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PORTO

DEVELOPMENT OF A SOFTWARE FOR MEDICATION MANAGEMENT IN RESIDENTIAL STRUCTURES FOR THE ELDERLY (GESTECH4I)

by
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Thesis presented to Escola Superior de Biotecnologia of the
Universidade Católica Portuguesa to fulfill the requirements of Master of Science degree in
Biomedical Engineering

by
Cristiana Pereira da Costa

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January 2023

Abstract

Demographic aging is a widespread problem in the European Union, and Portugal stands out as the European country with the highest proportion of elderly people, in 2050. Associated with the growth of the geriatric population is the increase in multimorbidities and, consequently, the concomitant medication consumption, the so-called polypharmacy.

The diseases and the conditioning of the activities of daily living of the elderly population lead to the search for Residential Structures for the Elderly (ERPI) to improve their quality of life. However, overcrowding, lack of sufficient staff, poor interpersonal communication, and the simultaneous performance of different tasks, namely clinical treatment and patient medication management and its recording, cause medication errors (ME) to occur compromising the treatment effectiveness. These MEs happen in the distribution and administration phases, which are the most critical phases of the medication circuit.

To fill the aforementioned gap, this Master's work was carried out to develop technology for medication management in ERPIs, a software (algorithm + interface) called GESTECH4I. This technology allows patient medication data registration, thus promoting a decrease in MEs. For software development, Microsoft Access was used to build the database, where the information resulting from the interaction between the user and software is stored. The algorithm and interface were also developed and coded using the MATLAB App Designer. In this way, GESTECH4I stores the patients' data, their medication, and administration allowing for an organized, intuitive, sustainable, and quick-to-interpret workflow.

The development of this technology is crucial because there is a need for ERPI expansion and the need for improvement in the health services provided. This type of software will enable better management of the medication circuit, as well as reduce associated errors. Although there are already technologies of this type in the market, the focus of them is not adapted to the institution's needs, regarding the critical phases (distribution/preparation and administration) of the medication circuit. Thus, it was sought to develop a software (GESTECH4I) capable of responding to the institution's needs in medication management, ensuring better healthcare provision. Therefore, GESTECH4I stands out for its fast interpretation and easy use in both medication distribution and administration.

Keywords: Demographic aging, Residential Structures for the Elderly, medication error, software.

Resumo

O envelhecimento demográfico é um problema generalizado na União Europeia e, Portugal, coloca-se numa posição de destaque, estimando-se que seja o país europeu com a maior proporção de idosos em 2050. Associado ao crescimento da população geriátrica está o aumento das multimorbilidades e, consequentemente, o consumo de medicamentos concomitantes, a chamada polifarmácia.

As doenças e o condicionamento das atividades da vida diária da populção idosa leva à procura de Estruturas Residenciais para Idosos (ERPI) com o intuito de melhorar a qualidade de vida. Porém, a sobrelotação, a falta de colaboradores suficientes, a comunicação interpessoal deficiente, as execução das diferentes tarefas em simultâneo, nomeadamente ao nível de tratamentos clínicos e gestão da medicação do paciente, e registo da mesma, faz com que erros de medicação (ME) aconteçam e comprometam a eficácia dos tratamentos. Estes MEs acontecem, essencialmente, na fase de distribuição e administração, sendo estas as fases mais críticas do circuito do medicamento.

Com o objetivo de colmatar a lacuna mencionada, foi realizado este trabalho de Mestrado, que teve como objetivo desenvolver uma tecnologia para a gestão da medicação em ERPIs, um *software* (algoritmo + interface) denominado de GESTECH4I. Esta tecnologia, permite o registo de todos os dados relacionados com a medicação do paciente, promovendo, assim, uma diminuição dos MEs. Para o desenvolvimento do *software* recorreu-se ao Microsoft Access para a construção da base de dados, onde é armazenada a informação resultante da interação entre utilizador e software. Adicionalmente, o algoritmo e a interface foram desenvolvidos e codificados através do MATLAB App Designer. Desta forma, o GESTECH4I armazena os dados dos pacientes, a sua medicação e administração permitindo o fluxo de trabalho organizado, intuitivo, sustentável e de rápida interpretação.

O desenvolvimento desta tecnologia é crucial numa altura em que existe uma necessidade de expansão das ERPIs, e a necessidade da melhoria dos serviços de saúde prestados. Este tipo de *software* irá permitir uma melhor gestão do circuito do medicamento, bem como reduzir erros associados. Apesar de já existirem tecnologias deste tipo no mercado, o foco de atuação destas tecnologias não está adaptado às necessidades das instituições, no que diz respeito às fases críticas (distribuição/preparação e administração) do circuito do medicamento. Deste modo, procurou-se desenvolver um software (GESTECH4I) capaz de responder às necessidades das instituições na gestão de medicamentos, garantindo uma melhor prestação de cuidados de saúde. Assim, o GESTECH4I diferencia-se pela sua rápida interpretação e fácil utilização tanto na distribuição como na administração de medicamentos.

Palavras-chave: Envelhecimento demográfico, Estruturas Residenciais para Idosos, erro de medicação, software.

Acknowledgements

Since this is a particularly challenging work, I cannot fail to praise the help of those who contributed so much to its development and who, directly or indirectly, helped to make it possible.

I would like to thank my supervisor, Professor Dr. Pedro Rodrigues, for introducing me to the idea expressed in this dissertation, and for all his patience, wise guidance, constant availability, and enthusiasm. Without his tireless assistance and the knowledge transmitted throughout the implementation of this thesis, it would be impossible.

I also thank Professor Dr. Patrícia Batista, my co-supervisor, for all her advice and suggestions, as well as for the time she gave to help me clear all the doubts that emerge during the process of making the dissertation. Her dedication and constant support were fundamental to its success.

I also express my sincere gratitude to Professor Dr. Ana Leite for her pieces of advice, incentives, and suggestions, contributing to the path chosen in this thesis.

Finally, I am eternally grateful to my family, not only for the financial support along my academic path but also for all their patience, their words of motivation, and encouragement. To be my greatest example of ethics, dedication, and wisdom, contributing so much to my personal and professional success.

To all, an honest and sincere thank you.

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Symbols and Abbreviations

ADE	Adverse Drug Event
CBRE	Global Commercial Real Estate Services
CNIS	National Confederation of Solidarity Institutions
CPU	Central Processing Unit
DaaS	Desktop-as-a-Service
DBMS	Database Management System
DRP	Drug-Related Problem
EMA	European Medicines Agency
ERPI	Residential structures for the elderly
EU	European Union
GB	Gigabytes
GEP	Gabinete de Estratégia e Planeamento
GHz	Giga-hertz
GUI	Graphical User Interface
ID	Identification
IPQ	Portuguese Institute of Quality
ME	Medication error
PCNE	Pharmaceutical Care Network Europe
PIC	Individual Care Plan
RAM	Random Access Memory
SDD	Solid State Drives
SQL	Structured Query Language
TB	Terabyte
UML	Unified Modeling Language
US	United States
WHO	World Health Organization

CHAPTER 1

Introduction

Worldwide, in 2019, the number of people aged 60 years and older reached 1 billion and it is estimated it will grow to 1.4 billion by 2030, representing 1 in 6 people who will be aged 60 years or over [1]. This actively demonstrates the unprecedented increase in the world's geriatric population and the expectation is that it will continue to accelerate in the incoming decades. According to Eurostat, in Europe, partially due to low fertility rates, migratory patterns, and increasing life expectancy an aged population has been evident for several decades [2].

In 2019, the European population of 65 years old or older was 90.5 million and will overtake 129.8 million in 2050 [2]. From the Portuguese perspective, the elderly population expanded from 16.2% to 23.5%, between 2000 to the present [3]. This growth can be explained by medical advances, mainly in medicines. New medication and medical technologies have allowed a decrease in mortality and extended life expectancy [4].

On the other hand, associated with aging come health conditions that compromise the performance of daily activities without assistance [5]. Therefore, residential structures for the elderly (ERPI) result from the need to provide care to the elderly and ensure social support and quality of life [4]. Accordingly to the World Health Organization (WHO), the elderly population in Portugal receiving long-term care at a residential care facility grew from 0.90% to 1.30% between 2010 and 2018 [5, 6]. Even though ERPIs grew 176% between 2000-2020, which represents an evolution from less than 1500 institutions with around 55 000 beds, in 2000, to over 2500 establishments with more than 100 000 beds, in 2020, there is still a large covering over the entire geriatric population, since the usage rate is almost 100% [6–8].

The ERPI residents have multimorbidities (multiple concomitant health problems) and therefore ingest multiple medications per day. Due to the extravagant clinical treatments and multiple medications, errors associated with it can occur. Indeed, Medication errors (MEs) are frequent in these institutions due to the high number of residents and their medication particularities [9]. The most frequent medication-related errors are missed or delayed doses, transcription and prescription errors, and miscommunication between professionals since the residents depend on the institution's employees to intake their medication. Indeed, according to the literature, these types of errors are preventable through the implementation of clinical pharmacy activities (review prescriptions, doses, intakes) to be safe and controlled. In this way, errors will be decreased, and the quality of care will improve, ensuring the safety and effectiveness of the intended care and reducing the associated costs [4, 9–11].

So, this work aims to develop a user-friendly technology for medication management in ERPIs can store information about patients and their prescriptions with secure, easy access and interpretation. Thus, this technology will allow safe patient drug administration in respect of the type of medicine, dose, and time of taking. It allows greater control and registration of all the information regarding the patient's medication and better medicine intake control by the caregivers and the stock.

To understand how the work was developed this dissertation is split into several chapters. Firstly, a chapter about a bibliographic overview expressing the reasons that lead to the elaboration of the present master dissertation, framing the needed pieces of information to understand the problem discussed. The next chapter approaches the development of the GESTECH4I, which discusses how the software works, particularly, the construction of the database and data selection, the coding program, and the design of GESTECH4I. The following chapter will focus on market analysis to perceive its reaction and how the product could fit in. Thereby it will analyze the possible customers, market share, and competition. The last chapters address conclusions and future perspectives of the work developed.

