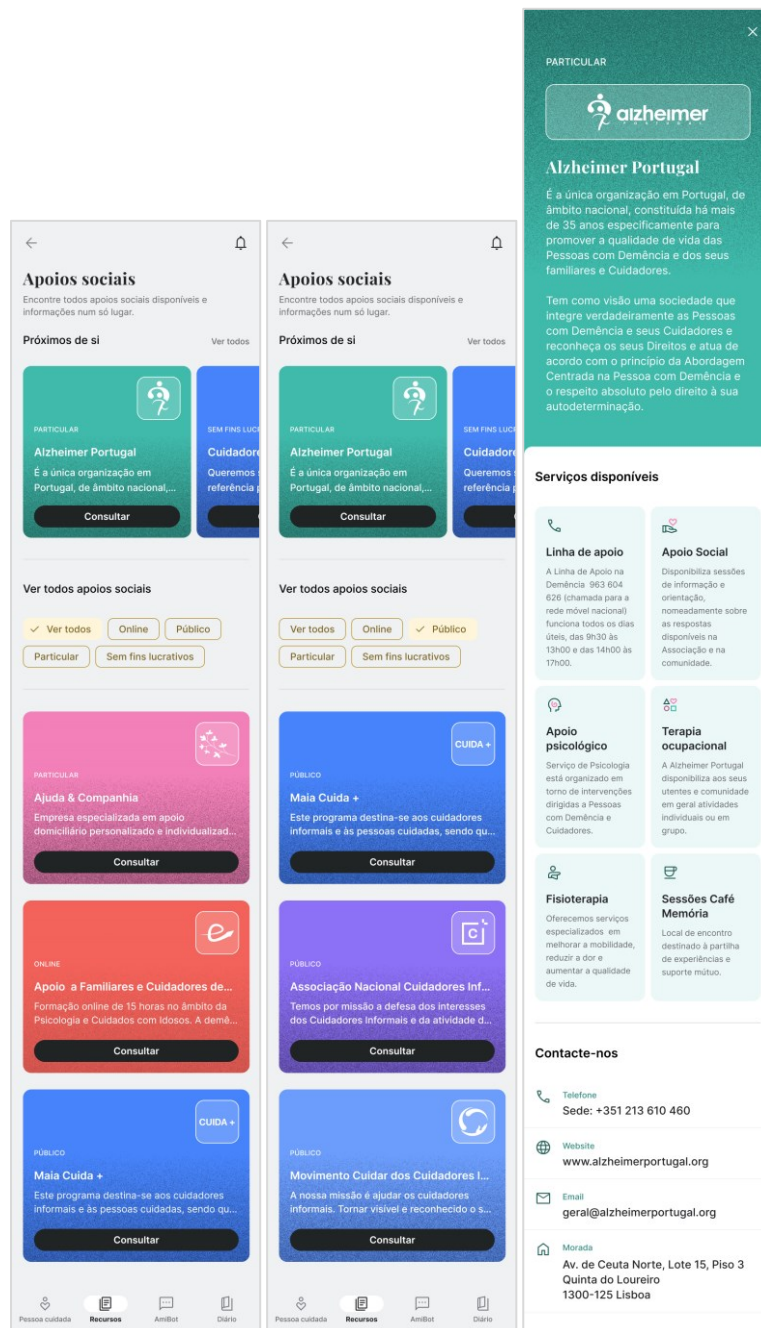


Figure 76: High-fidelity: Social support section and details screens

Annex H – Prototype high-fidelity sketches

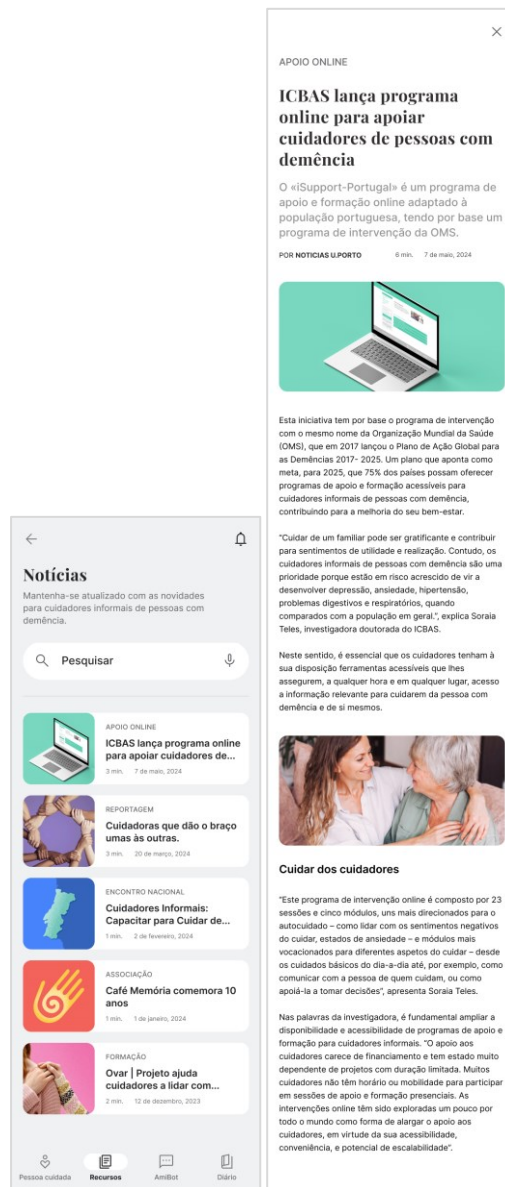


Figure 77: High-fidelity: News section and details screens

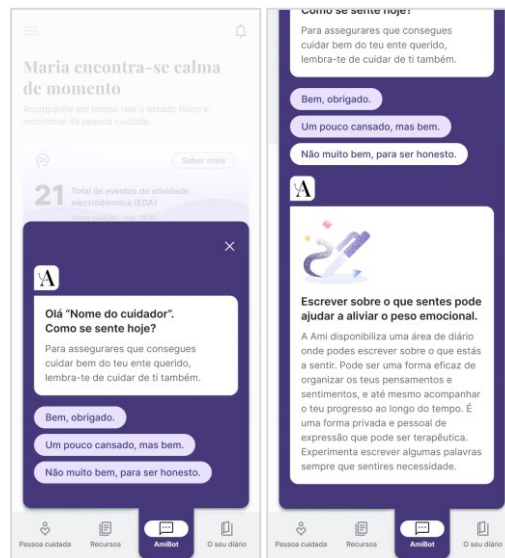


Figure 78: High-fidelity: AmiBot dialog screens

Annex H – Prototype high-fidelity sketches

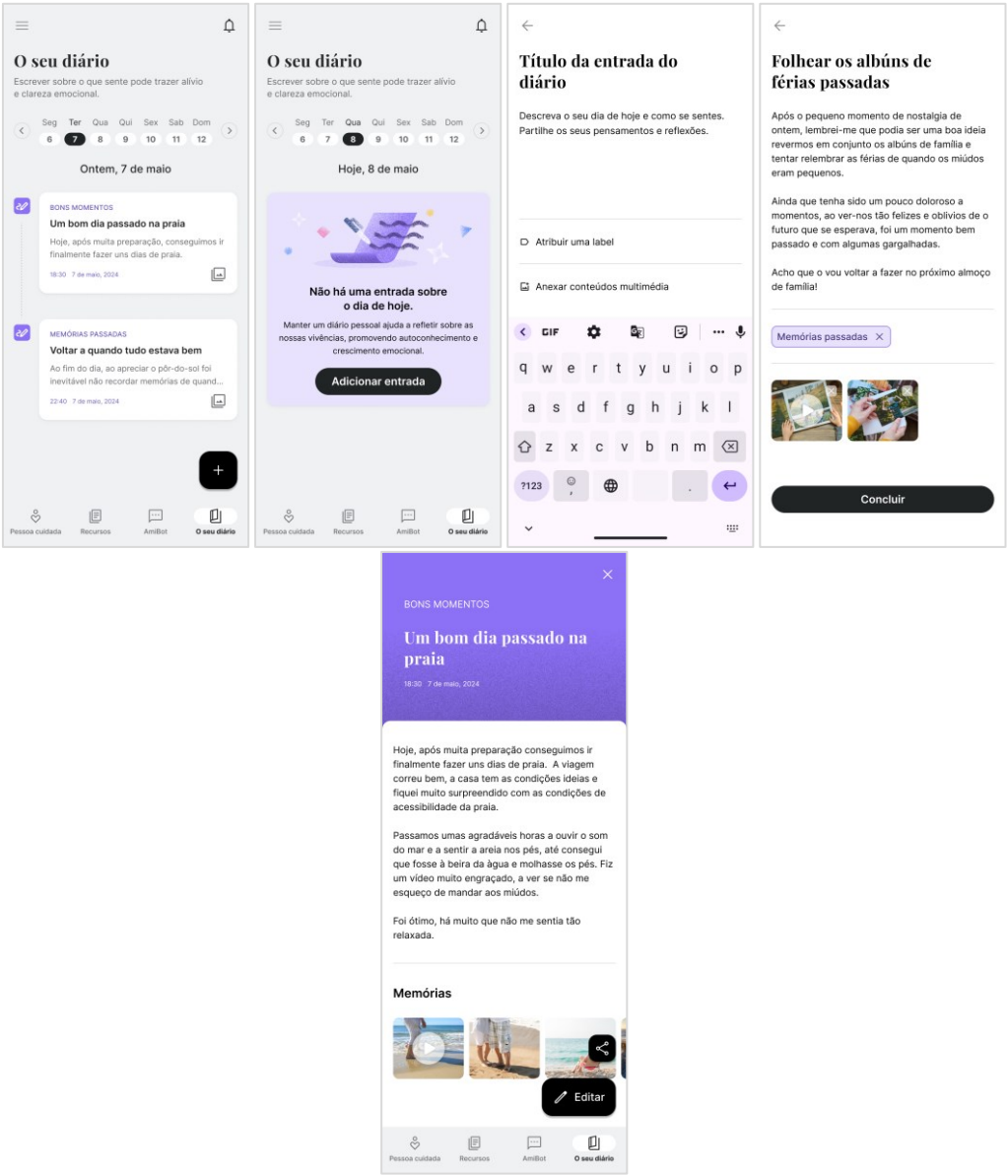


Figure 79: High-fidelity: Informal caregiver diary



Figure 80: High-fidelity: Notifications regarding the PLD screens

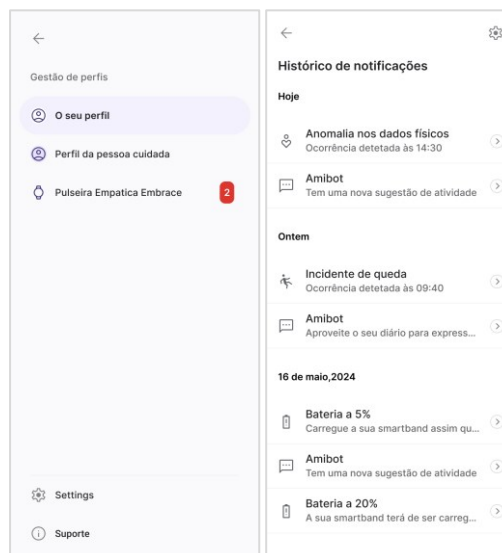


Figure 81: High-fidelity: Side navigation drawer and system notifications history screens

Annex I – Usability test plan and results report

This annex presents the detailed test plan of the prototype developed in this study, along with the results obtained.

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1. Introduction

This usability test plan aims to assess the overall usability and perceived impact of the MVP prototype of the Android app—"Ami"—among its primary users. Developed within the framework of our study, this prototype serves as a tool to validate the insights gathered from our research on emotional design and mobile technology, with the main goal of providing informal caregivers of PLD with a home-based and affordable Digital Health solution that could respond to their main emotional and practical needs.

Furthermore, we anticipate that the insights gleaned from this test plan can function as a valuable resource for the future design and development of additional Digital Health solutions, which aim to offer not just an enhanced user experience but also emotional resonance.

1.1 Objectives

This test plan will prioritize evaluating the efficiency and effectiveness of task completion aligned with the main user stories identified in our user research, which target the primary challenges within the three main categories identified in our study: lack of information and advice, lack of practical support, and lack of emotional support.

