



UNIVERSIDADE DA BEIRA INTERIOR  
Covilhã | Portugal

# **Mobile Platform Solution for Patient Ulcer Monitorization with Capacity for Integration into an Electronic Health Record**

**Luís Miguel Carvalho Correia Pedro**

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**Informatics Engineering**

Supervisor Prof. Doutor Joel José Puga Coelho Rodrigues  
Co-supervisor Prof. Doutor Henrique Manuel Gil Martins

**Department of Informatics  
University of Beira Interior  
Covilhã, Portugal  
[Http://www.di.ubi.pt](http://www.di.ubi.pt)**



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# Resumo

Actualmente, os dispositivos móveis são cada vez mais importantes e têm um impacto crescente tanto em países desenvolvidos e emergentes como subdesenvolvidos. O acesso rápido à informação tem uma enorme importância pois acelera processos de trabalho que resultam numa melhor gestão do tempo. Além disso, tem também muitas características importantes que podem acelerar os esforços, a fim de ajudar e salvar a vida das pessoas. A boa gestão do tempo, através de serviços de informação, é a chave para o sucesso em cada sociedade.

Aplicações móveis são cada vez mais usadas para apoiar o trabalho de enfermagem. Especificamente, as tecnologias da informação e comunicação móvel (TICM) têm potencial para apoiar iniciativas de tratamento para pacientes com ulcerações da pele ou com um alto risco para o seu desenvolvimento. Nesta dissertação é proposto um sistema móvel de monitorização de úlceras, designado por mULCER, que serve para controlar o estado do paciente e úlceras durante todas as fases do tratamento. Além disso, permite integrar com um sistema de registo de saúde electrónico (do inglês, *electronic health record* - EHR). mULCER sincroniza os dados das úlceras com o sistema EHR e permite um apoio em todo o lugar e a qualquer hora para os enfermeiros nas fases de prevenção, classificação e monitorização da úlcera. Também aumenta a segurança e qualidade do registo de enfermagem.

A solução pode ser utilizada em modo independente ou embutida num sistema EHR. Serve como uma ferramenta para integrar os cuidados de enfermagem entre serviços de instituições de saúde de forma a aumentar o

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nível da integração dos cuidados de saúde no ponto de vista de serviço. As vantagens e desvantagens dos dispositivos móveis foram tidas em conta neste trabalho. Este contém os conceitos envolvidos, assim como inclui um protótipo completo para demonstrar a contribuição proposta.

mULCER foi testado em diversos dispositivos móveis (LG Optimus One P500, Samsung Galaxy Tab, HTC Magic, Samsung Galaxy S e Samsung Galaxy i5700). Assim, foi possível verificar a experiência do utilizador em diferentes tamanhos de ecrãs e diferentes características de processamento de dispositivos móveis. Actualmente, todos os componentes do sistema estão concluídos faltando efectuar a avaliação sobre a interacção e melhorias do sistema através de questionários ao corpo de enfermagem.

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# Abstract

Nowadays, mobile devices are each time more significant and have growing impact either in developed, emerging or underdeveloped countries. Quick access to information presents a great importance, as it accelerates work processes, resulting in better time utilization. Additionally, it may increase the quality of care.

Mobile applications are increasingly used to support nursing work. Specifically, mobile information and communication technology (MICT) has potential to support treatment initiatives for patients with skin ulceration or with a high risk for its development. This dissertation proposes a mobile ulcer monitoring system, called mULCER, which control patient's ulcer status during all stages of treatment. Additionally, it integrates with an Electronic Health Record (EHR) system. mULCER synchronizes ulcer data with the EHR system and provides everywhere at anytime support for nurses on evidence-based advice for prevention, classification, and monitoring different phases of ulcer healing or prevention. It also increases security and extensiveness of nursing record. The solution can be operated in a stand-alone mode or embedded into an EHR system. It serves as a tool to integrate nursing care among hospital departments and institutions on an enterprise wide effort to increase level of health care integration at the point of service. The advantages and disadvantages of mobile devices were considered for this purpose. The dissertation describes the concepts and includes a complete prototype to represent the proposed contribution.

mULCER was experimented in different mobile devices ( LG Optimus one P500, Samsung Galaxy Tab, HTC Magic, Samsung Galaxy S and Samsung

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Galaxy i5700 ), taking the user experience into different screens sizes and processing characteristics. All the components are finalized and only evaluation by nurses, focusing mainly on application and improvement to their daily work is missing.

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# Keywords

Mobile Computing, Mobile Health, Electronic Health Records, EHR, EHR Integration, Healthcare Application, Mobile Monitoring Application, Android, Ulcer Monitoring, Wound Monitoring, Follow-up Wound Treatment, Braden Scale, Wound Picture registry, Centralize Ulcer/Wound, Protocol Information.

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# Acronyms

FTP	File Transfer Protocol
CI2	Centro de Investigação e Criatividade Informática
MICT	Mobile Information Communication Technology
EHR	Electronic Health Record
EPR	Electronic Patient Record
EMR	Electronic Medical Record
HFF	Hospital Fernando da Fonseca, Amadora, Portugal
OAL	Observatório Astronómico de Lisboa
DAO	Data Access Object
PU	Pressure Ulcer
NHS	National Health Service (United Kingdom)
UI	User Interface
IDE	Integrated Development Environment Software application
ADT	Android Development Tools
WCF	Windows Communication Foundation
XML	Extensible Markup Language

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JSON	JavaScript Object Notation
IIS	Internet Information Services
RPC	Remote Procedure Call
SOAP	Simple Object Access Protocol
REST	Representational State Transfer
SOA	Service-oriented architecture
HP-HCIS	Hewlett-Packard Health care information system

# Chapter 1 - Introduction

## 1.1. Focus

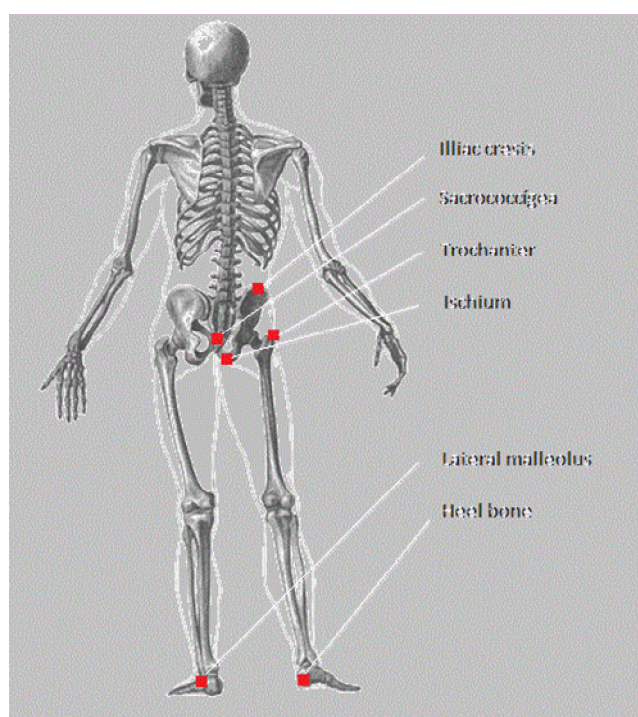
The aged or severely incapacitated patients often present reduced mobility (either at home or in hospital) which increases the risk for developing pressure ulcers. Those are uncomfortable co-morbidity that represents additional costs to hospitals and other health institutions [1, 2]. A pressure ulcer is an area of soft tissue damage that usually develop in areas where soft tissues are compressed between bony prominences and external surfaces, such as a bed or wheelchair, for an extended period of time. Figure 1 shows examples of these pressure ulcers.



**Fig. 1 - Pressure ulcers and wounds - adapted from [3, 4].**

The pressure ulcer, if not early detected and monitorized, will become a wound. For this reason, this document assumes that such mentioned expressions as wound or pressure ulcer have a similar meaning. In this case, a wound is pressure ulcer after a skin breakdown.

Usually, the body areas affected includes lower spine, hips, heels, and elbows. The most common locations are ischium (24%), sacrococci $\acute{g}$ ea (23%), trochanter (15%), and heel bone (8%). The other locations include lateral malleolus (7%), elbows (3%), occipital bone (1%), and scapular part [5]. In Figure 2, the most usual body locations where pressure ulcers occur are illustrated [6].



**Fig. 2 - Usual body locations where pressure ulcers occurs - adapted from [6].**

Pressure ulcers occur when pressure is applied to an area of skin within a short period of time. In fact, they can also appear with less pressure but over longer periods of time. The pressure interrupts the flow of blood through the skin. Consequently, without a blood supply, the affected area of skin suffers from lack of oxygen and nutrients. It starts to break down, leading to the creation of an ulcer. People with good health do not experience pressure ulcers because they are continuously altering their posture and position so that no part of their body is affected to unreasonable pressure. However, healthy people may develop pressure ulcers if they do not move their body.

People with normal mobility do not develop pressure ulcers as their body automatically makes regular movements that prevent from pressure creation on any part of their body. As an example, while sleeping, people change position up to 20 times during a night [7]. In addition, conditions that can affect the flow of blood through the body, such as type 2 diabetes, can turn a person more vulnerable to pressure ulcers [3, 7-8].

Once an ulcer has developed, it can become infected by bacteria, as illustrated in Figure 1. The risk factors that contribute to pressure ulcers are the following:

- ✓ Intrinsic risk factors - fundamental health condition or other factor that makes more vulnerable to develop pressure ulcers; At Intrinsic risk factors of pressure ulcers category may be included mobility problems, poor nutrition, an underlying health condition, ageing, incontinence, and mental health conditions.
- ✓ Extrinsic risk factors - elements in environment that puts a person at risk to develop pressure ulcers such hard surfaced, such as a bed or wheelchair.

In some cases, a person may have both intrinsic and extrinsic risk factors. Pressure ulcers can be classified into 4 grades of increasing disease severity. Grade three or four of pressure ulcers can be developed over a short time period. For example, persons with reduced mobility or persons which are more susceptible, a full-thickness pressure ulcer can sometimes develop in just a couple of hours. However, in some cases the damage will just become visible a few days after the injury has occurred [3,9,10-11].