CHAPTER 2

Bibliographic review

2.1 Aging in Portugal

According to PORDATA, in 2021, there were at least two million people 65 years old or older, representing about 23.5% of the Portuguese population. Thus, the aging community is increasing at an incredible pace, and by 2050, according to Eurostat, the Portuguese elderly proportion (ratio between the population 65 years old or more to the population 15-64 years old) will be 62.8%, the highest in Europe. As matter of fact, aging isn't equal for both genders, indeed, the average life expectancy at birth, in 2020, is 77.7 years for men and 83.4 years for women but these numbers are quite different when compared to the average life expectancy at 65 years old [12, 13]. People at 65 years old expect to live 17.4 years if we are talking about a man or 20.8 years if we are talking about a woman, but these expectations don't transpose to healthy living years. The expectancy of healthy years at geriatric age is 8.4 years for men contrasting with 7.1 years for women, becoming the age group more feminine, and suggesting that even though women live longer they have poorer health [12, 13].

With an older national population and low healthy years, the demand for formal care is higher, since informal care is decreasing. Hence, many reasons could lead to the search for ERPIs such as the difficulty in being recognized by social security as a caregiver, or lack of familiar net, or women´s entry into the labor market, or the inability of the caregiver to caring act [4, 14, 15]. So, 80% of the dependent geriatric population will be institutionalized in ERPIs [14]. Important to note that a dependent person is an individual who cannot autonomously perform the acts indispensable to the satisfaction of the basic needs of daily life, needing the assistance of someone else [16].

An ERPI institution is an establishment for temporary or permanent use being a collective accommodation with social and nursing care, providing activities to maintain an active aging [4, 14, 17]. Thereby, a dependent person is internalized mostly when losing their faculties (loss of autonomy induced by neuropsychologic and psychiatric or psychopathological health problems), which makes the residents of ERPIs, described by *Social Letter from Gabinete de Estratégia e Planeamento* (GEP), in 2021, as highly dependent on daily activities, namely bath, mobility, feeding, and bathroom use [4, 8]. Besides that, 86% of Portuguese residents in ERPIs are at least 75 years old substantiating the fragility of the population studied [8].

2.2 Polypharmacy in the elderly

Despite aging and disease are not synonymous, the main users of medications are the older population (>75 years) [18]. Naturally, there is a positive correlation between age and the increased prevalence of chronic diseases implying multimorbidity [4]. Multimorbidity is defined, by WHO, as the presence of two or more health conditions in an individual including physical or mental problems [19]. Therefore, to help treat multiple long-term health problems it is necessary several medicines, called polypharmacy which is characterized by the routine use of five or more medications [19].

Worldwide, 70% of the population over 65 years old have multimorbidity and 40% suffer from polypharmacy reaching up to 90% in adults over 75 years old [20]. In the European Union (EU), 65% of the population aged between 65-84 years old have more than two chronic diseases of which 21% take daily 4 to 9 medicines. In fact, 10% of the European population intakes at least 10 medications per day [18, 21]. This is a reality in several countries since from 18 countries present in a study, 32.1% of the participants over 85 years old ingest at least 5 medicines daily. Besides, it concluded that Switzerland was the country with the lowest polypharmacy incidence (26.3%) followed by Croatia at 27.3% and Slovenia at 28.1%, contrasting with the Czech Republic with the highest prevalence (39.9%), right after Israel (37.5%) and Portugal (36.9%) [22].

Nationally, according to Rodrigues *et al.* (2018) [23], 83.4% of the national elderly (80 years or older) suffer from multimorbidities, admitting that one of the factors for the increase in multimorbidity is aging. Another national study concluded that polypharmacy is present in at least 70% of the geriatric population [24]. Moreover, in a study conducted in 6 Portuguese ERPIs, the researchers found all elderly present in the work had multiple diseases with a mean average of 7.94 health problems where the most common were in the cardiovascular, nervous, and digestive systems. The literature has been reporting a median of 10-11 medicines per patient being aligned with the European mean [15, 25]. These results are quite different when compared to the intake of the average medicines in non-institutionalized elderly being 7.8 medicines per patient, concluding that institutionalization expands the probability of polypharmacy [26].

Statistics data show that the risk of multimorbidity is higher among older and less differentiated individuals demonstrating the relevance of patients with multimorbidity and having special importance in the way healthcare is organized and delivered [27]. Thus, polymedication is inevitable at ERPIs since patients who are mainly 75 years or older have multi-health problems which thrive on medicine use. Indeed, the ERPI profile of residents perfectly matches this state as it links multimorbidity, a derogatory perception of their health, and loss of autonomy, which promote fragility driving the use of multiple medications polypharmacy [28–30].

2.2.1 Drug-related problems

Polypharmacy is a key component not only to help live longer but also to improve quality of life since aging is directly linked to multimorbidities [29]. However, polypharmacy has been highly associated with negative health outcomes such as DRP, adverse drug events (ADE), impaired physical and cognitive function (drive to a fragility state), hospitalizations, and even mortality, when referred to an aged adult [31, 32].

As described by Pharmaceutical Care Network Europe (PCNE), a DRP is an incident or scenario involving pharmacological therapy that can interfere with expected health effects and occur in many forms specifically drug-drug and drug-disease interactions, adverse drug interactions, potentially inappropriate medications, and is often referred as a ME [33]. This ME is defined by the European Medicines Agency (EMA), as an unintentional breakdown in the drug treatment process that endangers or has the potential to hurt the patient [34].

Indeed, drug administration is a widely reported health problem, 30-50% of the total healthcare mistakes are related to MEs and the majority (50%-70.2%) are preventable even in a polymedicated aged person [4, 21, 35, 36]. Monetarily, these preventable mistakes have an estimated cost of 42 billion dollars per year, and, in Europe alone, cost approximately 21.8 billion euros annually [35, 36]. Moreover, MEs can compromise clinical treatment and proliferate commonly during the transfer of care (for example, from hospital-home, or hospital-ERPI) mostly because of polypharmacy. These conditions provide human error among patients and caregivers being the most reported factor [10, 11]. A study conducted by McDerby *et al.* (2018) [10], concluded that a high-risk situation in terms of MEs occurs when transiting to an ERPI, including new admissions or returning from hospital since 20% of residents experience delays or missed doses, and 13-31% of these errors implicate high-risk drugs. Similarly, in the study conducted by Ferrah *et al.* (2017) [9], it was found that 16-27% of the residents studied already experience some type of ME, and a percentage of 13-31% suffer from ME derived from transferring care. Still, 75% of the residents have been prescribed potentially inappropriate medication (type of ME). Besides that, the study found the most frequent ME was the wrong dosage caused by human error such as transcription, distractions, or miscommunication, which counted to 70% of all errors. Moreover, 9-15% of MEs in patients aged between 70-90 years old are deadly. It is also affirmed that institutions with more than 150 beds have a double rate to induce MEs.

The MEs result from the equation between weak medication systems and human factors, such as fatigue or high workload, or interruption during the task [36, 37]. A minimum of 20% of MEs in European hospitals are because of elevated work and poorer healthcare of personnel [36]. Likewise, in ERPIs, the employees have an unstable work environment, meaning high turnover, a lot of interruptions, high workforces, variable patient family participation, and autonomy by the patient [10, 37]. Allied that to different levels of training in the medication administration field calling into question the capacity of the judgment of the drugs administrated [9–11]. Further, the institutions have a deficiency in workers (0.8 ERPI workers per 100 people with 65 or more conversely to an average of 3.8 in the EU) being mostly women (95.8% in 2016), with low levels of education (64% of the employees) [6, 38].

2.3 Medication management in ERPIs

ERPIs are regulated institutions regarding the organization, operation, and installations (ordinance n.º 67/2012, of 21 March) [17]. In contrast, in terms of how the medicines are stored, distributed, dispensed, or administrated or if the employees have formation in the field, the ERPIs are not regulated, which can have repercussions, namely MEs [39, 40]. Polypharmacy is a reality in the geriatric group, particularly in ERPIs, so it's critical to adopt strategies to improve the medication circuit and management [40]. On the other hand, the Portuguese Institute of Quality (IPQ) stated that to use medicines correctly and safely, in ERPIs, must have competent employees in that field. Thus, professionals should have formation in medication management to guarantee that the patient receives the best treatment to have the maximum therapeutic benefit [39].

In the study conducted by Constantino *et al.* (2016) [7], in a sample of 39 national ERPIs, it was found that only 76.9% hold the nurse responsible for medication management while in 12.8% of the institutions, this role is attributed to the pharmacist. In addition, 2.6% of the institutions assign this role to the direct care assistants, which is above what is defined in the legal framework. However, in a smaller sample, 12 ERPIs, a nurse is always responsible for medication management [40].

Whereas all interventions carried out within the scope of medication management must be recorded, in a single process, in the Individual Care Plan (PIC), which must be available to all health professionals who interact with the patient medication [39]. Indeed, the PIC is characteristic of each institution and all must use this plan to centralize the resident's clinical process. Included in the PIC is the pharmacotherapeutic sheet where its constitution varies according to the institution, being the name of the resident and the name of the medication always present. Other parameters' such as dosage and posology of the medication, time and duration of treatment, date of prescription, route of administration, and allergies are often present, too. Therefore, every time one of these parameters changes, there must be a change in the plan. This sheet is where all relevant information about the resident and their medication is centralized [7, 40].

2.3.1 Medication circuit

In 2014, the IPQ recognized the evident lack of legislature to define procedures and quality norms to ensure the prescription, acquisition, storage, distribution, administration, and utilization of medicines in ERPIs. Still claims equality between residents, aged people in the general community, and the rest of the population in terms of effective, accurate, and safe access to drugs to ensure positive results and reduce MEs [39]. Moreover, EMA declared that the most frequent preventable cause of unintended adverse events in the use of medications is errors in prescription, dispensing, storing, preparation, and administration of drugs, which place a significant cost on public health [34].