Additionally, our second goal is to assess the perceived impact of applying the emotional design principles and guidelines outlined in the framework developed in this study. To achieve this, we will employ the Think Aloud method during testing sessions and administer a custom questionnaire afterward to gather the necessary information that will guide our conclusions.

Finally, we aim to assess the extent to which users perceive the MVP prototype of the Android app—"Ami" solution relevant and helpful for their personal situations.

1.2 Research questions

Following the outlined goals, with this test plan, we aim to gather both quantitative data—via task completion metrics—and qualitative data—through the Think Aloud Protocol and questionnaire responses—to form a conclusion that addresses our third and final study research question:

“Does applying emotional design principles to a Digital Health solution can positively impact its user experience and users’ level of adoption?”

Furthermore, we expect to gather some insights that may demonstrate positive longstanding outcomes regarding the informal caregivers of PLD quality of life and quality of care provided.

1.3 Location and setup

To address study limitations and ensure an adequate number of test participants for meaningful conclusions, we considered conducting testing sessions in two distinct scenarios: in-person and remote.

In-person Testing Sessions

The test environment will be accessible via interaction with a Figma prototype of the MVP of the Android app—"Ami". All sessions will be conducted in person, with participants using an Android smartphone provided by the moderator. The smartphone will run on the latest Android system (version 14) and feature a 6.1-inch screen size to ensure consistency in screen dimensions and display quality across all participants. Each testing session will be audio recorded to capture information provided by the tester participant through the Think Aloud Protocol, while interactions with the prototype will be video recorded using a third-party screen recorder app, pre-installed and activated by the moderator on the provided smartphone. All recordings will prioritize the anonymity of the tester participants and require prior authorization from them. Additionally, the required questionnaires will be distributed to the participants and completed using the moderator's computer.

Remote Testing Session

During the testing session, we will utilize the Microsoft Teams video conference tool for conducting and recording the session. Participants will access the test environment by interacting with a Figma prototype of the Android app—"Ami", accessible via a provided link on their own smartphones. To ensure effective observation, participants will be instructed to position themselves for optimal visibility of their interaction with the prototype. This setup ensures a seamless testing experience while maintaining the integrity of the session. Furthermore, all necessary questionnaires will be distributed as links for participants to complete using their own computers.

1.4 Recruiting participants

The participant recruitment process will primarily involve reaching out to previous user research participants of the study and reaching out to additional contacts through various non-profit associations dedicated to supporting informal caregivers of PLD. However, to mitigate the risk of a potential shortage of participants matching our main user persona profile trait of being an informal caregiver of a PLD, we will also consider recruiting participants who may not meet this trait. Below, we outline the key characteristics for each type of potential participant according to our three main primary personas profiles.

Participants' Key Characteristics:

Ideally, we aim for a balanced representation of both female and male participants, although we may have a slightly higher proportion of female participants, considering their typically more active involvement in informal caregiving roles.

The preferred age range is between 45 and 65 years old, but we will not exclude individuals based solely on age if they are over 18 years old.

Preferably, participants should be informal caregivers of a PLD, either full or part-time, without specifying a minimum number of caregiving hours, requiring a familiar relationship with the person being cared for or sharing residency as exclusion criteria.

Participants should possess some level of familiarity with interacting with a smartphone.

1.5 Methodology

We anticipate that each session will last approximately 50 minutes and will adhere to the following outlined steps:

Pre-test arrangements | approx. 2min

Before commencing the session, the moderator will inform the participant of our intention to record the session, applicable to both in-person and remote sessions. The moderator will ensure the participant that their anonymity will be safeguarded and that the captured information will only be used for the purpose of this study. If the participant consents, they will sign a permission document for the recording. In remote settings, a recorded statement of permission will be obtained.

Introduction to the session and gathering demographic data | approx. 5min

At this stage, the moderator will provide the participant with an overview of the test's context, its primary goals, and outline the subsequent steps of the session. The moderator will allow time for the participant to raise any questions and seek additional clarification. Additionally, the participant will be requested to complete a brief questionnaire. The

primary aim is to collect demographic information and assess their perceived level of expertise in interacting with a smartphone.

Presenting the overall context scenario and Q&A | approx. 3min

The moderator will then present the participant with a contextual scenario, which is detailed and available for reference in the Annex of this test plan. Once more, the moderator will provide an opportunity for the participant to ask questions and seek further clarification before moving on to the next stage of the session.

Task completion | approx. 30min

In this stage, the moderator will present the participant with a series of scenarios and corresponding objectives, prompting them to complete various tasks to achieve these goals.

Throughout this process, the moderator will fill in the task completion template spreadsheet, which is accessible for reference in the Annex of this test plan. Meanwhile, the participant will be encouraged to speak aloud their thoughts while executing the designated tasks.

Post-test debriefing | approx. 10min

To conclude the session, the moderator will request participants to complete both the User Experience Questionnaire (UEQ) and a tailored questionnaire, both are available for consultation in the Annex of the test plan.

1.6 Measures

To comprehensively evaluate the user experience of the MVP of the Android app - "Ami" we will gather both quantitative and qualitative data from the conducted testing sessions. As outlined in the objectives section of this test plan, our focus will center on two main aspects.

Firstly, we will assess the efficiency and effectiveness of task completion. Quantitative measurements will include task completion rates, deviations, errors, and assists. To categorize errors effectively, we have identified various types expected to occur: errors related to identifying specific on-screen elements, understanding the information hierarchy defined in the screen design, and failing to complete the task goal.

While we will not measure the efficiency metric for the time of completion of each task due to promoting the TAP (Think Aloud Protocol) throughout the test, the moderator will monitor overall application usage time. Special attention will be given to the response given to notification scenarios, more specific in the case of a disruption in the vital signs of the PLD or in case of a fall event, since these events would require a quick understand and response in a real context.

Introduction

Secondly, we will evaluate satisfaction and perceived value of the solution. The UEQ will provide quantitative insights into the overall usability of the MVP prototype, providing a standardized measure of user satisfaction and usability. Additionally, the custom questionnaire will delve deeper into participants' experiences, perceptions, and suggestions regarding the app's functionality, design, and emotional resonance. This dual approach aims to gather comprehensive qualitative and quantitative data, enriching our understanding of user perspectives and facilitating more informed decisions for future iterations of the app.