In addition to ulcer prevention strategies, optimal care in established situations can help to avoid deeper wounds [12]. Other types of ulcers, like venous and arterial ulcers, are becoming increasingly frequent as diabetes, heart failure, and age related vascular damage raise significantly in elderly populations. These may mean differences in nursing care strategies, but overall pose similar needs for follow-up and record keeping. To increase

quality of care while reducing costs, nurses and managers focus in two main strategies:

- i) Protocol based approach to ensure homogeneity and standards of care, while structuring costs with materials;
- ii) Ensuring effective use of expensive ulcer care consumables.

Many institutions have their own ulcer care protocols that span from classification to treatment suggestions. As first examples, the Braden Scale protocol, Norton Scale and the Water low Scale that helps to evaluate the patient risk on developing a pressure ulcer. In line with several Portuguese hospitals, Hospital Fernando Fonseca also adopted the Braden Scale protocol. It was adapted and validated for Portugal in 2001 (additional details in Appendix I) [13]. Another example is the skin breakdown prevention protocols that are inspired in indications of the agency for health care research and quality (AHRQ) [1,2,12,14]. The treatment process may also involve patient and patient family education; such guidance can also be incorporated in a treatment protocol-approach.

Protocols chosen by institutions are normally in a printed paper form and stored in some folder to be consulted in a case of doubts, but usually far away from the bedside or the patient home. The Figure 3 illustrates a picture taken at a Portuguese Hospital in a nurse room. On the left side of the image is illustrated protocol information located in the shelves. On the right side of the image are illustrated ulcer treatments and characteristics on the nurse's room wall at hospital service. This existing information is many times useless attending to the distance from patient treatment localization and does not have an effective impact on patient treatment. Even when the information available in protocols is correct, the difficult access to those documents may significantly reduce its capacity to impact on behavioral and knowledge aspect of ulcer care. A pressure ulcer management protocol like the one described in [15] and illustrated at Appendix II, includes images showing the layers of the wound, real images of pressure ulcers or wounds, and other



commercial versions of software for nursing care [20-21] may share some of these features, they often lack flexibility for use in MICT, like Android-based mobile phones, they are often limited in their use range by institution policy or licensing and thus, a patient who is discharged from hospital, may come to have records of its ulcer care stages in more than one electronic system. In the systems referred in [20-21] a treatment suggestion and ulcer monitoring by photograph is missing.

## 1.2. Motivation and Objectives

Being able to create something useful and important for the society increases the interest on this project. This idea is highlighted by the Dean Gordon Brown: "Engineering is not merely knowing or being knowledgeable, like a walking encyclopedia; engineering is not merely analysis; engineering is not merely the possession of the capacity to get elegant solutions to non-existent engineering problems; engineering is practicing the art of the organized forcing of technological change...Engineers operate at the interface between science and society..." Massachusetts Institute of Technology (1962).

In pressure ulcer, the prevention may bring some benefits such as better cicatrization, costs reduction during and after the treatment, no need taking chirurgical operations to recover the skin from scars, reduce hospitalization time and medical costs associated among others. During the solution analysis were evaluated the potential users. Thus appear the necessity to create a system in order to help during the ulcer prevention stage, allowing a strict ulcer monitoring and accompaniment during all the treatment process. The main objective of this dissertation is the design, construction, and deployment of a mobile integrated system for ulcer treatment monitoring, including photographic follow-up for Android. The main users should be nurses which are incorporated at a healthcare institution. The system should consider the usability and embedded ubiquitous approaches.

To reach the main objective the following intermediate objectives were defined:

- Review the state of the art about mobile health applications related with topic;
- Definition of clinically-relevant information needs and contexts for mobile nursing work for classification, treatment, and monitorization of ulcers (requirements analysis);
- Construction of a mobile-independent application programming interface (API) on Android, to capture photos and nursing ulcer assessments thereby helping nursing work. A standard pictorial guide functionality to ulcer management may be created for classification, treatment and monitoring of ulcers;
- Analysis and implementation of Web services to connect the main system database;
- Experiment and validate the capacity to share and view the registered information at diverse mobile devices with Android;
- Evaluation and demonstration of the capacity of output integration into a standard EHR, namely Siemens® Soarian® Clinical (installed at the Hospital choose for the case study).

This work of engineering and research is expected to produce not only the desired mobile application, but also to provide the opportunity to disseminate the knowledge and software through, at least, a conference paper.

### 1.3. Main Contributions

This section is devoted to the scientific contributions of this dissertation to the state-of-art on Electronic Health, Mobile Health, Ubiquitous Health, and Wound / Ulcer Treatment. The main contribution is the mULCER application - A Mobile Ulcer Care Record Approach for Integrative

Care system that allows ulcer monitoring with a complementary photographic register during ulcer treatment process. It is integrated and synchronized with an EHR. This contribution was presented at Centeris 2011, Conference on ENTERprise Information Systems, Algarve, Portugal, October 05-07, 2011. The article named mULCER - A Mobile Ulcer Care Record Approach for Integrative Care was published in Communication in Computer and Information Science 221 - ENTERPRISE Information Systems, Vol. 221, Part 6, pp. 392-401, DOI: 10.1007/978-3-642-24352-3\_41, ISBN: 978-3-642-24351-6, Springer.

## 1.4. Dissertation Structure

This dissertation is organized in six chapters. This first chapter presents the dissertation context, focusing on topics under study, objectives, main contributions, and dissertation structure.

Chapter 2 - Related Work - focus on mobile computing available solutions and presents related work about EHR interaction.

Chapter 3 - Construction of mULCER system - This chapter presents the requirements analysis for mULCER, the design and system architecture as well as the main functionalities diagrams.

Chapter 4 - Technologies - presents the technologies used to create the system solution as well as reason for their choice.

Chapter 5 - System evaluation and validation - presents the system evaluation and validation to the system.

Chapter 6 - Conclusions and Future Work - Concludes the dissertation and advances avenues for further work.

# Chapter 2 - Related Work

This chapter addresses the current state of art on Mobile Health, Electronic Health Records interaction and related applications. Firstly, mobile computing environment is presented, secondly, impact of Mobile Computing in Health and integration with EHR system, as well as some further concepts within Ulcer monitorization.

Nowadays, the mobility makes relevant part of life and like that, the new technologies are being continuously adapted to follow the new style of living. Mobility tries to bring each time more functionalities and commodity to the common user making everything more near like being at office or home with internet access.

## 2.1. Mobile Computing and its Impact on E-Health

Mobile devices have attracted a high interest in software development areas and there are many areas benefiting from MICT devices usage and adaptation to particular needs [22]. Important services to population are being deployed via MICT in several areas like education, tourism, business management, or budget control [23]. These devices may help interaction between people, in general, or among groups, such as, in schools among colleagues and in companies between employers and managers. Mobile computing, in general, tends to accelerate and facilitate access to information, resulting in higher productivity. Healthcare is not an exception. For instance, inside a health care facility, a doctor or a nurse potentially benefit from the use of a MICT such as a Personal Digital Assistant (PDA)-phone or a tablet computer equipped with medical applications that can help them measure or record a patient's condition or providing real time access to

relevant information. Applications developments of this sort are increasing at the biggest application markets like Android Market and Apple App Store. Today, according to Mobihealthnews there are more than 1200 applications designed mainly for Doctors, Nurses and Students under the Health category in Android market. Comparing it with more than ten thousand applications, under the "Medical" and "Healthcare and Fitness" categories in Apple Store can give us a wrong idea about the real dimension of an interest in Android OS and their applications [24]. According with latest studies by the end of 2013 would be more than twice the number of Android smartphones comparatively the iPhone from Apple [24]. There are many interesting medical applications in diverse specializations like Cardiology, Anatomy, Anesthesiology, Dental, Dermatology, Neurology, Oncology, Pediatrics, Orthopedy, Radiology and more as well as others for Nursing workers and students. There are some medical reference applications in the areas mentioned above like Anesthesiology i-pocket cards, Heart Pro, Lexi-Dental Complete, iMCQs in Dermatology, Neuro Toolkit, Nursing Central, CCO Oncology in Practice, CORE - Clinical Orthopedic Exam and many others [25-26]. It was checked that some Medical applications have a great level of sophistication in functionalities and features but unfortunately is still disappointing to see that is a big lack of applications to connect and lead with EHR systems.

## 2.2. Electronic Health Records (EHR)

Electronic health records consist of systems design to collect and store electronic health information related with individual patients or populations healthcare history. This is a record that can be shared across different health care settings, by establishing in network-connected enterprises, information systems. Those records may contain all scope of data in complex or summary form for example: medical history, demographics medication and allergies data, immunization status, laboratory test results, radiology images, vital

signs, personal stats like age and weight, and billing information. All patient encounters, medical experiences are saved within a record that permits simplicity, efficiency and automation of the workflow in the health care services. Moreover this settings increase safety through evidence-based decision support, quality management and outcomes reporting.

The terms EHR, EPR (electronic patient record), and EMR (electronic medical record) are often used in an interchangeable manner, even if the difference between them may be outlined. The EMR is the data source of the EHR systems and is formed by the legal patient records at hospitals and ambulatory. The EPR is a term that has its origins in the United Kingdom and fundamentally has the same definition as EMR. However the definition of EPR by NHS as “an electronic record of periodic health care of a single individual, provided mainly by one institution” makes EPR definition more patients centric. The term EHR is created and maintained within an institution, such as a hospital, integrated delivery network, clinic, or physician office [27-28]. In the world exists a lot of EHR solutions like AllegianceMD, MedLedger, InSync by Intivia, Chiro Touch, MediTouch EHR, Electronic Health Record Software, SuiteMed IMS, Web PT EMR, PrognoCIS by Bizmatics, Benchmark Systems EHR, mEMR and many others by different companies. However there are ones more adapted to Portuguese Health Care reality as Alert®, Siemens Soarian® Clinical or Hewlett-Packard Health Care information system (HP- HCIS®) that are the ones chosen by the bigger hospitals with more affluence in Portugal. The mULCER solution is being integrated at HFF with the Siemens Soarian® EHR system that the Health Care facility has. Figure 4 illustrates two EHR systems windows where it's visible the agglomeration of patient data as medical and personal information. The systems illustrated are HP-HCIS EHR and Siemens Soarian EHR. In order to see data generated by other applications these systems usually either present information by launching other application within a patient/item context or, they received and incorporate into the database data via Web services or other messaging mechanisms to later present information to the user.