Thus, being ERPIs institutions with high demand for medicines results in a bigger opportunity to commit errors related to medication [10]. Even though nurses are, in most institutions, responsible for medication management and are present in every stage of the medication circuit, there are other employees involved that

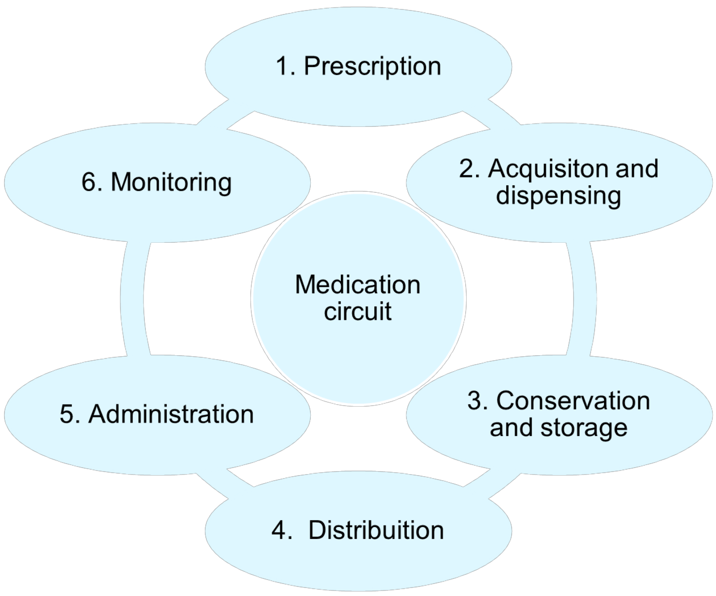


Figure 2.1: Medication circuit in ERPIs (Retrieved from [40]).

are not qualified in the field [41]. Indeed, as mentioned before 64% of the workers in these establishments, in Portugal, have low levels of education which boosts the gap to commit errors related to medication [6].

To attend to the problems exposed, IPQ advised a multidisciplinary team with adequate formation to improve communication, quality health care, and manage medication in ERPIs [39]. Therefore, the institute defined a drug circuit with multiple stages namely prescription, acquisition and dispensing, conservation and storage, distribution, administration, and monitoring [39, 40]. Figure 2.1 illustrates the referred medication circuit.

2.3.1.1 Prescription

In the prescription phase, IPQ recommends a conscious prescription to secure the best cost-effectiveness ratio, lowering wastage [39]. Doubtless, the use of medicines prolongs life and treats health conditions, but in the aged community, this is especially complex due to the physiologic (pharmacokinetic and pharmacodynamic) alterations and interaction with other medications. However, it is important to prescribe a conscientious amount of the appropriate medications for the treatment of morbidity patients [41]. Nonetheless, there is a cascade prescription when comes to the elderly, prescribing another drug to treat a side effect from other medicine [7].

To improve the quality of prescriptions, a systematic review of the medication, deprescribing (controlling and knowingly), and keeping prescriptions registers updated, legible, and precise. Besides, the records should indicate the resident name, medication intake, and the name of the prescribing doctor since these are also relevant information to keep in order. Still, the employee in charge should record the medicine's commercial name, the active principle, dosage, the beginning and ending treatment dates, and the administration route. A report of previous drugs taken and any discrepancies between prescriptions should be kept. All should be recorded on a computer system to minimize errors [7, 40, 41].

2.3.1.2 Acquisition and medicine dispensing

The medicine dispensing is necessarily done in a community pharmacy by a competent person who has to be legally able to evaluate the patient prescription and give all the information (potential negative outcomes or side effects) needed to the patient and/or caregiver, respectively. This briefing should be accurate, consistent, adaptative to each patient's understanding, and directed to the safe and right usage of the medicine. Additionally, all the details about the usage of the medicine should be written down and given to the patient and/or caregiver [39].

2.3.1.3 Conservation and storage of medicines

According to IPQ, generic medicines should be stored in a reserved zone with easy access to authorized professionals. The narcotics and psychotropics should be in an appropriate location with no resident access. This storage must follow all indications such as temperature, and humidity (preserving records of it), according to Portuguese law thus ensuring the correct storage conditions. In addition, the institution needs to control the lot number and expiration date, and keep the medicines in the original box, whenever possible, purposing to reduce errors inherent to administration [39].

2.3.1.4 Distribution/Preparation

In ERPIs the system works by distributing an individual daily dose, where each dose is prepared for each patient. The professionals must guarantee the 5 Rs (5 Rights), which are the right patient, right medicine, right dose, right administration route, and right time [39].

2.3.1.5 Administration

The administration of the medicines must be precise and at the right time, being supervised by a legally able professional who assumes responsibility for the correct usage of the administrated medicine [39]. In the medication circuit, the administration phase is particularly vulnerable at which MEs are more likely to happen since the staff needs to oversee the patient ingesting the administered drugs and then document. Thus, it is a difficult stage at which the employees' competence is tested [37].

2.3.1.6 Monitoring

The monitoring of pharmacotherapy is very important, especially in the elderly due to the natural physiological alterations. Thus, there is a need to evaluate the effectiveness, safety, and treatment status being done whenever the health conditions require it or at least twice a year [39]. Therefore, this phase aims to review medical prescriptions, identify flaws during the medicine intake, and record and promote reporting of possible adverse reactions to the treatment. This phase must be ensured by a professional with adequate training for its execution (normally this function oversees the doctor or nurse in charge) [40]. Besides that, the employees (nurses, health assistants, and caregivers) must record every problem related to medication usage and strongly promote adherence to chosen therapy. The *Sistema Nacional de Farmacovigilância* promotes the notification of ADE and the employees should know the system and report [39]. However, in a study conducted by Constantino (2016) [7], 36% of the 39 ERPIs studied were unaware of the system's existence which indicates that most ADEs are not reported.

2.3.2 Errors and technologies in ERPIs

The medication circuit is quite complex due to a high number of single tasks, varying degrees of linearity, requirements regarding documentation, and employees' apparent freedom as to how and when to perform medication-related activities. Hence, the process is prone to multiple interruptions, which is a potential source for MEs. Thus, associated problems are highlighting with special attention the errors related to medication distribution and administration [37].

The distribution/preparation phase requires time, and in ERPIs the employees have multiple distractions which compromise the quality, efficiency, and safety of the distribution process [40]. Indeed, an interruption in this phase increases by 60% the risk of adverse events [37]. Besides that, the medicine preparation is often planned for a week, and more than 50% of the institutions take the medications out from the original packaging, making it difficult to correctly identify them later [7, 25]. Additionally, the distribution is done according to the pharmacotherapeutic sheet which is not always updated [7].

Furthermore, the medicine administration is performed by several employees and some do not have formation in the field. For example, health assistants are always involved somehow in the administration process and, in some cases, are the only ones responsible for the task [7, 40]. The person responsible for administering the drug before documenting it must supervise and ensure the intake. However, due to a variety of reasons such as interruptions, recording the administration is often neglected, in ERPIs [25, 37].

Commonly, employees work in noisy environments where they are likely to be interrupted compromising their focus, thereby increasing stress and frustration in the workplace which can lead staff to commit errors. This can affect both communications as well as teamwork [37]. Therefore, the most frequently detected problems in ERPIs are the omission of intake, wrong patient, wrong medication, wrong dosage, and wrong time of administration [7, 9, 40]. These errors derive from default records at transcription, distribution, and administration phases [4, 9–11].

However, the daily records generate large amounts of stored paper, are sometimes difficult to access which makes it challenging to search for information, are poorly organized, provide loss of information if papers are lost, and can also lead to faulty interpretations due to poor handwriting understanding [40]. Besides, failures in communication between employees which leads to paper records being difficult to read, filled out twice, or not documenting all medication updates, are often characterized as the root problem of MEs described before. Thus, technologies are the solution since can link team members to improve communication, alert about possible errors such as drug interactions, reduce errors in the interpretation, and help in clinical judgment alerting and boosting to follow the safety processes [9]. Still, the technologies will prevent unnecessary interruptions, improve workflow, and increase staff documentation compliance mostly in medicine administration [37]. However, its use is dependent on a wireless connection, and on a mobile application, which can be broken leading to an unstable technical solution that contributes partially to non-adherence to digital solutions. Additionally, to make technological solutions for this type of work are needed as a source of energy and the system cannot break [37].

At this moment, nationally, the use of technologies during the medication circuit is clustered in the prescription phase since it is obligatory by the Portuguese law (*Portaria* nº 224/2015, from July 27, article 5.º and 8.º) [7, 41, 42]. However, not all institutions use technologies to help in that stage. Furthermore, most do not use computerized records for transcription, preparation/distribution, and administration which becomes a challenge to maximize the efficacy, specify treatment and minimize MEs [7, 40]. However, it is emphasized that the technological solutions presented in the market are not tailored to assist care delivery forcing staff to adapt to facilitate medication administration which affects workflow [37]. Indeed, in the Portuguese market does not exist many software options for record administration, even though have other features such as visits control, financial management, statistics of the establishment, and PIC. The platforms that can register the medicine intake are confusing and difficult to understand.

Chapter 3

GESTECH4I development

GESTECH4I is a software designed to improve the medication management services provided by ERPIs. The prime goal is to create a software capable of enhancing medication management, with several functionalities to allow a greater safety in the management and medication circuit.

Since the software is a virtual product, it needs a set of code and instructions written in a computing language. Besides that, to understand how the program will make decisions a communication design on Unified Modeling Language (UML) is needed to understand the use cases between software and user.

3.1 Communication design

A UML use case was performed to promote a better and easy understanding of how the software works. UML is a standard modeling language most suitable for a use case, iterative, and incremental development processes recurrently used to describe, specify, design, and document processes of software systems.

Thereby, it identifies deficiencies and artifacts in the software that should be developed, provide guidance to the order of team activities and give guidelines for measuring and monitoring a project's products and activities. In other words, UML consists of a set of diagrams integrated to help in the construction, visualization, specifying, and documenting of artifacts of a system that can be software related or not through graphical notations [43].

Moreover, a use case diagram in UML helps to identify not only the requirements but also the system behavior describing the functions and scope. Indeed, show the primary form of software or system under development expressing the expected behavior from the system but does not explain the method to achieve it. In addition, it clarifies the interactions between one or more external users, named actors (input in the system and receive outputs), and the system, describing how the actors use it, enabling it to show the aim of the system. In each use case, there is a behavior diagram associated that describes a series of actions, that a system or systems, meaning a subject, can do in collaboration with actors, summarizing randomly the relationships among the system, actors, and use case. Still, for each actor, the use case should produce some type of observable and useful result [43]. Important to note, these are particularly used in the early phases of the project to all the participants in it, share an understanding of the requirements that the software should do, specifying the context. Also, validate the system design. Apart from that, is used during the analysis and design phases to identify the classes and tests that the system requires [44].