2. Report Contents

The final report, drawn from the overall testing sessions, will provide a comprehensive presentation of all collected data, incorporating both quantitative and qualitative findings, along with identified correlations, limitations, conclusions, and future considerations.

Demographic questionnaire data of the participants will be structured into a table, potentially revealing correlations based on demographics.

Quantitative data related to effectiveness metrics will be tabulated for each task, facilitating necessary calculations. Additionally, this data will be visually represented using bar graphs to enhance legibility and comparison of results.

The results of each UEQ questionnaire will be presented, alongside the overall score calculation.

Moreover, qualitative data from the custom questionnaire and moderator insights collected during sessions, such as observations, encountered problems, comments, recommendations, and responses to open-ended questions, will be subject to content analysis methodology. Relevant insights will be summarized into concise statements for presentation.

3. Project schedule

3.1 Moderator role

The moderator will supervise all facets of the session, ensuring participants' consent to session recordings, introducing the session, administering the demographic questionnaire, explaining the contextual scenario, and ensuring participants fully understand the scope of the MVP of the Android app—"Ami" testing session. Furthermore, it will address any questions that may arise, encourage the Think Aloud Protocol during task completion, pose spontaneous inquiries, and meticulously record notes.

At the conclusion of the session, the moderator will distribute the UEQ and custom questionnaires to participants. Subsequently, it will meticulously review all gathered data, analyse the outcomes, and compile them into a comprehensive usability test report.

3.2 Deliverables

Each testing session will yield the following materials provided by participants: demographic questionnaire results, a table containing quantitative data obtained from task session completion, a summary/commentary of qualitative data gathered during the session via the Think Aloud Process, and corresponding data from the UEQ (User Experience Questionnaire) questionnaire and custom questionnaire.

3.3 Task plan

The test plan will consist of 16 main tasks, each comprising multiple steps. Through these tasks, we will assess participants' ability to navigate the ideal flow as presented, evaluating their capacity to relay necessary information swiftly and effectively within specific scenarios.

Project schedule

Table 1: Task Completion Plan, detailing each task and its ideal sequence for completion.

<i>Tasks completion plan</i>	
Task 1	“As an informal caregiver, I want to create a profile for myself and the person I care for on the app, so that I can access personalized information and resources tailored to our needs.”
Ideal flow	View the app presentation >> Select “Criar perfil” >> Select “Inserir nome” >> Select “Avançar” >> Select one gender option >> Select “Avançar” >> Scroll to correct birth year >> Select “Avançar” >> Select “Inserir morada” >> Select “Confirmar” >> Select “Avançar” >> Select “Inserir nome” >> Select “Avançar” >> Select one gender option >> Select “Avançar” >> Select one diagnose option >> Select “Avançar” >> Select one option of dependence level of the PLD >> Select the necessary options on symptoms presented by the PLD
Task 2	“As an informal caregiver, I want access the real-time health measurements of the person I care for through the app so that I understand how she is feeling.”
Ideal flow	Relay to the moderator what are the measures present and their status. The moderator will ask if the participant understands what EDA is, and ask the participant to search for more information on what is EDA >> Select the option “Saber mais” >> Select the option “Compreendi”
Task 3	“As an informal caregiver, I want to track the history by day, week and month of the health measures of the person I care for so that I can understand her well-being evolution overtime.”
Ideal flow	Access the menu option “Pessoa cuidada” >> Select “Ver histórico” >> Select the option “Semana” >> Select the option “Mês”
Task 4	“As an informal caregiver, I want to share the last month health measures history information with our family doctor and other health practitioners so that I can facilitate our communication.”
Ideal flow	Access the menu option “Pessoa cuidada” >> Select “Ver histórico” >> Select the float button “Share” >> Close “Successful Share message”.
Task 5	“As an informal caregiver], I want timely notifications when a major disruption is detected on the person cared for health parameters so that I can have a quick and appropriate response to the situation.”
Ideal flow	Relay to the moderator what the notification is about >> “Uma alteração nos dados vitais da pessoa cuidada” >> and what the values that have changed “EDA; Ritmo cardíaco; Freq. Respiratória”.
Task 6	“As an informal caregiver, I want to be able to confirm the medication intake at the correct time, so that I can ensure adherence to the prescribed routine.”
Ideal flow	Access the menu option “Pessoa cuidada” >> Scroll down to the section “Próxima toma de medicação” >> Select “Edit icon” >> Select “Marcar todos” at the current hour intake “12:00”.
Task 7	“As an informal caregiver, I want to be able to add a new medication to be taken at midnight to the prescribed routine, so that I can have it up to date.”
Ideal flow	Access the menu option “Pessoa cuidada” >> Scroll down to the section “Próxima toma de medicação” >> Select “Edit icon” >> Select float button option “Adicionar” >> Select “Inserir nome” >> Select “Avançar” >> Select one pill shape option >> Select “Avançar” >> Select “Inserir gramagem” >> Select “Avançar” >> Select intake frequency option >> Select “Avançar” >> Scroll the time option till midnight >> Select “Avançar” >> Select one of the instructions option >> Select “Concluir”.