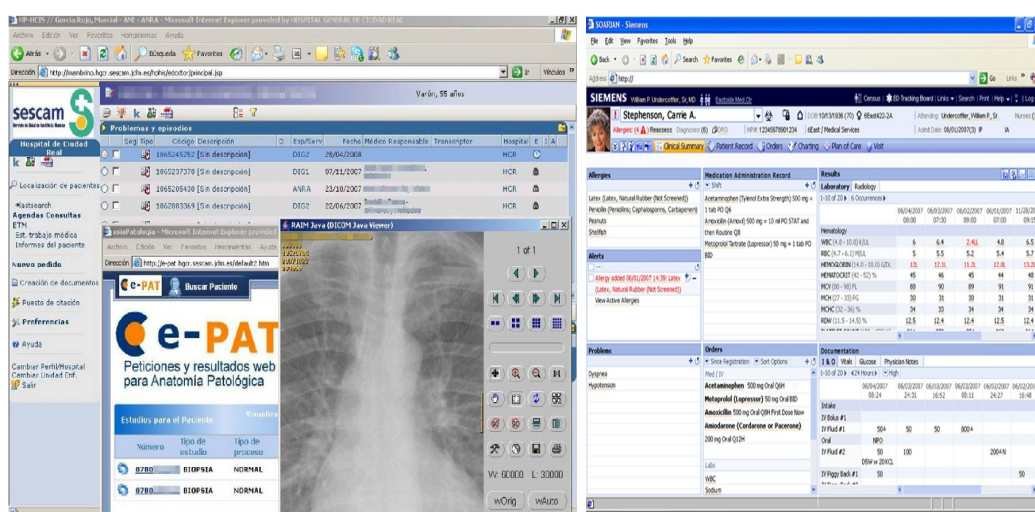


Fig. 4 - Examples of HP-HCIS EHR system and Siemens (Soarian) EHR system.

For example, to see the data created/registered by mULCER application, Soarian should have the possibility for Ulcer data register by their own users. Like this it is possible to see data entered via both applications: Siemens Soarian or mULCER application. As referred before, to our knowledge, there are many applications that allow connectivity to EHR but few Android Based Applications which integrates with EHR.

In the last years large investments have been done into exploring the potential of mobile solutions to support healthcare services [29-30]. The need to support mobile clinical practices and make health information increasingly more available to patient and professionals continues to stimulate M-Health solutions development. Examples span from hospital-based services for patient care to educational programs, made available on mobile platforms with the intention to combat the epidemic rise of obesity and diabetes [31]. To improve the services of searching and locate clinicians the Qatar government developed a Smartphone application for that purpose. In the United States, the Veterans Administration, known for its extensive EHR, also presented a mobile application that permits patients to access a central account. Such functionality allows the patient to download their health information, fostering information sharing between health care providers.

These, and other, usages of MICT will only expand as society learns to act and react to mobile computing and harvests investment on mobile platforms, such as Android®, and communication capabilities [32-33].

Nextly, would be explained the concepts around ulcer monitorization and how works paper based ulcer registry data, by nurses in the hospitals.

### 2.3. Ulcer Monitorization

Analyzing the characteristics of available EHR solutions it seems difficult to find one with all the functionalities that a health care facility needs to work daily. Namely in Ulcer Care, the mobility of professionals, the difficulty of bringing cameras to the bedside connected to desktop based-solutions. There are some functionalities that take precedence of others according to the destiny population treated, enterprise main goals, or financial interest. Normally, what happens is some adaptation and customization of each EHR system to the reality that it would take care. Ulcer cares and registers are often not making part of the basic functionalities that the EHR system product managers have in mind to create. However when it is well analyzed this kind of ulcer development situations, can make a huge impact in the society because of the reasons mentioned in the first chapter. Nowadays the nurses in many hospitals have to register this kind of data in papers forms and then in the end of the treatment send it to the administration archive. All steps of ulcer treatment procedures, since the ulcers evaluation, treatment and registration takes too much time and with the risk of lost the registered data. The Appendix III represents the paper form used at the HFF by nurses to register ulcer treatments. Numbered as "1" are the fields to register the most important patient personal data as name, age, sex, utente number and hospital internal process number. Related with the ulcer evaluation, in the place marked with "2" can be checked and registered the Braden Scale evaluation, fill the respective variables and

calculate the risk that the patient has to develop pressure ulcer. Marked as "3" it is possible to fill the localization and wound category by the nurse. On "4", can be registered the wound characteristics observed as ulcer category, wound type, exudates characteristics, treatment applied, next observation time, and many other important ulcer aspects. On "5", are shown some help information in order to fill the ulcer characteristics. In the last part marked as "6" is presented the meaning of ulcer characteristics.

When the EHR system allows nurses to register this ulcer information normally the procedures are to register it in paper, and then pass it to the respective application. Or when there is no paper, normally there is not accessible an information system nearby the patient to register on time, the observations and treatments applied. During the treatment is also limited the continuous treatment and ulcer evolution attending to the absence of ulcer picture and registers from last observations. The distance between the patient bed and the nearest computer at nurse room normally distances a minimum of 15 meters and makes impossible picture analysis, picture impact and ulcer reaction since the last treatment applied. Thereby, there is always a risk of data lost till the final registration of the ulcer patient information as well as photography missing impact during the ulcer patient treatment.

The usability of the mULCER application nearby the patient during the treatment may reduce the problems referred when using a paper based register type. The future seems better, efficient, with better quality and with high possibility to create better conditions to patient treatments. The idea to develop a system to assist the ulcers monitoring, growth with nurse's community necessities. This may have impact since the first phase of evaluation, classification until the stage of monitoring, and ulcers treatment. Thus, is being created a solution with impact on patient ulcer treatment and health.

# Chapter 3 - Construction of mULCER Application

This chapter presents the design, requirements of the mULCER system, and then the UML diagrams of the main mULCER functionalities.

The Object Management Group (OMG) created the Unified Modeling Language (UML) that helps to visualize the system architecture in a standard way. The use of UML supports visually the system specification and the development process, in order to lead the product under development to the success. A good requirements analysis and study of necessities, defines the objectives to increase the success rate of the project and decreases the actual and future development costs.

During the conversations with ulcer healthcare specialists concerning treatment processes, was possible to learn about ulcer evaluations procedures and treatments. This made clear that would be very important to accomplish the registered information with the wound photography. Also could be highly beneficial that the solution would take part of the main functionalities of the mobile devices, and include an image component to suggest the treatment to apply.

## 3.1. Requirements Analysis

The functionalities of the system were established after an analysis of requirements with nursing staff, in order to know exactly what is desired for the final product. This process contributes to defining goals and functionalities to achieve in the end of the development process.

The aims defined to the system are to be an enabler of ulcer follow-up, benefiting from mobile devices' capabilities. This is expected to increase the quality in terms of treatment and ulcer record keeping. It is also very important for nurse's community the existence and interaction with an application that can bring information proximity and new resources such as:

- i) Photography wound register.
- ii) Alerting functionality.

The application interface should be simple, intuitive and with large buttons with appropriate size for the user finger, offering a simple and powerful User Interface (UI) to interact and handle the system. This user-machine interaction makes the user experience easy and intuitive. The information that would be provided should be concise to accommodate the limited screen size devices, while still easy to read. The application need to include a functionality to limited access/ sign-in, with credentials validation, before allowing user interacting with patient data/any functionality. This is a security and privacy requirement and reinforces wound data records privacy, security, and audit ability.

In summary, mULCER should offer an intuitive, stable, and helpful application to health care users. The ability to easily access and share the register data and wound photographs, easy access to protocol information, accompanied with an alert system may give a user-machine interaction with easy handling and a good ratio between data quality and high interactivity.

Once the mULCER is installed and connected to a main hospital system it may share information over Web Services. These allow that a built application implemented for any operative system may interact and communicate with others over a network connection [34].

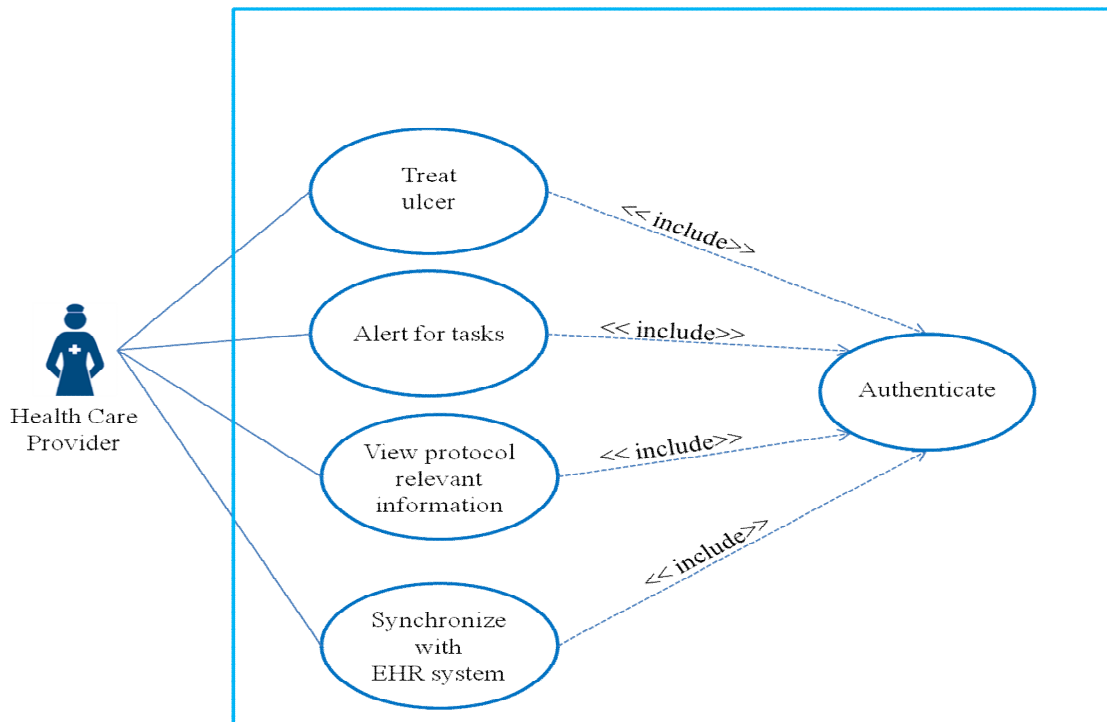
Next the conceptual design of mULCER proposal is presented and the Unified Modeling Language (UML) diagrams of the main actions and

procedures. Those diagrams define and explain what functionalities the external elements may interact in the system. Posteriorly in the chapter five is detailed explained how to interact in practice with these main functionalities.