Relative to the present work, there is a subject that is a classifier representing a GESTECH4I software, several actors which represent the external users of the program particularly, pharmacists, nurses, health assistants, doctors, and the secretariat, the relationship between them which can be by association, include or extend. Therefore, in figure 3.1 it is easy to understand the system design (through different tabs where access is restricted according to function in the company), the relationships between the different use cases, and the tests needed to ensure that the software is operational and updated.

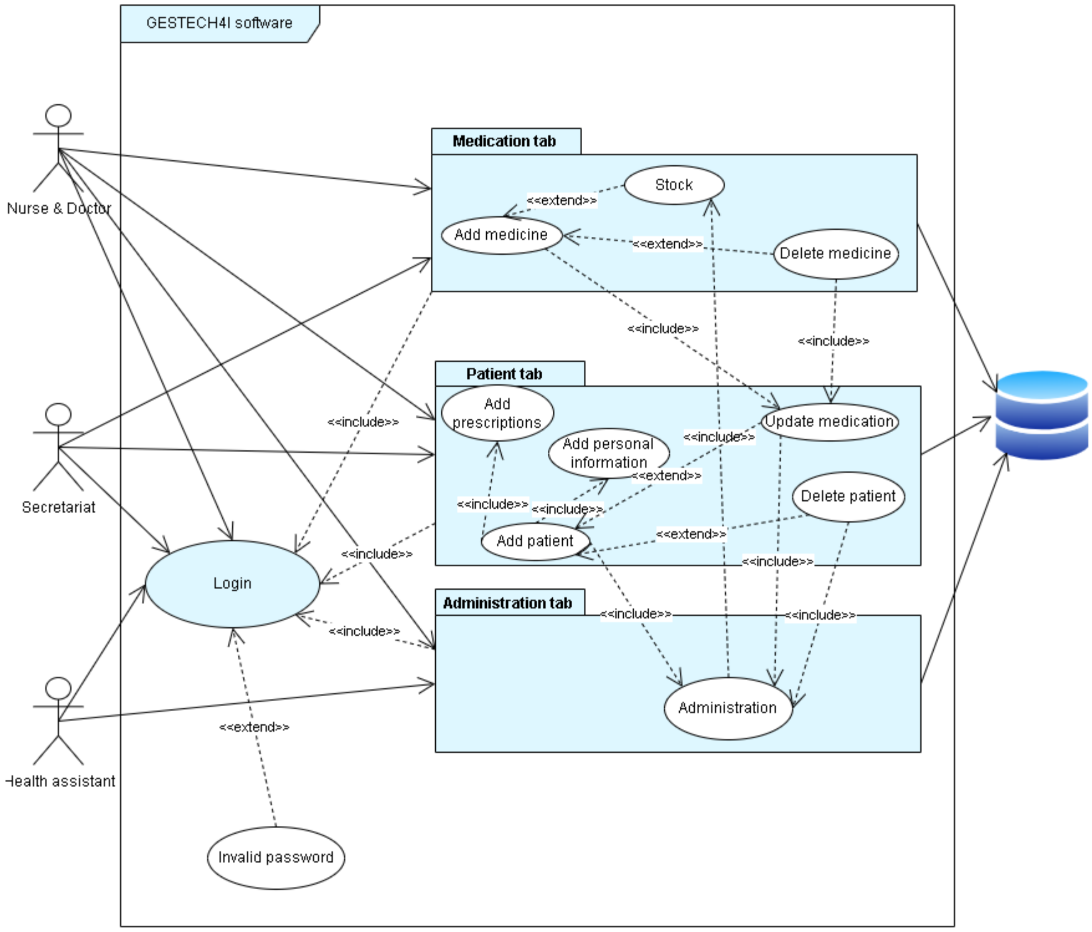


Figure 3.1: UML use case diagram (Developed online with draw.io).

3.2 Database building

After understanding the market's needs, and drafting the layout points, the development of the code starts, but first, a database is needed for storing data resulting from the interaction between the user and software.

Hence, it is possible to write and read data from the database during the use of the software. Besides that, it allows the storage and management of information in an organized form [45].

Also, tests are mandatory to prove the efficiency and efficacy of the software since every business (ERPIs in this case) generates data that the company must have control over. Besides that, it is possible to identify errors and bugs during coding ensuring minimal later errors. However, to do that it is required data, which can be real or not. If dummy data are chosen it is not mandatory authorization of the personnel involved so it cut short the process and the tests are reliable anyway. Therefore, it was crucial to choose an intuitive database software and facilitated work, namely, Microsoft Access, when coding in MATLAB.

3.2.1 Microsoft Access

Microsoft Access is an integrating part of the Microsoft Office and is described as an information management tool that stores data for analysis and reporting. Indeed, is a database management system (DBMS) that allows storing in one place, managing, and analyzing vast amounts of data efficiently and accurately. The data can have multiple sources and Microsoft Access easily store it in Structured Query Language (SQL) with the aim of reliability, scalability, security, and long-term manageability. Therefore, provides large-scale projects with long-term solutions. Although is recommended for small-to-medium businesses. The software enables users to create tables, forms, queries, and reports connecting with the aid of macros but avoiding always double data to enhance data management. Additionally, it allows the storing of several types of data with an SQL server connection and promotes a structured programming code language that facilitates handling large amounts of data with fewer code lines [46].

3.2.2 Data Selection

To create the database is crucial to understand how the user wants to analyze it, and what data is important to review and store. Also, it is essential to have a good database structure to prevent redundancy, so dividing the information into tables is the best option [45].

As GESTECH4I is a medication management technology it is relevant to have medication data, specifically name, storing localization, and stock of it. The first two parameters were chosen due to the rules mentioned in the medication circuit in chapter 2.3.1, and the last one was due to help manage medication inventory. However, to become the data more reliable as possible, the medications used for this were the most taken in the aged community according to the literature.

A study involving 4 representative EU countries, including Portugal, concluded the 10 most frequent prescriptions, in 2016, for people over 65 years old. Focusing on Portugal, the medicines with more prescriptions were [18]:

- Simvastatin and Atorvastatin (lipid-modifying agents), with impact in cardiovascular diseases;
- Omeprazole and pantoprazole (gastroprotectants);
- Paracetamol (analgesic);
- Alprazolam (benzodiazepine drug - psichotropic);
- Metformin (diabetes treatment);

- Amoxicillin (antibacterial);
- Furosemide (diuretic drug);
- Ibuprofen (anti-inflammatory).

Besides that, to enlarge this table more medications were selected according to other countries (England, Slovakia, and Poland) top 10 of the most prescribed namely, Lansoprazole, Cholecalciferol, Acetylsalicylic Acid, Metoprolol, Bisoprolol, Amlodipine, and Ramipril (see Appendix) [18].

Now, it going to need dummy patients to imitate residents with prescriptions within the medicine database. To simulate that, first, it is necessary to understand the relevant parameters so, name, and age, as described before in chapter 2.3.1, are important to identify. The medicine name, as well as the dosage, are relevant to medicine preparation, to facilitate review and detection of possible errors along the way. In those terms, medicine intake was divided by meal moments (see Appendix).

To register the medicine administration, it is key to create a table to store the data generated when the medicine intake. Therefore, it is necessary to attribute columns to each meal, in that way it will store if the patient took the drug or not. Besides that, since the records are daily it is indispensable having the date associated with the intake so the records do not overlap (see Appendix). To note, all three tables are connected within the software.

3.3 MATLAB code

After the creation of the database, it is time to develop the algorithm. Therefore, MATLAB was the platform selected to code GESTECH4I since it is a programming and numeric computing platform with numerous toolboxes which enhance the development capabilities. Indeed, MATLAB has a database toolbox that allows the exchange of data with relational, particularly SQL, and non-relational databases, and operationalizes its workflow. Also, it converts database data into MATLAB data type automatically. Consequently, it enables exploring data from a relational database (SQL) without the domain of the language of SQL programming and later applying MATLAB tools and functions to perform subsequent analytics. Thus, importing and exporting data to it within MATLAB and interacting with it without using SQL language, but doing queries through coding to the database managing easily larger amounts of data [47].

Through a toolbox named App Designer, it is possible to create the interface and the algorithm at the same time. In this way, MATLAB App Designer gives a visual layout of the components of a graphical user interface (GUI) and programming app behavior. Visually, has a design canvas to improve a precise layout and automatically generates the object-oriented code for that. Besides, allows adding component callbacks that enable keyboard interactions and execute functions when the user interacts with the app developed [48].

3.4 Data flow

To understand how the information is supplied to the software it is crucial to comprehend how the data flow works. Knowing the movement of the data within the software allows an understanding of its structure. Thus, to provide an organized vision of the data flow of the GESTECH4I software it is elaborated a graphic representation (see figure 3.2).