<i>Tasks completion plan</i>	
Task 8	"As an informal caregiver, I want to be able to register on the app events related to the person I care for , so that I don't forget to discuss these events with the family doctor.
Ideal flow	Access the menu option "Pessoa cuidada" >> Scroll down to the section "Últimos eventos" >> Select "Adicionar novo evento" >> Select "Adicionar título do evento" >> Select "Descreva o que aconteceu" >> Select "Atribuir uma label" >> Select "Adicionar dados biométricos ao momento" >> Select "Adicionar conteúdos multimédia" >> Select "Concluir" >> Scroll to confirm the event was added.
Task 9	"As an informal caregiver, I want access to information tailored to my needs, for example in dealing with obsessive behaviour , so that I can gain a better understanding of their condition."
Ideal flow	Access the menu option "Recursos" >> Horizontal scroll on "Guias práticos para si" >> Select the card "Apenda a lidar com comportamentos obsessivos" >>
Task 10	"As an informal caregiver, I want to know what strategies to try when dealing with obsessive behaviour , so that I can gain a better understanding of their condition."
Ideal flow	>> Scroll down to "O que tentar" >> Select the expand button to view the full information.
Task 11	"As an informal caregiver, I want to know more about the nearest social support service available to my location so that I can get the necessary support in my role as a caregiver."
Ideal flow	Access the menu option "Recursos" >> Scroll down to the section "Apoios para si" >> Select the option "Apoio Social" >> Select the first card on the section "Próximos de si" >> View the full information displayed >> Select the close icon to get back to the previous screen.
Task 12	"As an informal caregiver, I want to know all public social support services available so that I can look for affordable solutions to my necessities."
Ideal flow	Access the menu option "Recursos" >> Scroll to the section "Ver todos os apoios sociais" >> Select the filter public >> Scroll to view the available options.
Task 13	"As an informal caregiver, I want to get suggestions about well-being activities that can help me deal with the emotional demanding's of being an informal caregiver."
Ideal flow	Access the menu option "Amibot" >> Select one option from the provided conversation >> Read the provided suggestion >> Select the close icon.
Task 14	"As an informal caregiver, I want to keep a diary where I can express my feelings about my role as an informal caregiver."
Ideal flow	Access the menu option "Diário" >> Select the option day "7" >>
Task 15	"As an informal caregiver, I want to add an entry to my diary about the positive aspect of conducting the activity of viewing old family vacation albums with the person I care for , so that I can remember this good memory on a not so good day."
Ideal flow	>> Select the option day "8" >> Select the button "Adicionar entrada" >> Select "Título da entrada do diário" >> Select "Descreva o seu dia de hoje..." >> Select "Atribuir uma label" >> Select "Anexar conteúdos multimédia" >> Select "Concluir".
Task 16	"As an informal caregiver, I want to establish a direct connection with the emergency services through the app in the event of a violent fall, so that I can ensure immediate help.
Ideal flow	Relay to the moderator what the notification is about >> "Queda" >> and what the values that have changed "EDA; Ritmo cardíaco; Freq. Respiratória" >> Select the button "Contactar 112".

4. Results

4.1 Participant Demographic Information results

Table 2: Demographic information and other characteristics of the participants of each testing session

<i>Characteristics of the participating informal caregivers</i>	<i>Results (in absolute values)</i>
Age	
18 to 24 years old	N/A
25 to 34 years old	5
35 to 44 years old	2
45 to 64 years old	N/A
65 to 84 years old	3
> 84 years old	N/A
Gender	
Female	6
Male	4
Are you an informal caregiver of a PLD?	
Yes	2
No	6
I have been	2
What is your level of expertise using a smartphone?	
Beginner	N/A
Intermediate	3
Proficient	7

4.2 Test plan results

Table 3: Final results from the Test Plan, presented by task.

<i>Tasks</i>	<i>Errors</i>	<i>Assistances</i>	<i>Deviations</i>	<i>% Completeness (Unassisted tasks)</i>	<i>% Completeness (Assisted tasks)</i>
Task 1	“As an informal caregiver, I want to create a profile for myself and the person I care for on the app, so that I can access personalized information and resources tailored to our needs.”				
Total	0	1	0	90%	10%
Task 2	“As an informal caregiver, I want access the real-time health measurements of the person I care for through the app so that I understand how she is feeling.”				
Total	0	3	0	80%	20%
Task 3	“As an informal caregiver, I want to track the history by day, week and month of the health measures of the person I care for so that I can understand her well-being evolution overtime.”				
Total	1	3	1	80%	20%
Task 4	“As an informal caregiver, I want to share the last month health measures history information with our family doctor and other health practitioners so that I can facilitate our communication.”				
Total	0	2	0	80%	20%
Task 5	“As an informal caregiver, I want timely notifications when a major disruption is detected on the person cared for health parameters so that I can have a quick and appropriate response to the situation.”				
Total	0	2	0	90%	10%
Task 6	"As an informal caregiver, I want to be able to confirm the medication intake at the correct time, so that I can ensure adherence to the prescribed routine."				
Total	2	5	5	50%	50%
Task 7	"As an informal caregiver, I want to be able to add a new medication to be taken at midnight to the prescribed routine, so that I can have it up to date."				
Total	0	0	0	100%	0%
Task 8	“As an informal caregiver, I want to be able to register on the app events related to the person I care for, so that I don’t forget to discuss these events with the family doctor.				
Total	6	7	2	30%	70%

Results

<i>Tasks</i>	<i>Errors</i>	<i>Assistances</i>	<i>Deviations</i>	<i>% Completeness (Unassisted tasks)</i>	<i>% Completeness (Assisted tasks)</i>
Task 9	"As an informal caregiver, I want access to information tailored to my needs, for example in dealing with obsessive behaviour, so that I can gain a better understanding of their condition."				
Total	0	4	0	90%	10%
Task 10	"As an informal caregiver, I want to know what strategies to try when dealing with obsessive behaviour, so that I can gain a better understanding of their condition."				
Total	0	1	0	90%	10%
Task 11	"As an informal caregiver, I want to know more about the nearest social support service available to my location so that I can get the necessary support in my role as a caregiver."				
Total	1	7	0	50%	50%
Task 12	"As an informal caregiver, I want to know all public social support services available so that I can look for affordable solutions to my necessities."				
Total	0	1	0	90%	10%
Task 13	"As an informal caregiver, I want to get suggestions about well-being activities that can help me deal with the emotional demanding's of being an informal caregiver."				
Total	1	4	1	70%	30%
Task 14	"As an informal caregiver, I want to keep a diary where I can express my feelings about my role as an informal caregiver."				
Total	0	0	0	100%	0%
Task 15	"As an informal caregiver, I want to add an entry to my diary about the positive aspect of conducting the activity of viewing old family vacation albums with the person I care for, so that I can remember this good memory on a not so good day."				
Total	0	1	0	90%	10%
Task 16	"As an informal caregiver, I want to establish a direct connection with the emergency services through the app in the event of a violent fall, so that I can ensure immediate help."				
Total	0	2	0	80%	20%