### 3.2. UML diagrams and Database mapping

Diagrams represent the user interaction with the application features. This relation is presented under graphical representations from the actor point of view. Nextly follows the diverse diagrams that illustrate the several actor interactions. At the diagram in Figure 5, the Health Care Provider may choose between four main functionalities: i) "Treat ulcer", the user may register the patient observations during the treatment. There, may register wound characteristics, wound treatments, Braden Scale evaluation, wound photography or check a suggested treatment to a specific wound according to protocol information. Also may view all patient episode data. ii) "Alert for tasks", alerts the user for pendent tasks related with patient ulcer treatment. iii) "View protocol relevant information", allows search relevant information from the protocol hospital documentation. iv) "Synchronization with EHR system", may synchronize the existent application data records with the main system that centralize all patient records. Those options are just available after successful authentication, and are illustrated in detail on chapter five where are shown the user interactions with the UI.

As previously explained the user may access the features of the application mULCER after valid authentication in the system. Thus, the system features can be summarized on alert for tasks, seeking relevant protocol information, data synchronization with the main system, to record patient treatment with accompanying photographic, suggest the proper treatment, Braden Scale evaluations register, and visualize the episode resume with all data registered at patient episodes.



**Fig. 5 - Use case diagram with main functionalities of mULCER.**

After the initial phase to understand what was meant, it was necessary to evaluate how to save the data. Thus, it was decided to keep the data in the database, either on local application or main system. Nextly is explained the data model that stores the values of the several features in order to understand the main functionalities and data model associated to represent that in the database. In summary, at Appendix IV is illustrated image representing the data model relationships between the various tables and functionalities of the application. In Figure 6, are illustrated the main features of the Alert for Tasks functionality. The table "Reminders" was defined to keep the information and it is represented at Figure 7.

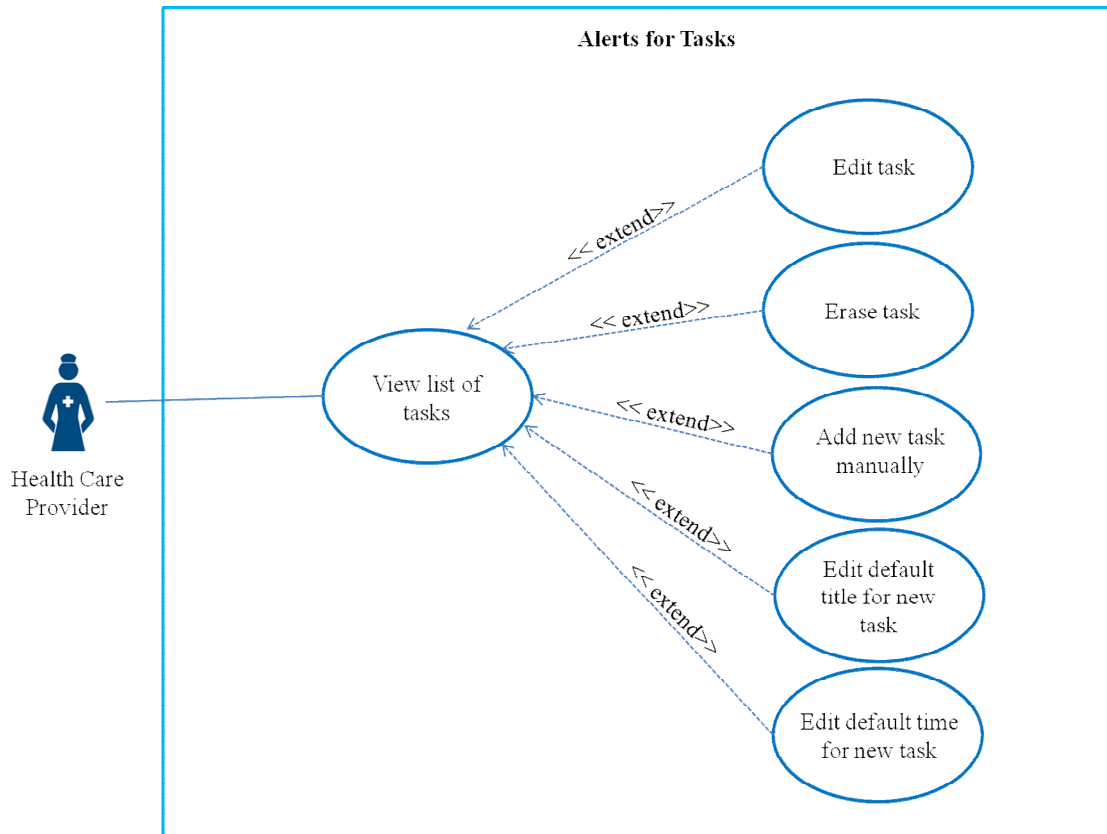


Fig. 6 - Use case diagram Alert for tasks.

ALERTS  
FOR TASKS

REMINDERS
_id
title
body
reminder_date_time
syncr

Fig. 7 - Table reminders.

At table “Reminders” are kept the alerts information such as short description, long description and also the date and time when the system would reminds the user for a specific task.

At the functionality to “search relevant protocol information” has been defined the main features that are illustrated in Figure 8. To keep the functionality data it is defined the table “Protocolar\_Info” and it is illustrated in Figure 9.

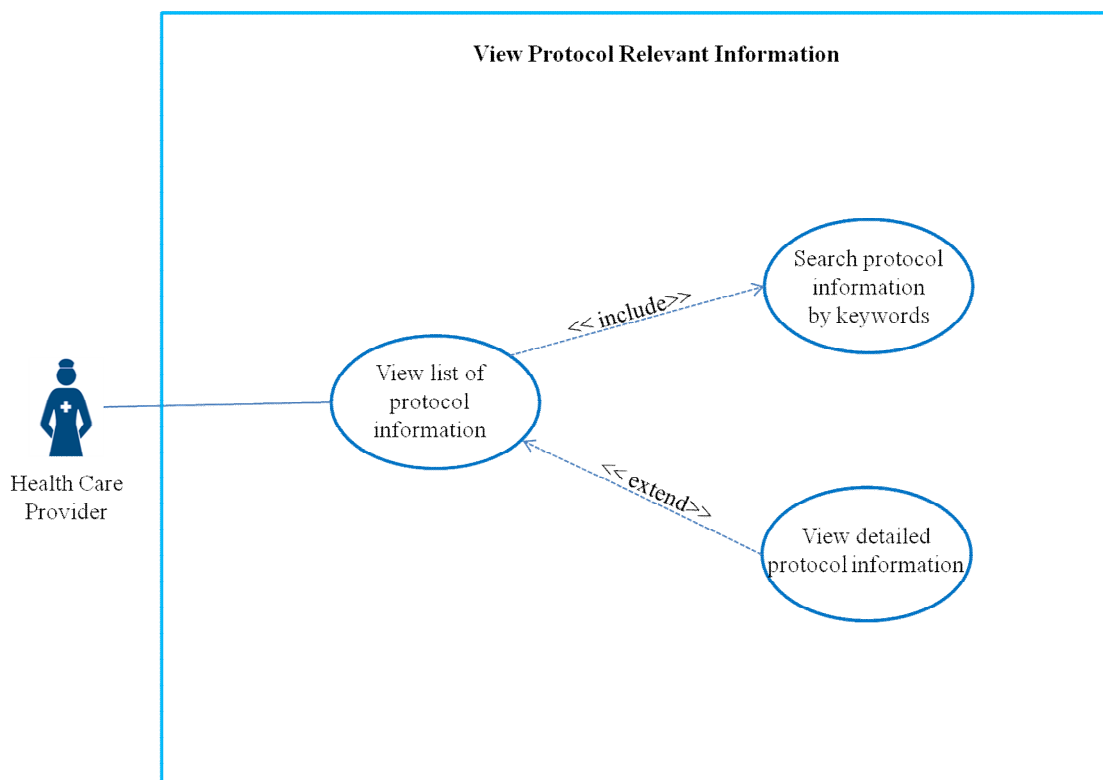


Fig. 8 - Use case diagram to View Protocol Relevant Information.

SEARCH PROTOCOL  
RELEVANT INFORMATION

PROTOCOLAR_INFO
_id
short_desc
long_desc
keywords
syncr

Fig. 9 - Table protocolar\_info.

At this table are kept protocol information records. Each one is represented on the table by the short description, long description and keywords. The last one has the expressions from which the user may search. From the search is retrieved a list of short descriptions representing a protocol information long description, represented on the table by "long\_desc" column. After press one item from the list appears a window with the matching "long\_desc".

At the "Synchronize with EHR System" functionality was defined the table "sync\_control" in order to control the last update made from the main system to the mobile device database. The data controlled by this table may be reminders, protocol information, and system users. The other types of system data are just brought from the main system to the mobile device database when such data its needed. At Figure 10, are illustrated the table and fields for this functionality.

SYNCHRONIZE RECORDS WITH EHR SYSTEM

SYNC_CONTROL
_id
type
system
updateDateTime

Fig. 10 - Table syncr\_control.

In order to control the data synchronization between the mobile application and the main mULCER database, was created the column "syncr" in almost all tables. This column validates the data synchronization with the main database. After successful synchronization the default value "N" is updated to "Y". The functionality "Treat ulcer" represented at Figure 5 has the features illustrated on Figure 11.