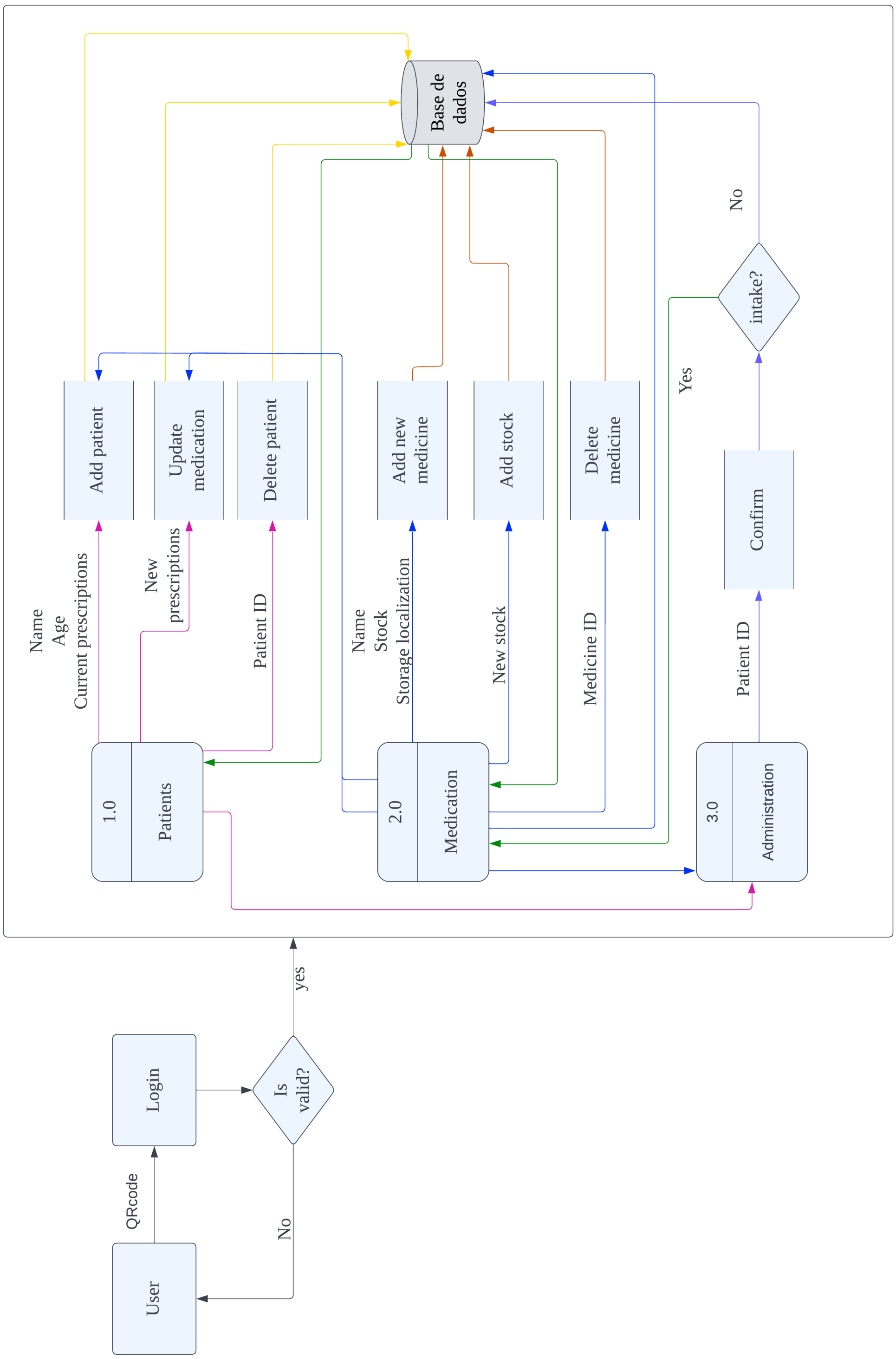


Figure 3.2: Data flow of the GESTECH4I software.

First, the user needs to login via QRcode, and if this is not valid the system returns an invalid message, and the user needs to try again. After the login is completed, the user is allowed to interact with the software according to the credential's rules. The software has 3 main tabs, where each tab has different tasks and information being connected between each other through the database. The credentials give access to different tabs according to the function of the employee, so if it is a health assistant only has access to the administration tab. If it is a nurse or a doctor it has access to the 3 tabs, and if it is a secretariat it has access to the patients and medication tabs.

In the patients tab, after the login, the patient data is read by the software and loaded to the interface so the user can analyze it. Here, the user can insert new data related to patients such as name, age, and current prescriptions which will be written in the database and read to update. Additionally, this tab needs access to the medicines identification (ID) in stock due to inserting the patient prescriptions, so the data from the medicines is also read from the database to update the interface.

In this way, in the medicines tab, the information about the stock, storage, and name of the drug is loaded into the interface where the user can insert new data. When inserting new data the software writes in the database and loads it to update the interface. Contrarily to the patients' tab, this table does not need access to other parameters.

The administration tab is where all the information is connected. Here, the software read both patient and medical information. The user chooses a patient ID and the system read the medicines database associated, loading it, so the user can validate the administration of the medicines. If the user confirms the intake of the medicines, the new entry is written in the database and the new information is read by the software to update the medicines tab. Important to note, all the data changed by the user after confirmation of the action is written in the database and then read by the software to update the interface.

3.4.1 How the software operates

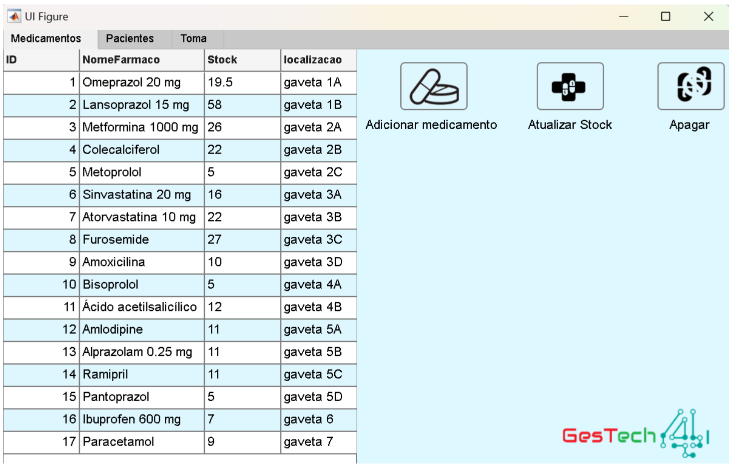
The GESTECH4I software aims to store patient data, such as identification, age, medication, and dosage, and link this information to the institution's medication stock to minimize MEs. This software will be suitable to analyze the patient's current medication, hence it will reduce human error in terms of transcription, distraction, and dosing. The stock of medicines will be linked to improve its management and ensure that patients' medication is updated. Indeed, to guarantee that the software is secure, there will be necessary a credential security control embedded in a QRcode to facilitate the platform login. The users will be the ERPI staff, namely health assistants, nurses, and pharmacists, among others with responsibilities for medicine preparation and administration. Beyond that, it will record if each patient takes the medicines according to the time that is supposed to be taken, becoming every step traceable. To note, the software works, at this moment, only in Windows.

Indeed, when the software is open it is shown different information, particularly, data from the company that developed the technology (for customer service purposes), information about the institution in which the software is operating, and the login button which allows through a QRcode to enter in the software. When clicked, the login button opens a pop-up window that is connected to the camera to read the pieces of information embedded in it (see figure 3.3).

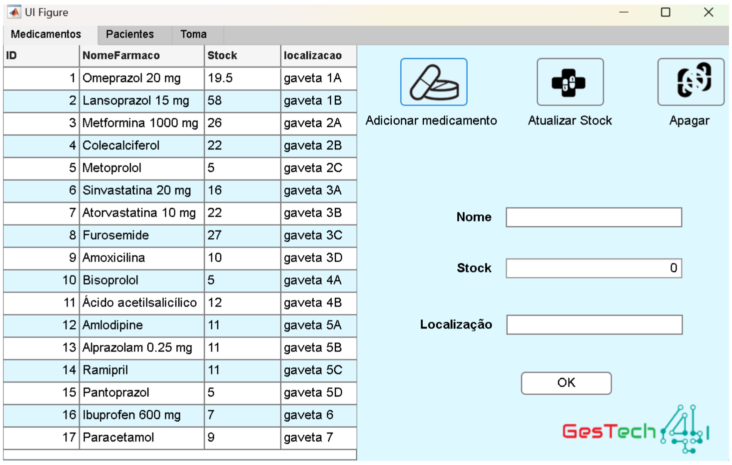
Figure 3.3: Layout when the app starts, at login.

After passing the software security, according to the authorization, the user can access several tabs, namely the medicines tab, where can add new medicines, update the stock, and even delete a medicine. All actions are controlled by a warning window to make sure that the action has been understood and is also expressed visually in a table that is linked directly to the database in Microsoft Access (see figure 3.4). It also does not allow new drugs to be added with the same name or location. Furthermore, this table relates to other software functionalities, namely with the medication administration to the patient, subtracting the administered dose, when ingested, from the stock. In the event of medicine being eliminated, automatically is removed from the patient's prescriptions. Thus, it guarantees easy and up-to-date medication management.

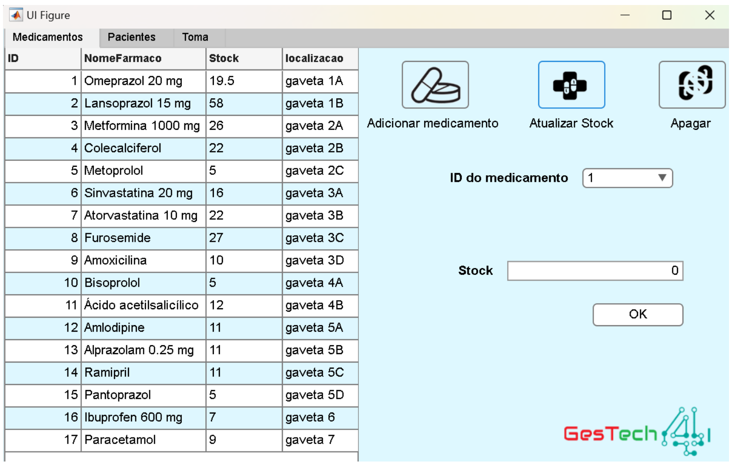
The patient tab operation is based on the same principle as the previous one. In this way, 3 buttons are displayed, which change the patient's medication, add a new patient and delete a patient. It also has warnings about the actions and visually they are expressed in the table. When it is needed to change the patient medication, first the user needs to choose the patient ID and then the medication ID, where on the side the user can check the medicine name. After the software search if the selected patient is already taking the medicine or if it is a new prescription. If it is to update the dosage of a current medicine the software only allows that, on the other hand, if the prescription expired the user can delete it. Still, if it is a new prescription the user needs to add all of the information (dosage and when). The deleting patient the user only needs to select the patient ID and confirm the action. The add new patient button creates an organized workflow to make sure that the necessary patient personal information is added, and only then the patient's prescriptions (see figure 3.5).



(a) Layout of the medications tab.

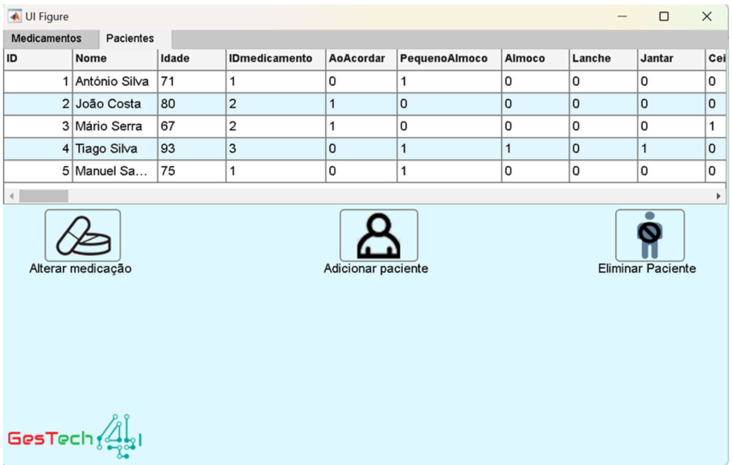


(b) Layout of medications tab when adding a new medication.