4.3 Usability Experience Questionnaire (UEQ) results provided by the UEQ data analysis tools

Item	Mean	Variance	Std. Dev.	No.	Left	Right	Scale	
1	↑ 2.6	0.7	0.8	10	annoying	enjoyable	Attractiveness	
2	↑ 2.4	0.3	0.5	10	not understandable	understandable	Perspicuity	
3	↑ 2.7	0.2	0.5	10	creative	dull	Novelty	
4	↑ 2.4	1.8	1.3	10	easy to learn	difficult to learn	Perspicuity	
5	↑ 2.9	0.1	0.3	10	valuable	inferior	Stimulation	
6	↑ 1.3	3.1	1.8	10	boring	exciting	Stimulation	
7	↑ 2.7	0.2	0.5	10	not interesting	interesting	Stimulation	
8	↑ 1.4	4.3	2.1	10	unpredictable	predictable	Dependability	
9	↑ 2.1	1.7	1.3	10	fast	slow	Efficiency	
10	↑ 1.8	5.3	2.3	10	inventive	conventional	Novelty	
11	↑ 2.2	0.6	0.8	10	obstructive	supportive	Dependability	
12	↑ 2.9	0.1	0.3	10	good	bad	Attractiveness	
13	↑ 2.0	2.0	1.4	10	complicated	easy	Perspicuity	
14	↑ 2.7	0.2	0.5	10	unlikable	pleasing	Attractiveness	
15	↑ 2.2	0.8	0.9	10	usual	leading edge	Novelty	
16	↑ 2.4	1.2	1.1	10	unpleasant	pleasant	Attractiveness	
17	↑ 2.3	0.9	0.9	10	secure	not secure	Dependability	
18	↑ 2.6	0.5	0.7	10	motivating	demotivating	Stimulation	
19	↑ 2.9	0.1	0.3	10	meets expectations	does not meet expectations	Dependability	
20	↑ 2.2	3.5	1.9	10	inefficient	efficient	Efficiency	
21	↑ 2.5	0.9	1.0	10	clear	confusing	Perspicuity	
22	↑ 2.8	0.2	0.4	10	impractical	practical	Efficiency	
23	↓ -2.8	0.2	0.4	10	organized	cluttered	Efficiency	
24	↑ 2.9	0.1	0.3	10	attractive	unattractive	Attractiveness	
25	↑ 2.8	0.2	0.4	10	friendly	unfriendly	Attractiveness	
26	↑ 2.5	0.9	1.0	10	conservative	innovative	Novelty	

Figure 1: Full data results provided by the UEQ data analysis tool.

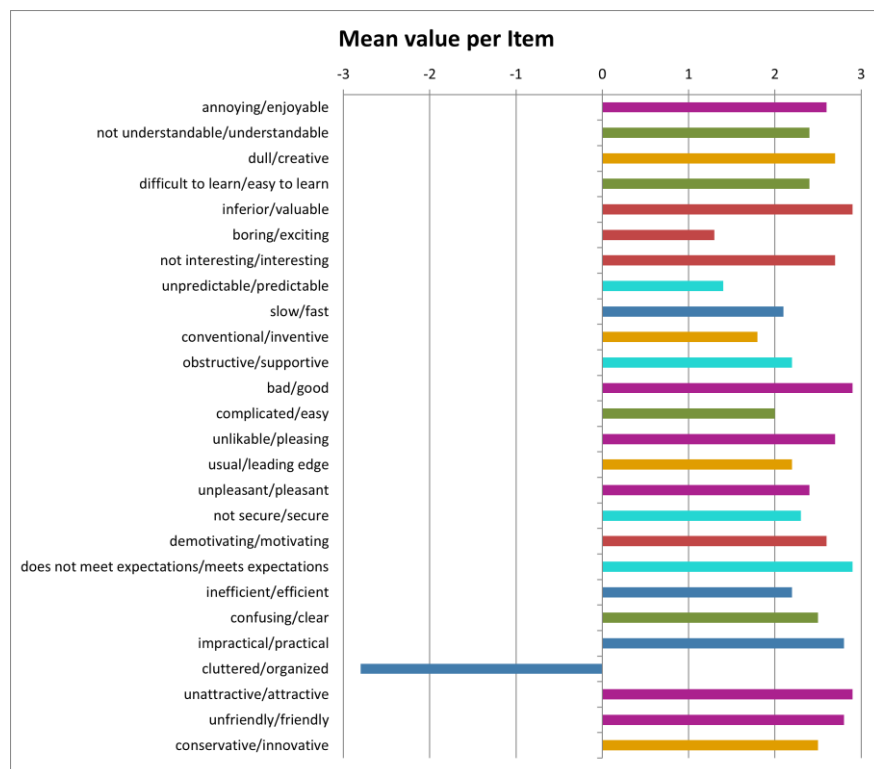


Figure 2: Mean value results per Item

Results

UEQ Scales (Mean and Variance)		
Attractiveness	↑ 2.717	0.14
Perspicuity	↑ 2.325	0.85
Efficiency	↑ 1.075	0.29
Dependability	↑ 2.200	0.55
Stimulation	↑ 2.375	0.28
Novelty	↑ 2.300	0.61

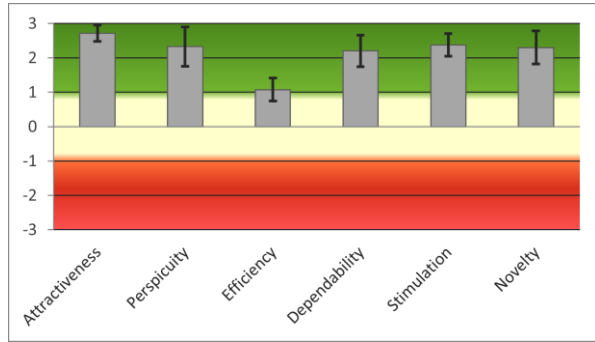


Figure 3: UEQ Scales values (Mean and variance)

Pragmatic and Hedonic Quality	
Attractiveness	2.72
Pragmatic Quality	1.87
Hedonic Quality	2.34

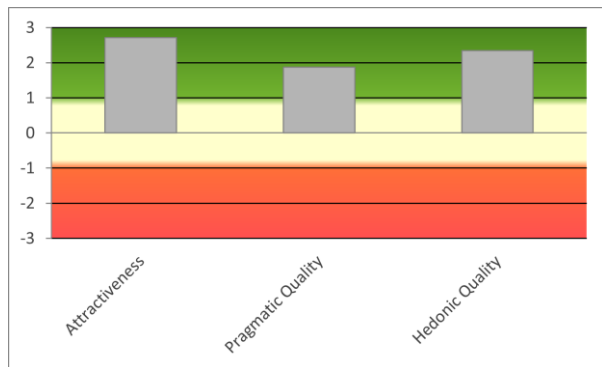


Figure 4: UEQ Scales values (Mean and variance)