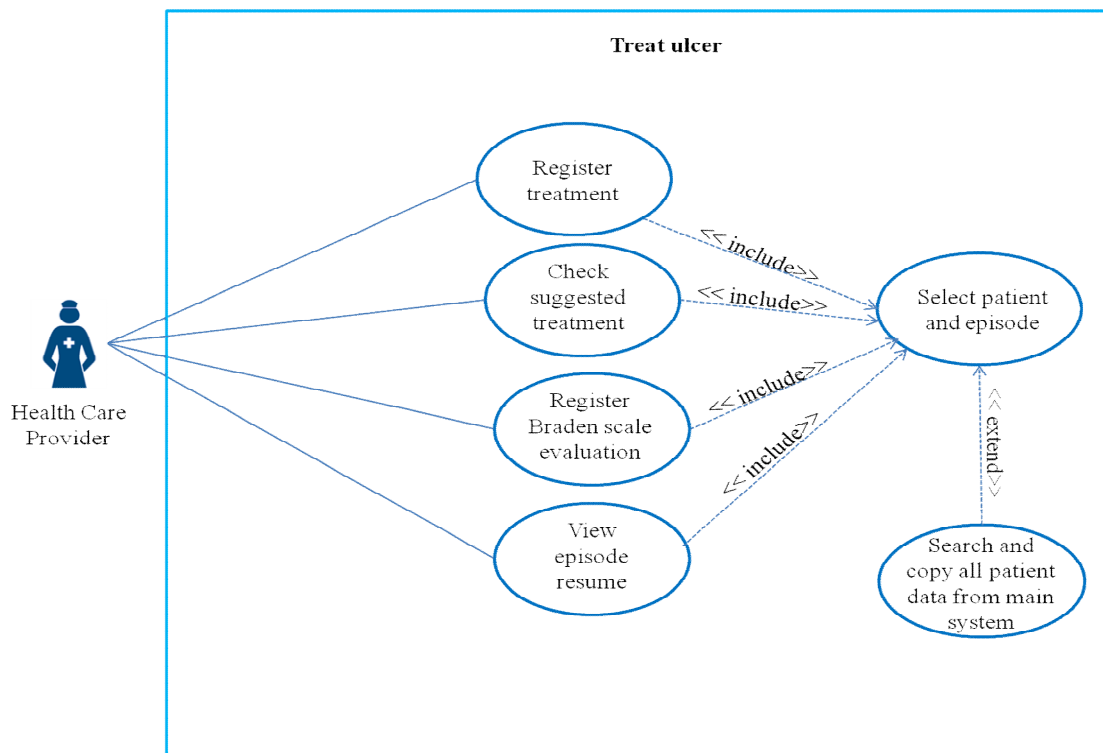
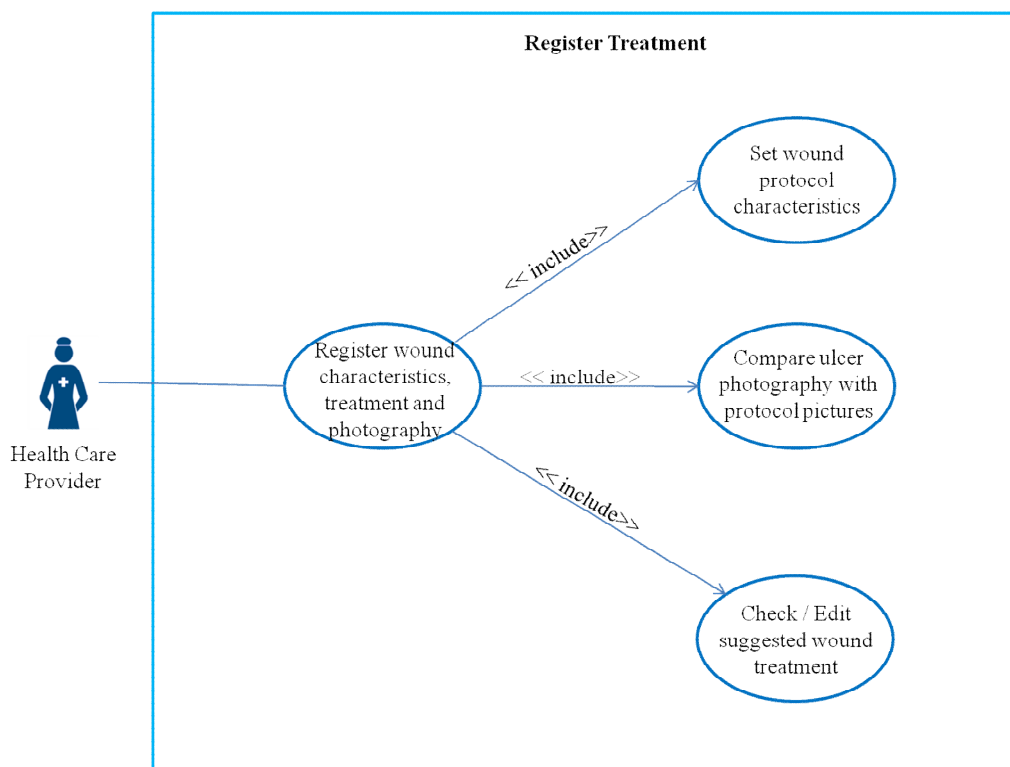


Fig. 11 - Use case diagram treat ulcer.

The "Check suggested treatment" option guides the user to a possible wound treatment to apply, taking into consideration a variety of protocolar photographs with specific characteristics. The option "Register Braden scale evaluation" evaluates the patient state and gives a score representative of the patient risk to develop pressure ulcer. The option "View episode resume" summarizes registered data as Braden Scale evaluations, wound characteristics, treatments applied, and wound pictures at the patient episode. To create a treatment record, at the option "Register treatment", it is needed to record the wound characteristics, wound photography, and wound treatment with the possibility to receive a treatment suggestion with the photo compare with protocol pictures. This is illustrated on Figure 12.



**Fig. 12 - Use case diagram register treatment.**

To register patient treatments has been defined the table "wound". This table and related are represented at Figure 13. At table "wound" is indicated a field named "Utent". This may keep a unique Portuguese national

number named *"número do utente"*. This is a National Public Entity number and insures that the patient is unique in the system. In the field Picture is kept the filename of the picture wound. This unique picture name is created by the actual time in milliseconds concatenated with the patient number. This picture keeps always the same identification even after being sent to the File Repository. When the application needs to show the picture and it is not present locally, the application gets the picture from the remote File Repository with the same identifier. This means that the picture was taken by another mobile device. The tables connected to the table "wound" as "wound\_type", "wound\_width", "wound\_depth", "exudate\_cat", "skinaround", "wound\_category", "wound\_height", "tissue\_type", "exudate\_qtt" and "wound\_pain" keep the protocol data configuration to the respective types. At table "wound\_type" are the possible types of wound, at "wound\_width" the possible wound width values, at "wound\_depth" are the possible wound depth values, at "exudate\_cat" the possible wound exudate category values, and at "skinaround" are the possible values for the skin around the wound. At "wound\_category" are the wound categories, at "wound\_height" the possible heights wound values, at "tissue\_type" the types of wound tissues, at "exudate\_qtt" are the possible exudate quantity values, and at "wound\_pain" the possible values from the pain scale. In summary, table "wound" keeps each wound treatment registered in the system. At the "Check suggested treatment" functionality there were no tables specifically defined. To this subject are used the same tables as for the functionality "Register treatment".