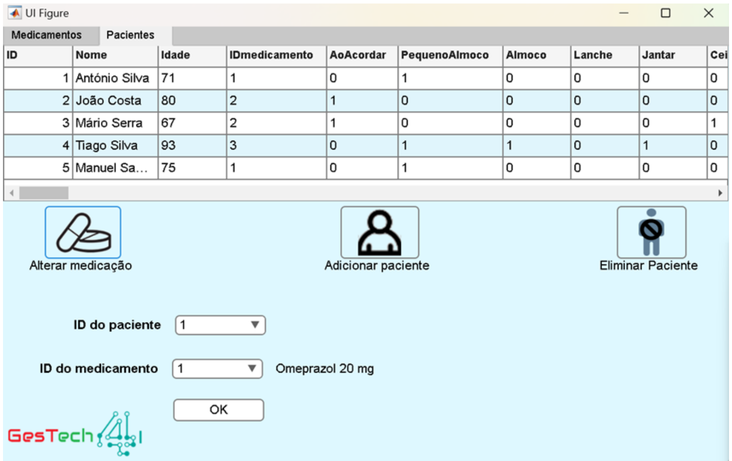


(c) Layout of medications tab when adding more stock to the respective medication.

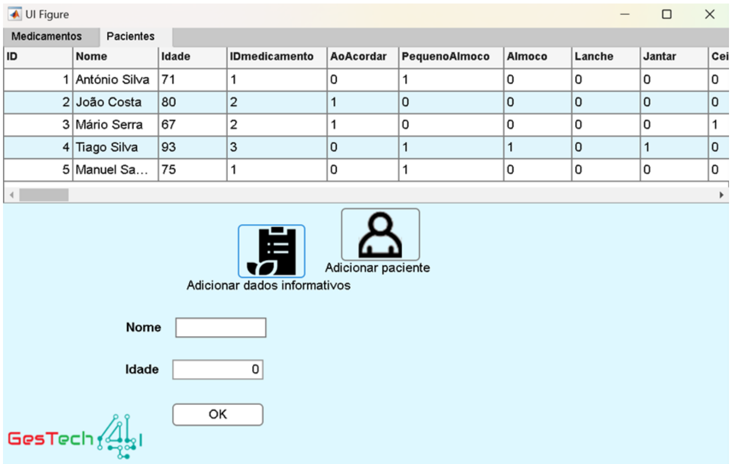
Figure 3.4: Layout of GESTECH4I medication tab: (a) general; (b) when adding a new medication; (c) when adding more stock to the respective medication.



(a) Layout of patients tab.



(b) Layout of patients tab when altering patient medication.



(c) Layout of patients tab when adding a new patient.

Figure 3.5: Layout of GESTECH4I patient tab: (a) general; (b) when altering patient medication; (c) when adding a new patient.

The administration tab, allows the user to select the patient ID to whom the medication must be administered. After that, the software shows the patient medication to ingest associated with a meal and time. If the ingestion of it is not validated after a few hours, the software will assume that this patient did not take it and will not allow alterations. Therefore, it strongly promotes recording at the moment of administration (see figure 3.6).

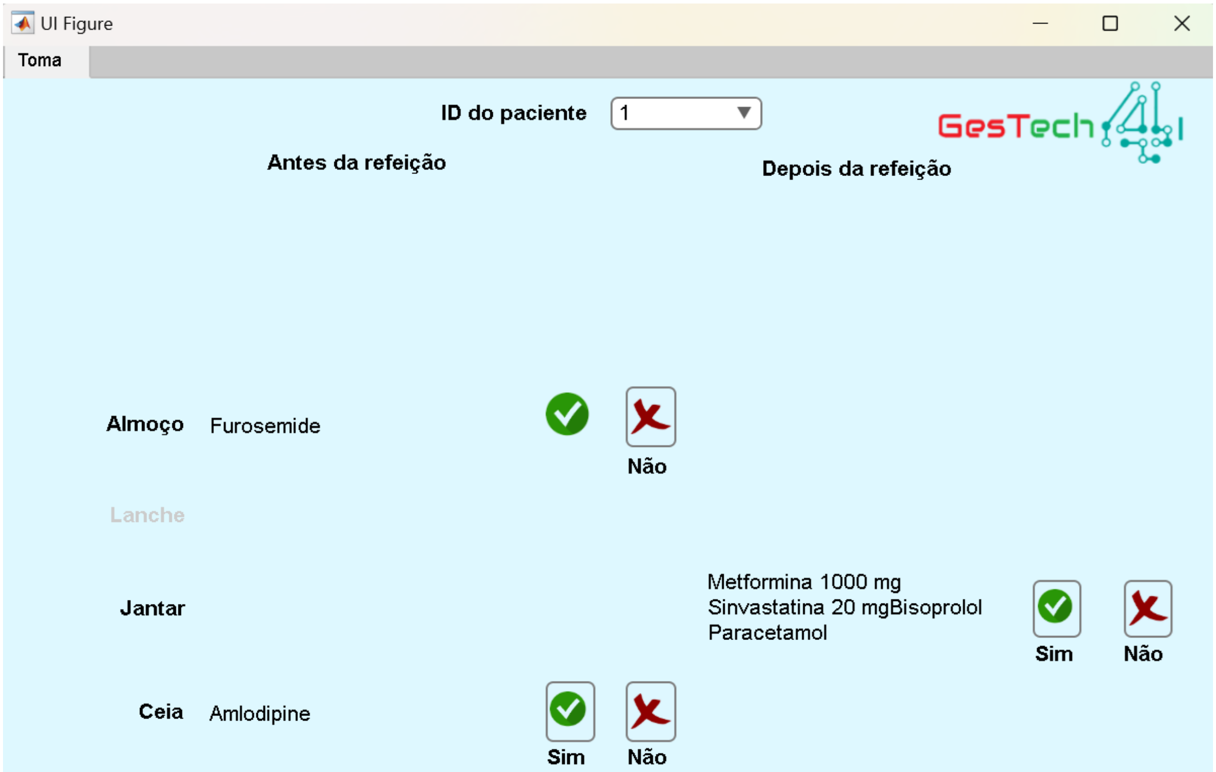


Figure 3.6: Layout of administration tab.

In short, the different tables are linked to promoting effective and easy medication management in the ERPIs. For each button, an event cascade is created to clearly define an organized and simple workflow being internal to the software. Still, it is emphasized the use of visual means for all actions and interactions software-user to speed up the user understanding.

For a demo of the software please check `https://drive.google.com/file/d/1JdXl5Uoq3K_h_zIPzO9dZ3aRHO-rD9qV/view`.

3.5 Design of GESTECH4I

Then, being the app already working, it is time to build an appellative and easy-to-understand design of the interface to enthrall the users. Considering the target, which is ERPIs, especially employees, since they are the ones that work with the GESTECH4I software, it is critical to fit into the ERPI workers' average profile. Hence, as abovementioned, the workers of these institutions are mostly women with low education [6]. For these reasons, adherence to technology is hard due to being difficult to handle and understanding the features with a lot of information delivered at once.

Therefore, to meet these challenges, GESTECH4I has a user-friendly interface to be easily understandable and intuitive. Thus, images are used for buttons to facilitate identifying their function. In addition, for all actions a warning message is given to confirm the action done, also, it visually updates, through a table, the data which allows identifying once again the changes made. Besides that, tables are used to facilitate data visualization.

From another perspective, the interface is organized in a way that each worker only has access according to the user function, so a health assistant, who in most institutions in Portugal is responsible for administering the medication, has access only to administration, where the user can choose the patient to whom the medication is being administered, confirm if has the necessary drugs according to the meal, and also select whether or not the patient has taken the medication, all in an intuitive view. This way the software enables a self-organized workflow, with an intuitive interface that is easy to use by any worker in the institution. Besides that, it allows reviewing prescriptions most simply and easily preparing/distributing the medication to each patient preventing mistakes in the after steps. Thus, GESTECH4I assists in the critical phases of the medication circuit.

3.6 Specifications

The software and the simulations were performed on a computer equiped with: (1) an Intel(R) Core(TM) i7-10510U as a Central Processing Unit (CPU) at 2.30 GHz max.; (2) 16.0 Gigabytes (GB) of Random Access Memory (RAM); (3) 1 Terabyte (TB) of Solid State Drive (SDD); (4) NVIDIA GeForce MX250 as graphics card; and (5) Windows 11 64-bits as Operation System. Besides that, the used Microsoft Access version was the one released in 2022 and the MATLAB version was the R2022a version.

CHAPTER 4

Market analysis

From a financial view, a market analysis is imperative for the commercialization of this product. The market analysis consists of a detailed review of the pre-existing businesses in the area marking the competitive landscape, as well as, explaining the success expected, how to introduce the product, and how the market will receive it. These results are speculated by analyzing, not only, important quantitative data such as market dimension, the profile of the customers, and revenues, but also qualitative data namely buying motives, desires, and consumer values [49].

4.1 Market dimension and customers

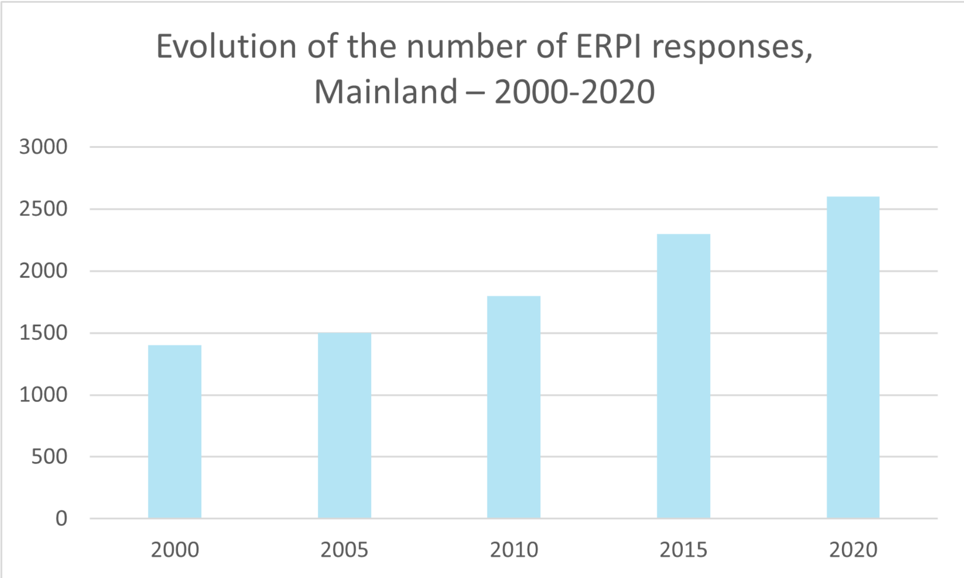
Initially, it is fundamental to analyze market tendencies to identify and characterizes the customer profile to ensure that the product is directed to the target public to maintain company expectations aligned with the demand.