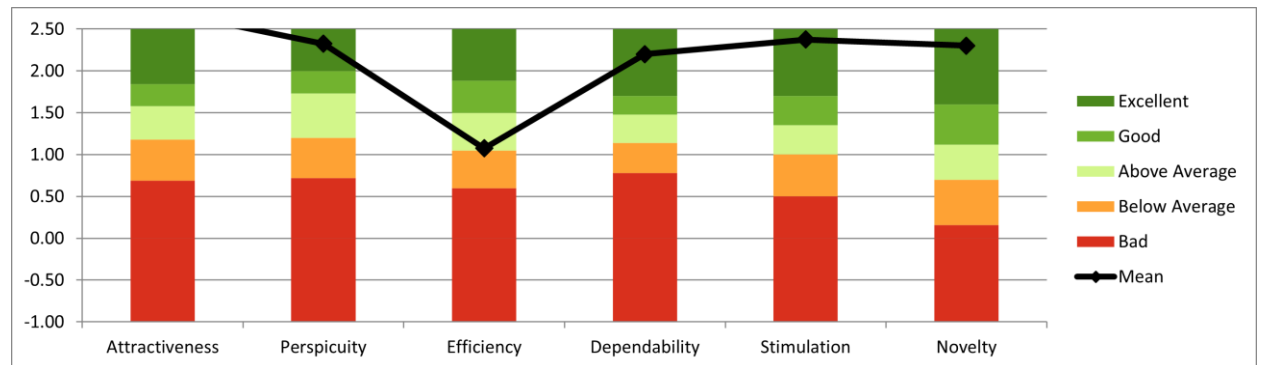


Figure 5: UEQ Benchmark results

4.4 Custom Questionnaire results on the Implementation of Emotional Design Principles in the Prototype

Table 4: Custom Questionnaire results by participant

Questions	Answer by Participant		Average	Standard Deviation
1 - How would you rate the attractiveness of the app in terms of its ability to draw you in and engage you during your interaction?	P1: P2: P3: P4: P5: P6: P7: P8: P9: P10:	6 6 7 6 7 7 6 7 7 6	6.5	0.5
2 - How would you assess the dominance versus submissiveness conveyed by the aesthetic elements of the app?	P1: P2: P3: P4: P5: P6: P7: P8: P9: P10:	6 4 5 3 6 1 2 3 5 4	3.9	1.7
3 - How would you assess the friendliness versus unfriendliness, conveyed by the aesthetic elements of the app?	P1: P2: P3: P4: P5: P6: P7: P8: P9: P10:	7 6 1 7 7 7 7 7 7 6	6.2	1.9
4 - How would you evaluate the quality and adequacy of the following aesthetic elements in the app: images, illustrations, icons, colors, forms, and typography?	P1: P2: P3: P4: P5: P6: P7: P8: P9: P10:	7 7 7 1 7 7 7 7 7 7	6.4	1.9
5 - How do you perceive the level of complexity of the	P1: P2:	1 5	2.9	2.3

Results

Questions	<i>Answer by Participant</i>		<i>Average</i>	<i>Standard Deviation</i>
capabilities offered by the app?	P3:	5		
	P4:	1		
	P5:	2		
	P6:	1		
	P7:	6		
	P8:	1		
	P9:	1		
	P10:	6		
6 - How do you feel about the sense of empowerment and control provided by the app during your interactions with it?	P1:	6	6.7	0.7
	P2:	7		
	P3:	5		
	P4:	7		
	P5:	7		
	P6:	7		
	P7:	7		
	P8:	7		
	P9:	7		
	P10:	7		
7 - How would you rate the effectiveness of the conversation between you and the app in terms of aligning with your emotional context, conveying personality, fostering a connection, and establishing trust and credibility?	P1:	6	6.8	0.4
	P2:	7		
	P3:	7		
	P4:	7		
	P5:	7		
	P6:	7		
	P7:	6		
	P8:	7		
	P9:	7		
	P10:	7		
8 - How would you evaluate the alignment of the app with your expectations and satisfaction regarding both its aesthetics and interactive features?	P1:	7	6.9	0.3
	P2:	6		
	P3:	7		
	P4:	7		
	P5:	7		
	P6:	7		
	P7:	7		
	P8:	7		
	P9:	7		
	P10:	7		
9 - How would you rate the app in terms of establishing trust with you as a user?	P1:	6	6.7	0.5
	P2:	7		
	P3:	6		
	P4:	7		
	P5:	7		
	P6:	7		
	P7:	7		
	P8:	7		
	P9:	7		
	P10:	6		

5. Annexes

5.1 Participant background questionnaire template

Table 5: Template for gathering demographic information of the participants of each testing session

<i>Participant identifier</i>	<i>What is your age?</i>	<i>Gender</i>	<i>Are you an informal caregiver of a PLD?</i>	<i>What is your level of expertise using a smartphone?</i>
P (X)	18-24 YO; 25-34 YO; 35 – 44 YO; 45 – 64 YO; 65 – 84 YO; > 84 YO.	Female; Male; Other	Yes; No.	Beginner (<i>Can perform basic tasks such as making calls, sending texts, and using pre-installed apps. May require assistance with more advanced features like downloading apps or adjusting settings.</i>); Intermediate (<i>Comfortable with basic functions and navigation of a smartphone. Can use various apps for communication, social media, and basic productivity tasks. Able to troubleshoot minor issues independently.</i>); Proficient (<i>Highly skilled in using a smartphone for a wide range of tasks. Can efficiently navigate through different apps and settings. Comfortable with advanced features such as multitasking, managing and connecting multiple devices such as wearables, customizing settings, and troubleshooting technical issues.</i>).

5.2 Context scenario script

"Ami" represents the Minimum Viable Product (MVP) of an Android application designed to assist informal caregivers of Persons Living with Dementia (PLD). This affordable, home-based solution comprises both the application utilized by the caregiver and a wearable device worn by the individual under their care.