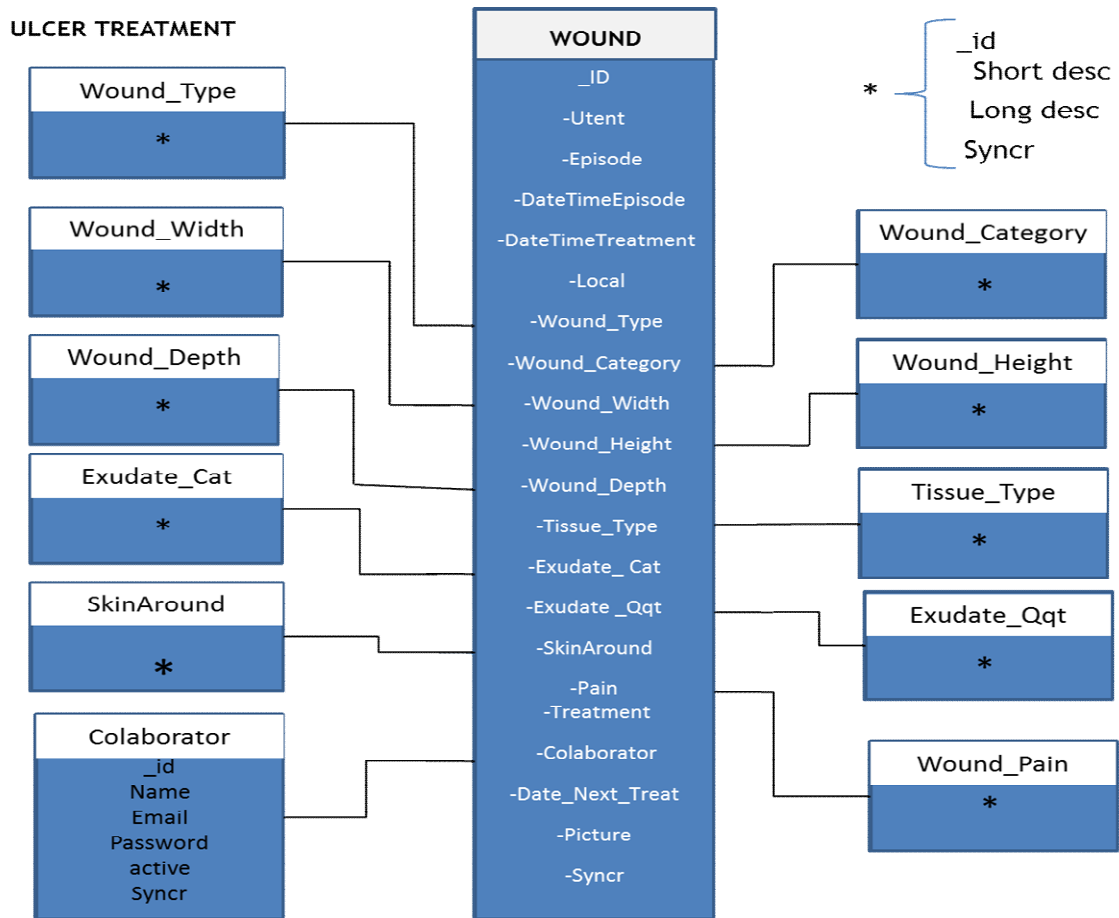
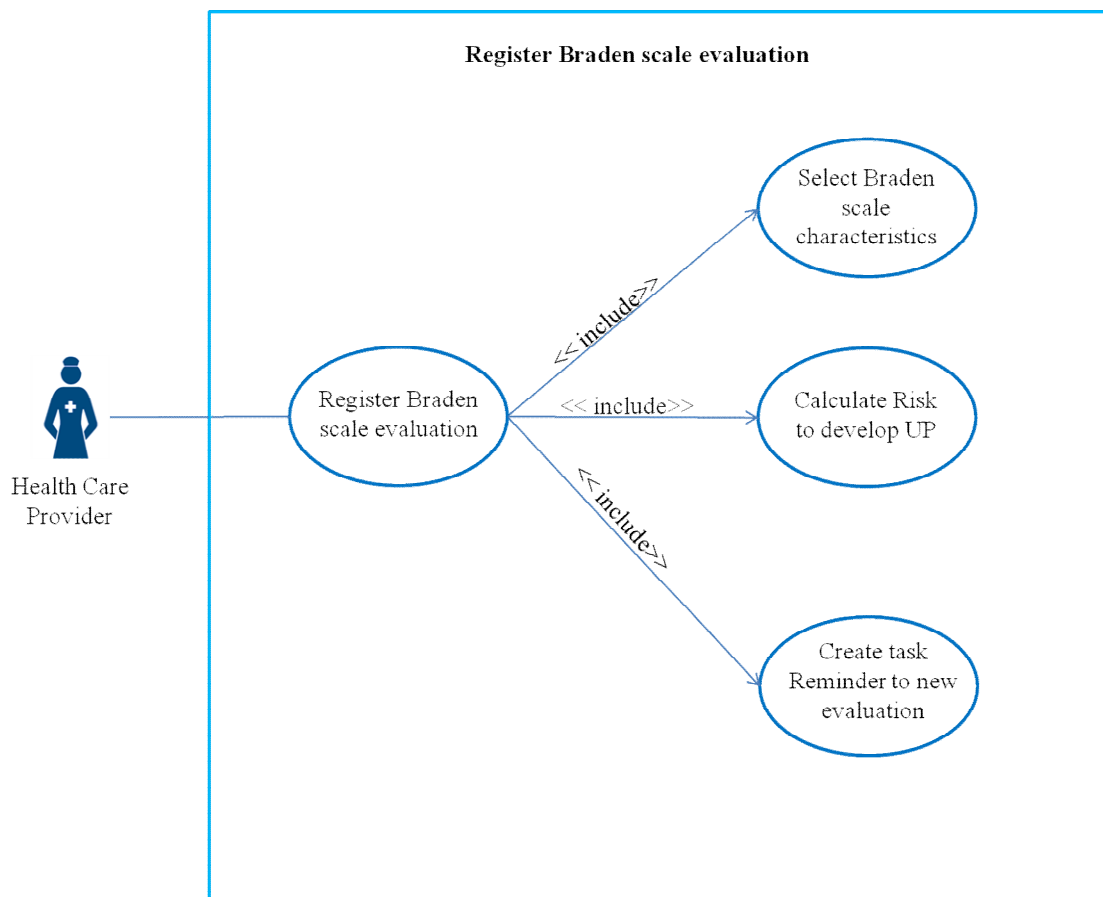


Fig. 13 - Table wound and related tables.

At “Register Braden Scale evaluations” functionality are defined some features illustrated in Figure 14. In order to register a Braden Scale evaluation the user should fill Braden scale characteristics, define the next date and time evaluation. Then, is calculated the patient risk to develop pressure ulcers. After that, is populated the database with the respective evaluation and patient characteristics. To register the patient risk evaluations have been defined the table “Braden” and related tables.



**Fig. 14 - Use case diagram Braden Scale evaluation.**

This table relations and fields are illustrated in Figure 15. In this table “Braden”, as in the table “wound” exists the field “DateTimeEpisode” that represents the patient episode time.

At table “episode” the fields “Dateini” and “Patient” compose the primary key. Mostly, the decision to make those fields the primary key of the table was tending in consideration the synchronization functionality. Like this when getting data from this table, is needed to use both fields to get a specific register. The column “id” in this table just is unique inside the local device database. It is taken in consideration that is physically impossible that a patient would be treated at the same time in two different places. Also is important to refer that at table “patient” the field “idnum” keeps the

"número de utente" of the patient. This field it is related with the "nutent" of the "braden" table.

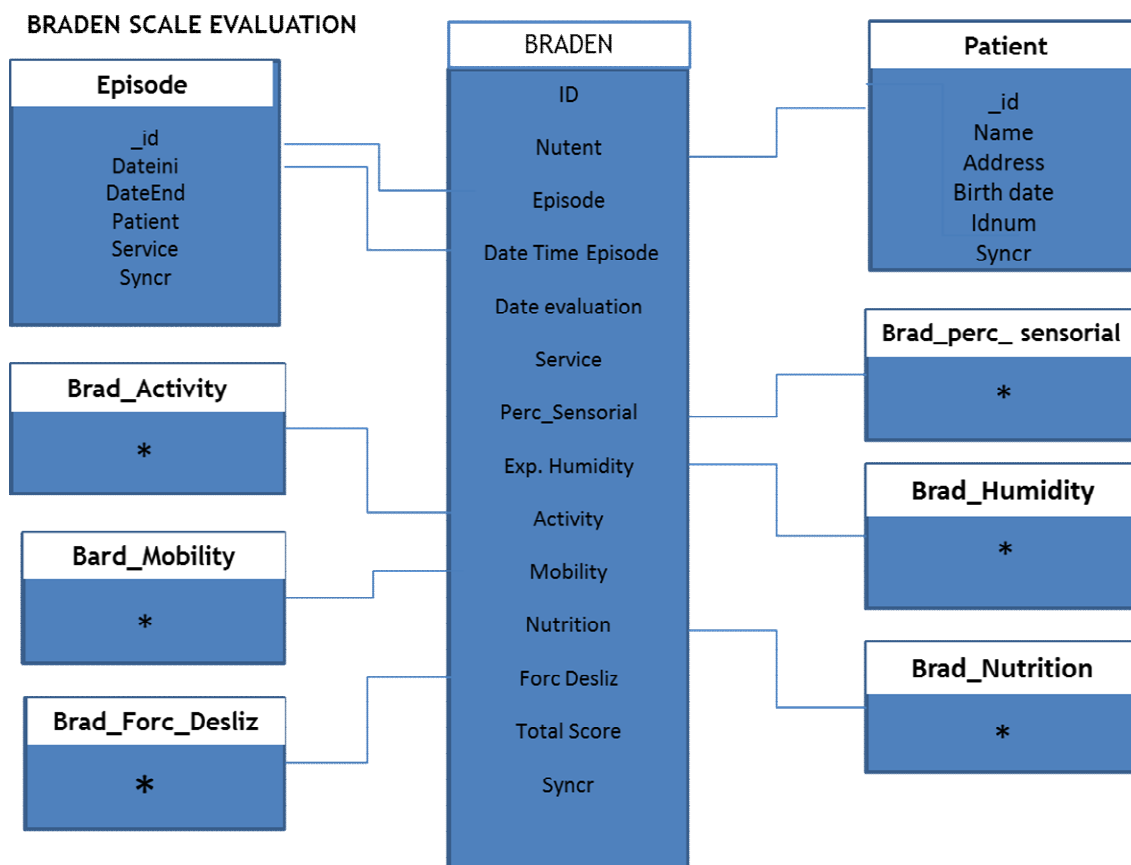


Fig. 15 - Table Braden and related tables.

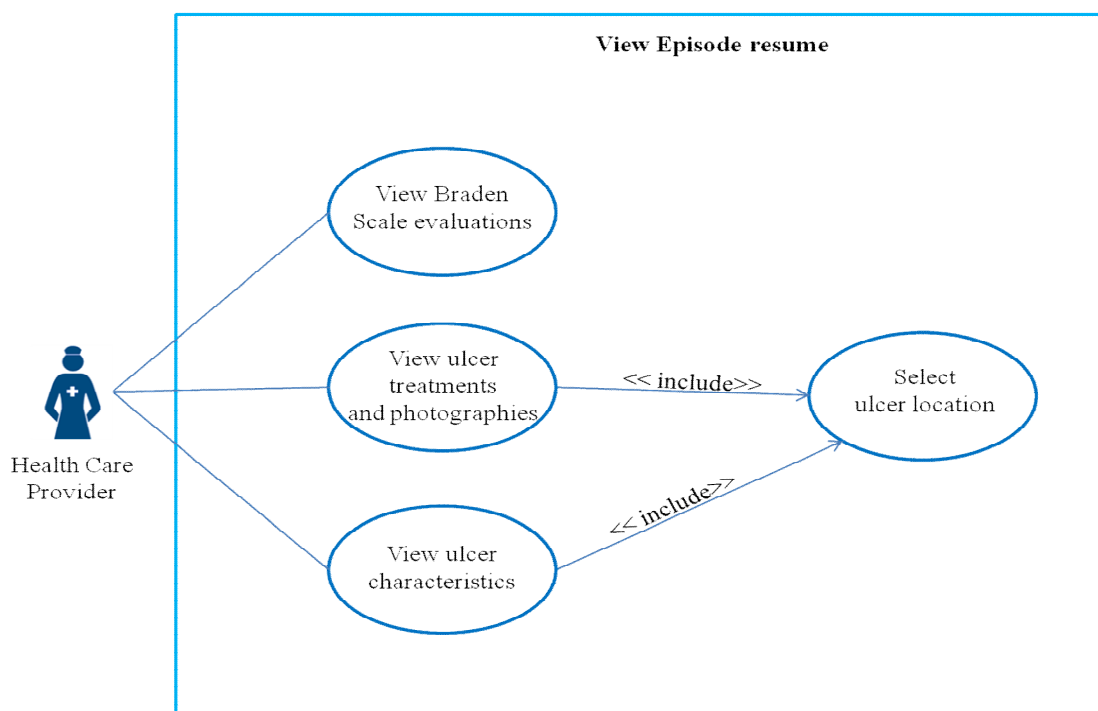


Fig. 16 - Use case diagram View Episode Resume.