The Global Commercial Real Estate Services (CBRE) conducted a study, in 2021, that concluded the next generation of real estate investment, in Portugal, will be in the senior sector namely in ERPIs since the national older population tend to rise drastically, causing high demand. In addition, Portugal is very appellative to the international aged group, which causes an even greater increase in the demand for this residence [50].

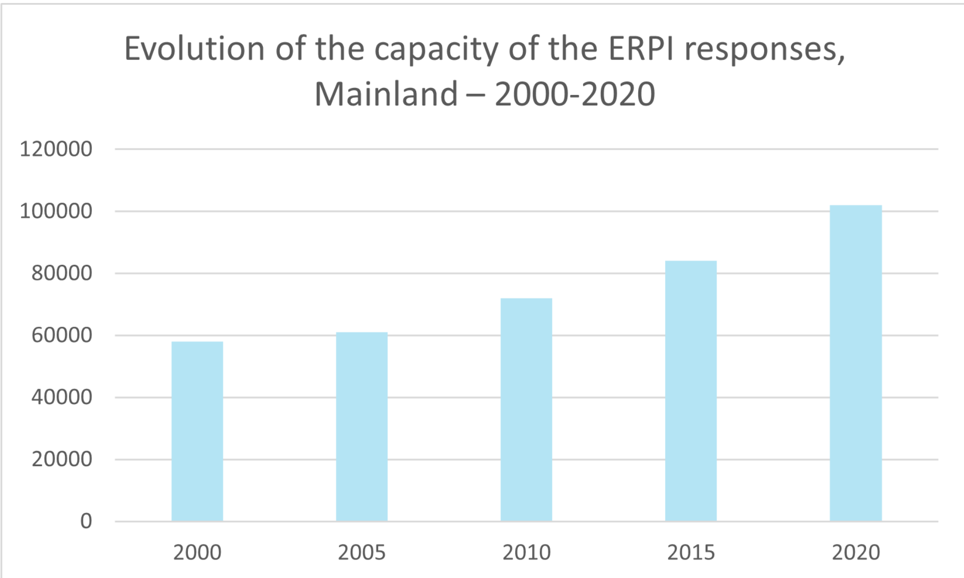
Since 2000, the demand for ERPI has been growing exponentially (see figure 4.1) and it is expected to continue. It is predicted that the geriatric population will increase from 23.5%, in 2021, to 26.2%, in 2030, of which 13.2% will be 75 years old or more, and finally grow to 33.7%, in 2050, of which 19.6% will be 75 years old or more [3, 6].

In 2020, there were over 2500 establishments, with a total of more than 102 000 beds [8, 50]. However, there was a deficit of 4500 beds to match the WHO guidelines, which advises that each country should have beds available in ERPIs for at least 5% of the older population [50].

On the other hand, regarding the management of the drug circuit is concerned the records are mostly done and filed on paper except in the prescription phase. This practice makes access, monitoring, and storage difficult and means that more time is spent on these tasks. Indeed, the records are centralized in a specific



(a) Evolution of the ERPI responses to the elderly, Mainland 2000-2020.



(b) Evolution of the capacity of ERPI to older people.

Figure 4.1: Statistics of ERPIs from 2000 to 2020: (a) Evolution of the ERPI responses to the elderly; (b) Evolution of the capacity of ERPI to older people (Retrieved from [8]).

model for each institution that follows the resident when transitioning care but is underused to register the medication circuit [7]. According to Lopes (2020) [40], 88.9% of the employees present in the study affirmed that it would be useful to have a computer system to record that data.

Undoubtedly technology improves and optimizes services and appointments in the department of health. As matter of fact, expenses in technology and innovation are in an emphasis position since it improves the gains, for example, preventing mistakes, improving management, enhancing diagnosis, and early detection of disease, etc. With the aged population comes the need for more residences and extending the existing ones which implies upgrading technology to facilitate patient management [51]. However, in national ERPIs the purchase of technology to improve care in the medication circuit is neglected due to the financial investment needed and/or by lack of communication between employees and management [40].

However, it is important to note that ERPIs management is the client but they aren't the only users. So, the software must please the consumer and the user. Indeed, the employees mainly the health assistants (one of the main users) are people with advanced active age and 64% have low levels of education [6, 38].

4.1.1 Market competitors

From the Portuguese market perspective, there are a few offers when comes to medication management technology namely *F3M* which is a software leader in the national market specializing in the ERPIs management area and has agreements with the National Confederation of Solidarity Institutions (CNIS), being the supplier to the *União das Misericordias Portuguesas*. This software has several features such as patient management (control of the waitlist, calculation, and control of payments, etc.), home support management (service shit, service appointment control, delivery control, etc.), stock management (expire dates, temperature control, month spend of medicines), among others [52].

The *MySenior* is an application designed to touch screens for ERPI, day centers, and in-home patients. Allows planning, registration, and consult the individual plan of care for each resident with easy and simple access by users and traceability of employees' actions. Besides that, have multiple characteristics like a file of the patient, planning of shift, time dedicated to each patient, registration of wounds, prediction of resources needs, follow-up sheet, and others. Important to note, that it is available online and can be consulted at any time in any location [53].

GeriCarePro is a management technology for ERPIs, which is separated into 3 different areas: professionals who register daily activities, create alerts to other professionals and write clinic protocols. In the residential area, the program records the patient's personal information (socioeconomic, family, and clinical) allowing the geriatric evaluation, adding vital signs measures, and sending alerts to potentially inadequate medicines, among other features. It is possible to analyze the institution's statistics and stock management in the management area and evaluate quality standards and financial performance. Important to reference that, in 2019, GeriCarePro won start-up of the year in the medical innovation field [54].

The platform *Ankira* is software to help in the management of elderly healthcare, storing, in one place, administrative, social, and patient information allowing access at any moment. This program can monitor expenses, plan and improve service distribution, visualize statistics, view real-time changes in the registers, etcetera. In addition, can record medication intake (who, when, and which drug) or other relevant information to improve care [55].

The software named *TSR-processos clínicos ERPI*, is another program to use in ERPI. This software has minimum requirements such as Microsoft Windows, at least 1GB of RAM, and an active connection to the internet. It has several features namely in the medical area (prescriptions, clinic diary), nurse area (therapeutic sheet, nursing record, evaluation scales), social area (social report, individual intervention plan, plan of socio-cultural animation), physiatrics area (physiotherapy, occupational therapy, and speech therapy), psychology area (psychology sheet, procedures register), nutritional area (food plan, enteric feeding), medication control (controlled substances). This way, the software allows the record of the therapeutic, medicine, and administrative control, and a record of vital signs, among others [56].

There are still more programs on the market such as: *GERPI*; *Softgold*; *Softwaipss*; *OfficeGest*; but all function in the same terms as the ones above-mentioned. In short, GESTECH4I has a competitive advantage over the market, since it is user-friendly, customizable, encourages immediate administration registration, and allows features to be easily incorporated (see figure 4.2).

Feature	GesTech4I	Competitors
Real time information	✓	✓
Easy to review patients' medication	✓	✗
Trace medication type, dose & time	✓	✓
Recording of all care medications	✓	✓
Stock control	✓	✓
User friendly	✓	✗
Easy and personalized reading by Qrcode	✓	✗
Alerts for missing medications	✓	✓
Sustainable	✓	✓
Easy Incorporation of other functions (e.g. registration of vital signs...)	✓	✗

Figure 4.2: GESTECH4I comparison with competitors.

4.2 Strategic planning

To evaluate the strength and how the product will possibly be perceived by the market, it is essential to identify and quantify the customer's needs and define a strategy. This review is possible by identifying the advantages and disadvantages of the product through tools such as SWOT analysis [49]. The SWOT analysis is a strategic tool to evaluate the strengths, weaknesses, opportunities, and threats of businesses in the sense of understanding the product's position in the market [57] (see figure 4.3).