The features of the Ami app are strategically tailored to address three primary areas of caregiving intervention. Firstly, it serves as a hub for accessing accurate and reliable information, offering guidance and facilitating connections to external support resources such as associations, respite services and others. Secondly, it provides practical assistance

in monitoring the physical well-being of the person being cared for, enabling the caregiver to track medication intake and log significant events for easy sharing with family members and healthcare professionals. The app is designed to provide caregivers with access to a range of biometric data, such as heart rate, skin temperature, respiratory rate, oxygen saturation, and stress levels. Notably, it can identify any irregularities in these metrics and promptly alert the caregiver. This feature becomes especially crucial in scenarios such as a fall or if the individual under care goes missing, as the app can track their location and notify the caregiver accordingly. Furthermore, the app extends emotional support to the informal caregiver through a companion feature, which offers suggestions for self-care practices and engaging activities. Additionally, it includes a dedicated journaling area where caregivers can express their feelings and reflections.

During this testing session, our primary objective is to assess the functionality and usability of the key features of the app designed for informal caregivers of PLD. However, if a participant does not identify as an informal caregiver, we will provide them with a scenario to immerse themselves in the caregiving experience.

In this scenario, the participant will step into the shoes of an informal caregiver responsible for a person living with dementia (PLD). The person cared for is a close relative who has been diagnosed with Alzheimer's disease, rendering them unable to perform most daily activities independently. Additionally, the person cared for has begun exhibiting new symptoms, including repetitive behaviour, sudden changes in behaviour, and hallucinations. There are even instances where the PLD fails to recognize their caregiver.

By simulating this caregiving scenario, participants can gain insight into the challenges faced by informal caregivers of PLDs. The app interface has been tailored to address these real-life caregiving challenges, allowing participants to evaluate its effectiveness in supporting caregivers and enhancing the caregiving experience.

5.3 Test plan spreadsheet template (per user)

Table 6: Template for collecting information of each testing session participant

<i>Tasks</i>	<i>Errors</i>	<i>Assistances</i>	<i>Deviations</i>	<i>% Completeness (Unassisted tasks)</i>	<i>% Completeness (Assisted tasks)</i>	<i>Comments</i>
Task 1						

5.4 User Experience Questionnaire (UEQ)

"This survey adheres to the standard Usability Experience Questionnaire (UEQ) and is designed to evaluate your satisfaction with the user experience of the MVP prototype of the Android app—'Ami.'

We would like to thank you again for your contribution towards this study."

	1	2	3	4	5	6	7		
annoying	☐	☐	☐	☐	☐	☐	☐	enjoyable	1
not understandable	☐	☐	☐	☐	☐	☐	☐	understandable	2
creative	☐	☐	☐	☐	☐	☐	☐	dull	3
easy to learn	☐	☐	☐	☐	☐	☐	☐	difficult to learn	4
valuable	☐	☐	☐	☐	☐	☐	☐	inferior	5
boring	☐	☐	☐	☐	☐	☐	☐	exciting	6
not interesting	☐	☐	☐	☐	☐	☐	☐	interesting	7
unpredictable	☐	☐	☐	☐	☐	☐	☐	predictable	8
fast	☐	☐	☐	☐	☐	☐	☐	slow	9
inventive	☐	☐	☐	☐	☐	☐	☐	conventional	10
obstructive	☐	☐	☐	☐	☐	☐	☐	supportive	11
good	☐	☐	☐	☐	☐	☐	☐	bad	12
complicated	☐	☐	☐	☐	☐	☐	☐	easy	13
unlikable	☐	☐	☐	☐	☐	☐	☐	pleasing	14
usual	☐	☐	☐	☐	☐	☐	☐	leading edge	15
unpleasant	☐	☐	☐	☐	☐	☐	☐	pleasant	16
secure	☐	☐	☐	☐	☐	☐	☐	not secure	17
motivating	☐	☐	☐	☐	☐	☐	☐	demotivating	18
meets expectations	☐	☐	☐	☐	☐	☐	☐	does not meet expectations	19
inefficient	☐	☐	☐	☐	☐	☐	☐	efficient	20
clear	☐	☐	☐	☐	☐	☐	☐	confusing	21
impractical	☐	☐	☐	☐	☐	☐	☐	practical	22
organized	☐	☐	☐	☐	☐	☐	☐	cluttered	23
attractive	☐	☐	☐	☐	☐	☐	☐	unattractive	24
friendly	☐	☐	☐	☐	☐	☐	☐	unfriendly	25
conservative	☐	☐	☐	☐	☐	☐	☐	innovative	26

Figure 6: UEQ questionnaire in English

5.5 Custom questionnaire

"This survey was designed to assess whether the implementation of emotional design principles and guidelines in the development and design process of the MVP prototype of the Android app—"Ami" has influenced your overall user experience.

We would like to thank you again for your contribution towards this study."

Scale metric of 5 values adapted to the context of each question.

Annexes

1. How would you rate the attractiveness of the app in terms of its ability to draw you in and engage you during your interaction? (Not engaging at all (1) to Highly engaging (7))
2. How would you assess the dominance versus submissiveness conveyed by the aesthetic elements of the app? (Strongly portrays submissiveness (1) to Strongly portrays dominance (7))
3. How would you assess the friendliness versus unfriendliness, conveyed by the aesthetic elements of the app? (Strongly portrays unfriendliness (1) to Strongly portrays friendliness (7))
4. How would you evaluate the quality and adequacy of the following aesthetic elements in the app: images, illustrations, icons, colours, forms, and typography? (Very poor quality and inadequately represented (1) to Excellent quality and perfectly represented (7))
5. How do you perceive the level of complexity of the capabilities offered by the app? (Extremely simple (1) to Extremely complex (7))
6. How do you feel about the sense of empowerment and control provided by the app during your interactions with it? (Strongly unsatisfied (1) to Strongly satisfied (7))
7. How would you rate the effectiveness of the conversation between you and the app in terms of aligning with your emotional context, conveying personality, fostering a connection, and establishing trust and credibility? (Very ineffective (1) to very effective (7))
8. How would you evaluate the alignment of the app with your expectations and satisfaction regarding both its aesthetics and interactive features? (Completely misaligned and unsatisfactory (1) to Completely aligned and satisfactory (7))
9. How would you rate the app in terms of establishing trust with you as a user? (Strongly disagree (1) to Strongly Agree (7))
10. Feel free to provide any additional comments or feedback that you believe is important. (Open field question)