To understand the tables illustrated at Figure 15 and the reasons of their existence, is being explained how it is calculated the patient risk to develop a pressure ulcer and all the variables involved. Mainly there are six variables related and that should be taking in consideration into Braden Scale evaluation. The variables are Activity, Mobility, Sliding Forces, Sensory Pressure, Humidity, and Nutrition. The possible values for those variables are kept in the tables illustrated around "braden" table, represented in the Figure 15. The entry values in the tables are used to calculate the risk score to develop a UP. After being calculated the addition of the partial classifications is obtained the total score. This value may represent the patient risk to develop pressure ulcer and in the case that it is equal or fewer than 16 means that the patient has a high risk to develop a UP. In the case that is higher than 16 the patient has low risk to develop UP.

Finally, in order to visualize an episode resume are considered the values existent in the tables "wound" and "braden". It is not needed to

create new tables because this functionality gathers the data kept in other tables. The data just need to be queried, parsed and displayed to the user in the UI. All tables and respective fields described above are being created in the first time that the application runs. Then when application is running, in order to access the information at those tables were created classes to be used as DAO, Data Access Objects. Like this, to access the database it is needed to instantiate those objects in DAO layer. Thereby, it is created a class for each table and in each one are defined the specific methods to access the table data.

Nextly are presented the main activity diagrams to describe the business operational components of the mULCER system step-by-step, and the overall flow of control. Figure 17 presents the activity diagram with one main action for mULCER application named register treatment. Figure 18 presents the activity diagram for other main task in the system, the Braden scale evaluation. There is evaluated the patient risk to develop UP.

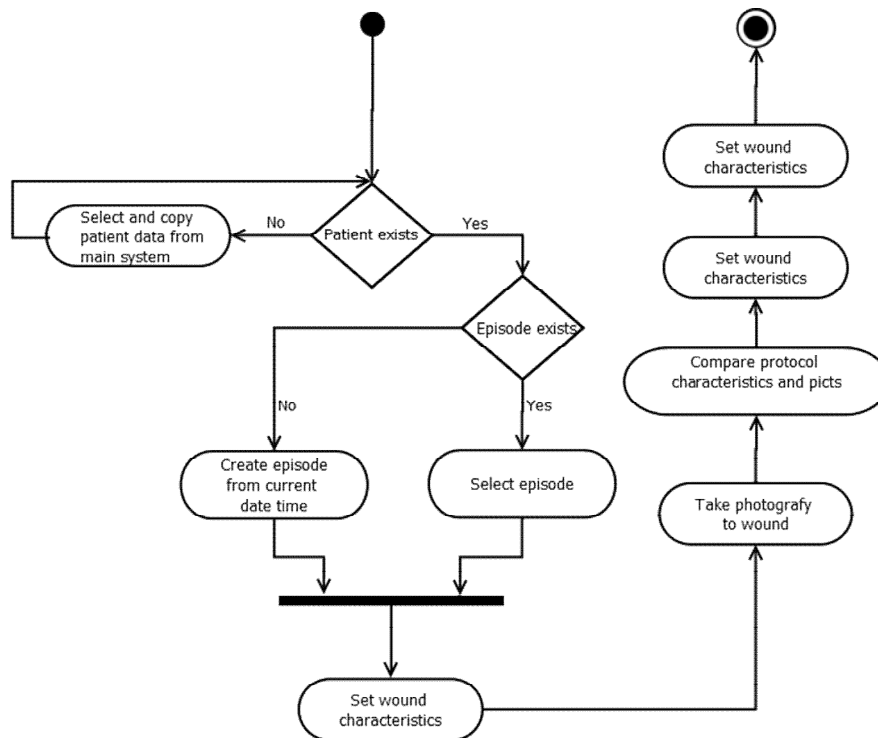
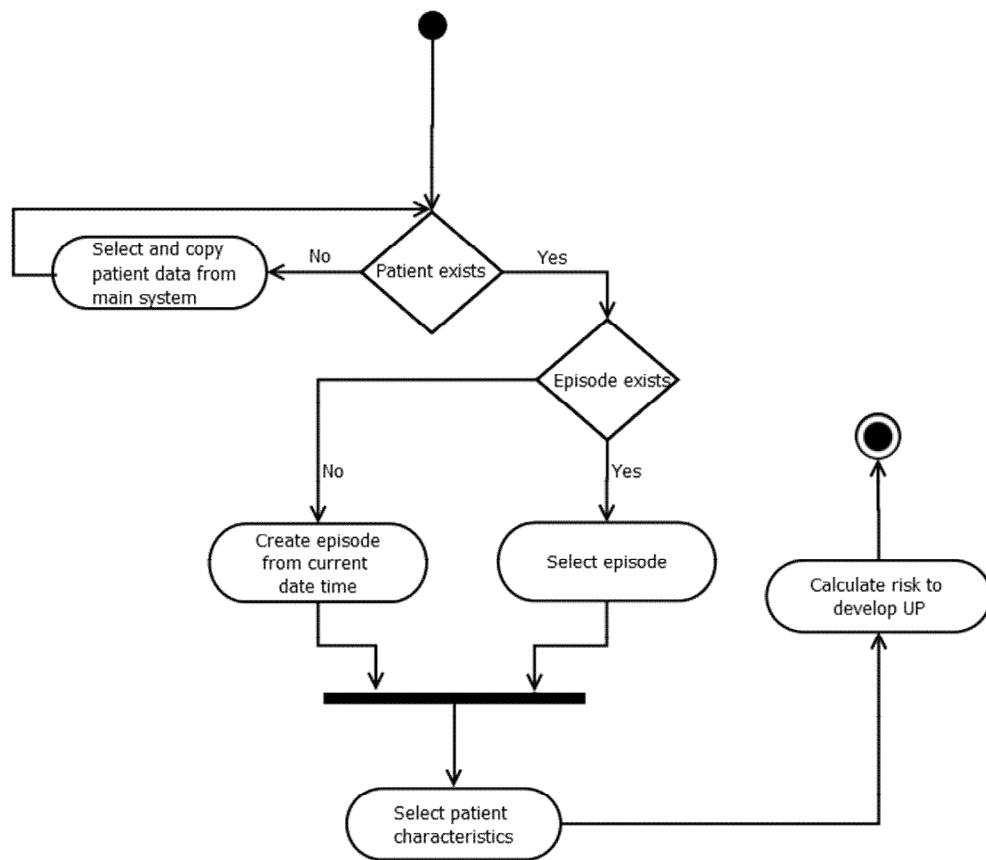


Fig. 17 - Activity diagram for mULCER register treatment wound.



**Fig. 18 - Activity diagram for mULCER Braden Scale evaluation.**

Nextly is shown how processes interact and it is illustrated at the sequence diagram. At the mULCER system there are some tasks that have more importance. The chosen functionalities to be illustrated at the sequence diagrams are: Register treatment, Update Main system with registered wound treatments, and Braden Scale Evaluation.

Figure 19 presents the Register treatment. After user successful login the user creates a new wound treatment register and inserts it on the local device database.

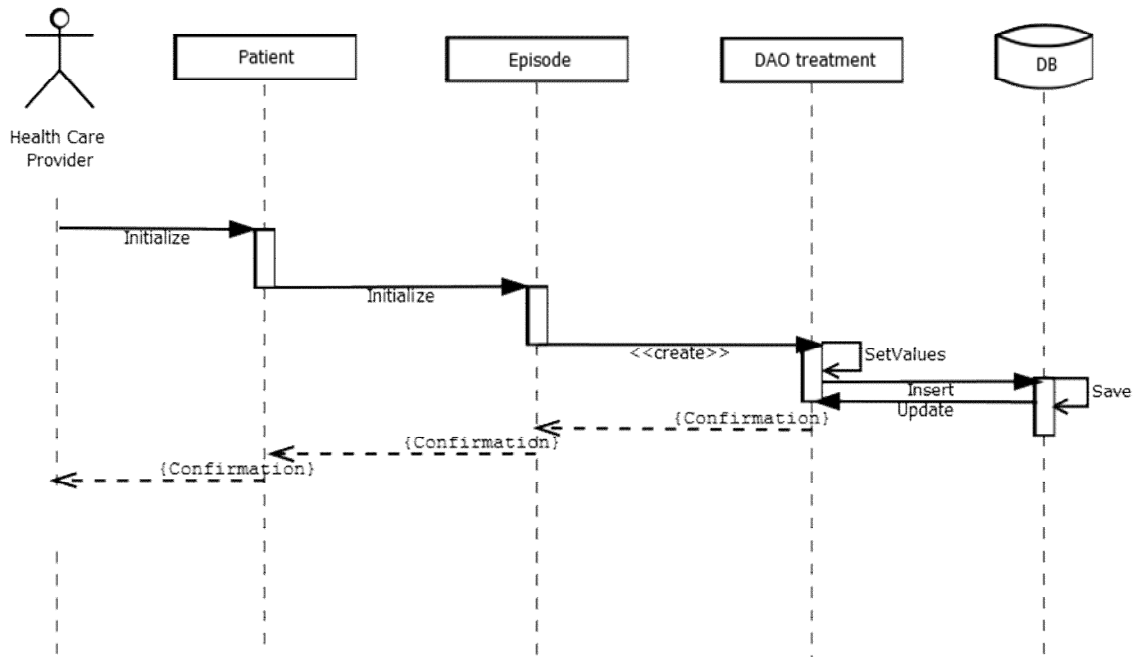


Fig. 19 - Sequence Diagram - Register treatment.

Figure 20 presents the Braden Scale evaluation. After user successful login the user creates a new Braden Scale evaluation record, and inserts it on the local device database.