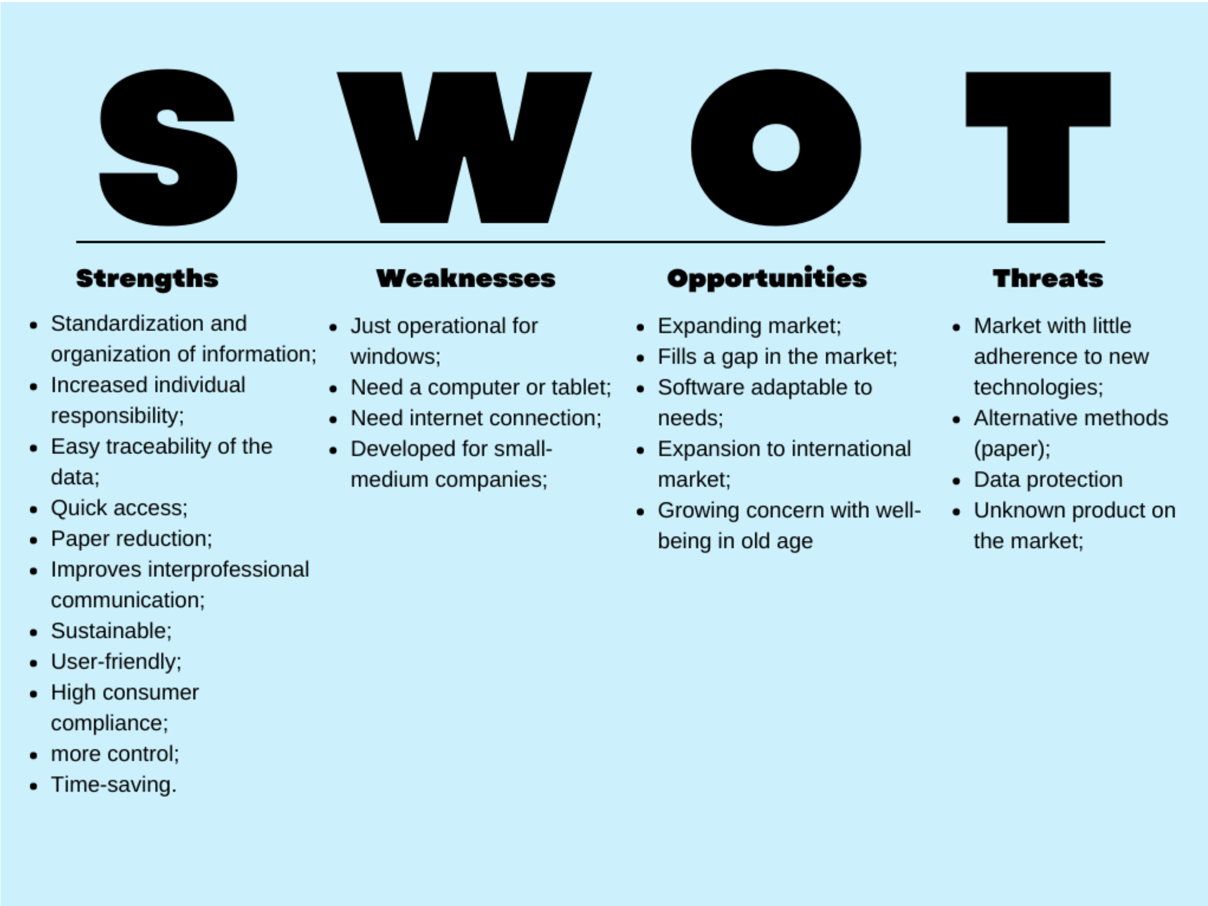


Figure 4.3: GESTECH4I SWOT analysis.

CHAPTER 5

Conclusion and Future work

With the growing aging population around the world, the need for greater investment and improvement in healthcare delivery is growing. The lack of caregivers and the comorbidities associated with the elderly means that the demand for ERPIs is increasing. As such, there is a need for improving care in these facilities and medication management is one of the areas where there should be a greater investment. However, problems related to medication management occur in these facilities in part due to complex drug treatments, lack of interprofessional communication, and outdated records. Therefore, MEs are reported all over the world and result from faulty medication management systems and human factors. Indeed, MEs are costly to the community, compromise clinical treatment, and most of them can be preventable.

Therefore, the literature recommends strategies to upgrade care in ERPI facilities, namely investing in a multidisciplinary team, communicating highly, and documenting medication updates. So, to suppress these errors, a medication circuit is created that addresses the various phases of medication management. Nevertheless, MEs still happen during the practice of the phases of the medication circuit due to low levels of education of the staff, default registers, interruptions during the performance of a task, and more than one person doing the same task. In this way, the most reported problems are related to the distribution and administration phase such as omission, wrong dose or patient and wrong time of administration.

Moreover, is beaded that technologies are welcomed to assist care to enhance communication, link team members, warn of drug-related problems, reduce transcription and distribution errors, and facilitate review of current prescriptions to have the best treatment cost-effectiveness. However, the use of technologies can lead to interruptions during the performance of the task since they are dependent on a wireless connection and mobile application. Thus, this may contribute to the fact that paper documentation is still prevalent despite digital solutions' availability. On the other hand, it is a fact that the solutions available in the market aren't tailored to meet all the needs in terms of drug administration and management.

Therefore, GESTECH4I fills gaps in the provision of care to the elderly as it encourages the immediate registration of medication intake in a user-friendly and sustainable way, reducing problems such as missing, double, or delay doses, and lack of communication among employees. Besides that, the technology will be suitable to analyze the patient's current medication, hence it will reduce human error in terms of transcription, distraction, and dosing errors. Connected to that, is the stock of medicines to improve its management and ensure that patients' medication is updated. Indeed, to guarantee that the software is secure, there will be necessary a credential security control embedded in a QRcode to facilitate the login into the platform promoting better workflow. In other words, GESTECH4I is mainly focused on the distribution and administration phases of the drug circuit but it provides other important features that enhance the minimization of MEs.

The software makes use of 3 tabs with information regarding medications, patients, and medication administration. In the medications tab, it is possible to insert new medications, insert new stock or eliminate medication. On the patients' tab, it can add new patients, update prescriptions and delete residents. Also, when inserting prescriptions it is only possible to choose between the existing stock in the institution. In the administration tab, you can search by the resident, check the medication to be administered in each meal, and validate its intake. All this information is related to each other, and whenever a medication is taken, it is subtracted from the stock.

This software intends to replace all relevant records, both of the patients and the medications associated. Thus, make all the information (that before would have been stored on paper) available in a single, easily accessible place, where it is only necessary to search for the resident by patient ID.

It is important to note that the work developed, described in this dissertation, is only a proof of concept, and the software developed is just suitable for Windows operating systems. However, the suitability and market space of the software is explicit.

Keeping in mind the space in the market, this software can be commercialized by a start-up company. Thus, embedding the software in the cloud, and adapting it for the Android and IOS operating systems are necessary. In this way, the user has access everywhere, anywhere as long as the user has access to an internet connection, and it is cloud base software. Therefore, the GESTECH4I software should progress to a Desktop-as-a-system (Daas) since it is a cloud computing solution in which the virtual desktop infrastructure is outsourced to a third-party provider, allowing easy management of various types of computer resources, including desktops, laptops, handhelds, and thin clients. Thus, the software will be secure and optimized with a low initial investment. The data flow of GESTECH4I will be improved but with the same principle as the proof of concept (figure 5.1).

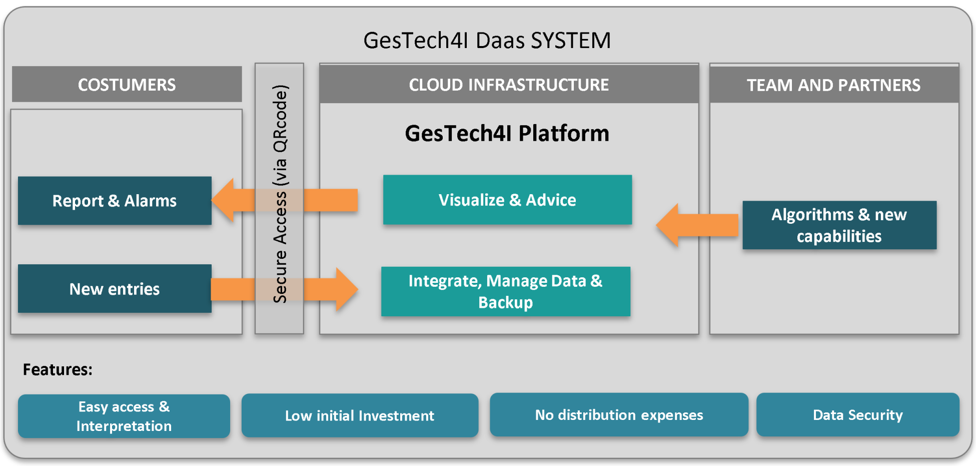


Figure 5.1: Daas system for GESTECH4I.

The users will be allowed access through a QRcode and receive reports and alarms when needed. The team and partners will develop new capabilities and improve the existing ones, and the GESTECH4I software will expand to a platform embedded in the cloud. Also, it is important to expand the database and continuous platform improvement appears indispensable as well as inserting new capabilities to meet all the needs of the market. Another important improvement will be to obtain medical software/device certification, to be commercialized, and the financial investment for this placement in the market.

Appendix A

Appendix

ID	NomeFarma	Stock	localizacao
1	Omeprazol 20 ı	19.5	gaveta 1A
2	Lansoprazol 15	58	gaveta 1B
3	Metformina 10	26	gaveta 2A
4	Colecalciferol	22	gaveta 2B
5	Metoprolol	5	gaveta 2C
6	Sinvastatina 20	16	gaveta 3A
7	Atorvastatina 1	22	gaveta 3B
8	Furosemide	27	gaveta 3C
9	Amoxicilina	10	gaveta 3D
10	Bisoprolol	5	gaveta 4A
11	Ácido acetilsali	12	gaveta 4B
12	Amlodipine	11	gaveta 5A
13	Alprazolam 0.2	11	gaveta 5B
14	Ramipril	11	gaveta 5C
15	Pantoprazol	5	gaveta 5D
16	Ibuprofen 600	7	gaveta 6
17	Paracetamol	9	gaveta 7

Figure A.1: Table developed in Microsoft Access for medicine database.

ID	Nome	Idade	IDmedicame	AoAcordar	PequenoAlm	Almoco	Lanche	Jantar	Ceia	IDmedicame	AoAcordar_
1	António Silva	71	1	0	1	0	0	0	0	3	0
2	João Costa	80	2	1	0	0	0	0	0	4	0
3	Mário Serra	67	2	1	0	0	0	0	1	7	0
4	Tiago Silva	93	3	0	1	1	0	1	0	5	0
5	Manuel Santos	75	1	0	1	0	0	0	0	3	0
(New)											

Figure A.2: Table developed in Microsoft Access for the patient database.

ID	IDdopacient	Data	AoAcordar_a	AoAcordar_(	PequenoAlm	PequenoAlm	Almoco_ant	Almoco_dep	Lanche_ante	Lanche_dep	Jantar_antes
1	1	10-Jun-2022	1		1		1				
2	2	13-Jun-2022	1	1	0	1					1
3	2	15-Jun-2022		1	0						1
4	3	30-Jun-2022	0					1			
5	2	30-Jun-2022		1	0						1
6	1	15-Jul-2022			1		1				
7	5	18-Jul-2022									1
8	1	18-Jul-2022			1		1				
9	1	19-Jul-2022			1		1				
10	4	19-Jul-2022									
11	1	20-Jul-2022			1		1				
12	1	23-Jul-2022			1		1				
13	1	25-Jul-2022					1				
14	6	29-Jul-2022			1						
15	2	02-Sep-2022									1
16	1	07-Jan-2023					1				
(New)	0										

Figure A.3: Table developed in Microsoft Access for administration database.

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