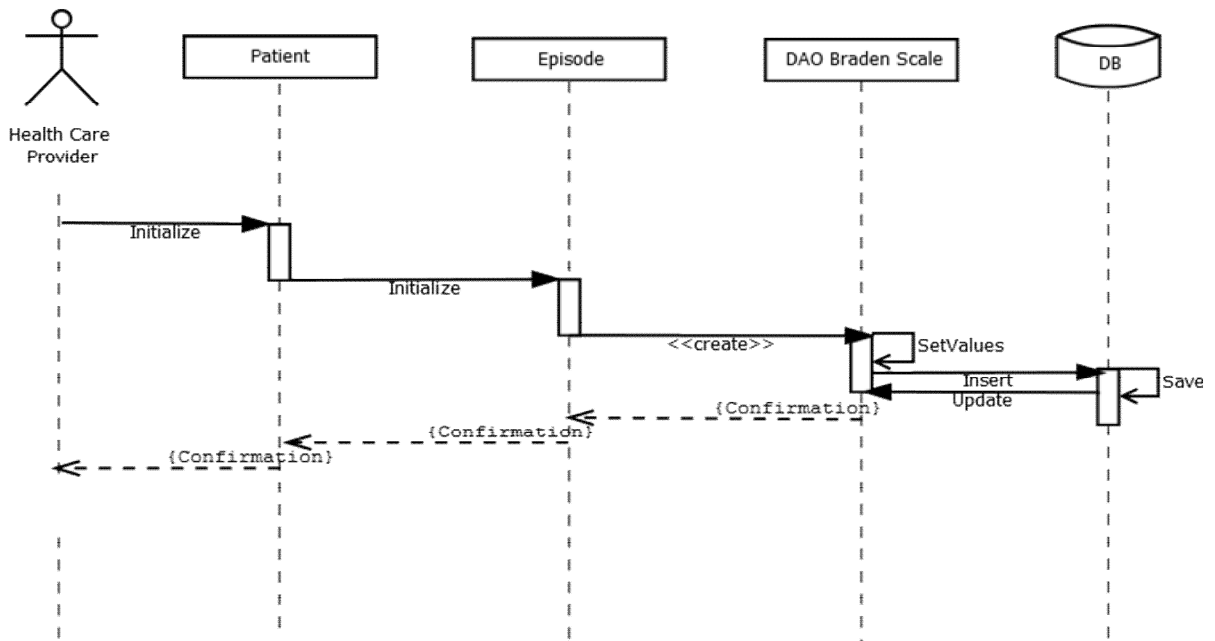


Fig. 20 - Sequence Diagram - Braden Scale evaluation.

Figure 21 presents the main system update with a wound treatment register. After user successful login the user gets the record to insert in main system. Then is called the service and the main system database is updated.

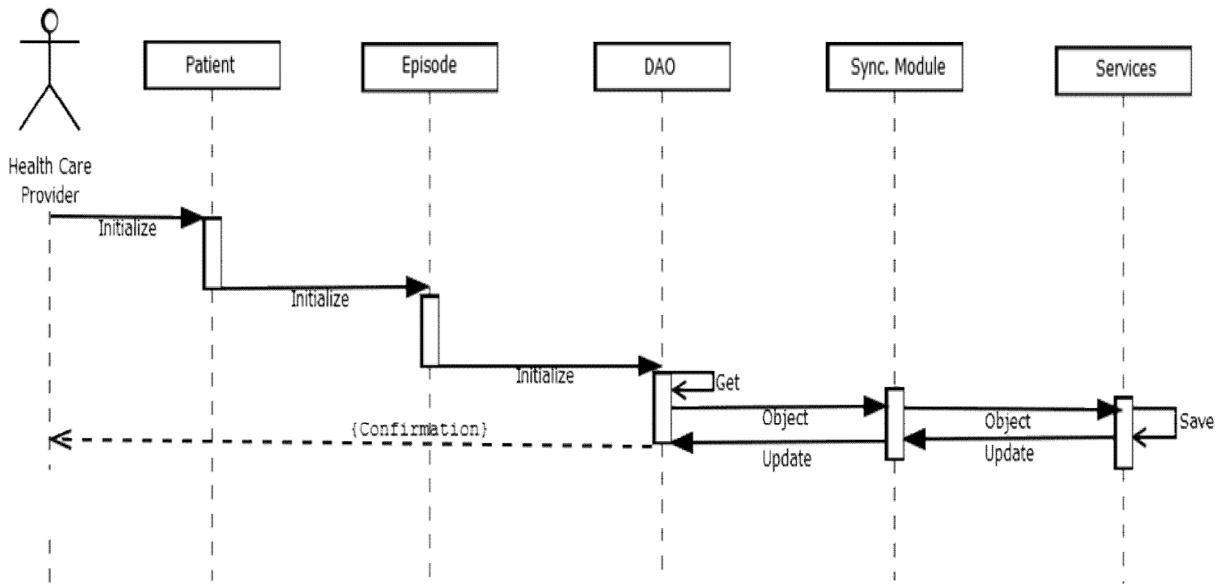


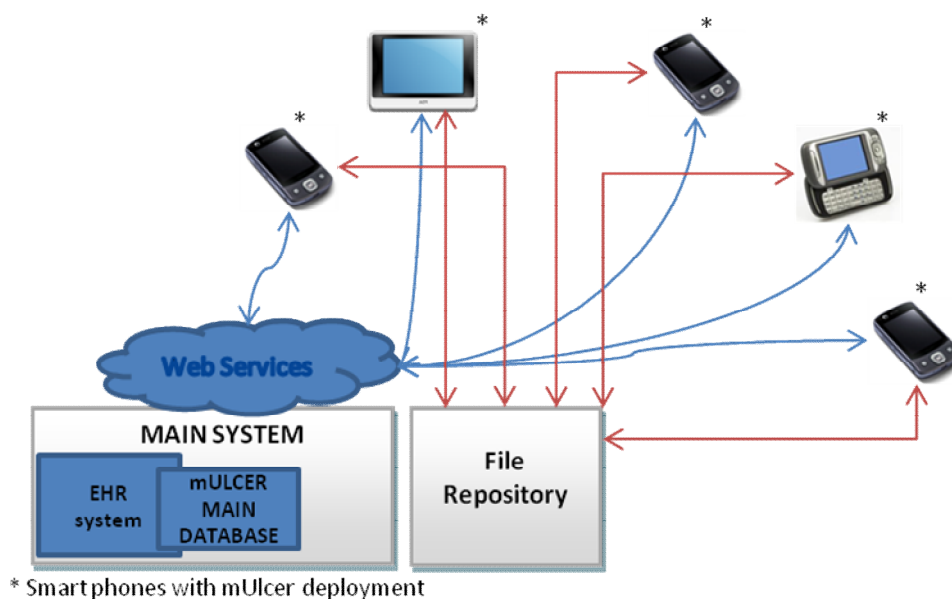
Fig. 21 - Sequence Diagram - Update Main system with wound treatments.

### 3.3. System Design

The architecture of the proposed ulcer monitoring system is illustrated in Figure 22. It includes an EHR system, a File Repository, a mULCER main database, web services to allow the data synchronization between the mobile devices and the main system, and a group of Smartphones to be carried by nurses or other health care agents. Each Smartphone has the mULCER application installed. This application has a local database that keeps the data registries. The wound photographs are kept locally in the SDcard of each device.

The application may be used in standalone version or Integrated to EHR version. In the first one the application works independently of any external

system. The data registries are saved locally at the database and the photographs files locally at the SDCard. In the second mode the registers and files also are kept locally. However the applications synchronize and copy the registries and files from the main system database and file repository. These functionalities can be automatic or manual and are illustrated and detailed explained on chapter 5. Each mobile application can download photographs from the File Repository. Any picture also may be accessed to allow the integration to any hospital EHR system.



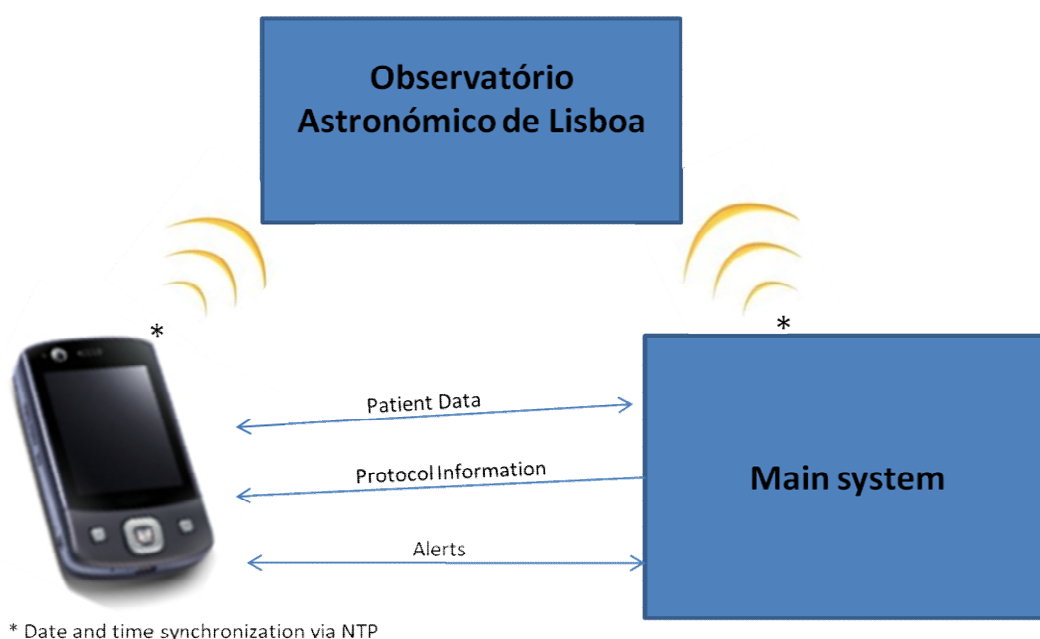
**Fig. 22 - Illustration of the system architecture.**

The EHR system holds all information for each patient episode as well as those created via the mULCER application.

This system allows the application to write in the main system at the mULCER main database through Web services. In this database all synchronized mULCER records are stored and linkage can be established with the EHR patient information. The file repository is a system that stores and keeps images. Each picture is identified by a unique name that is composed with the current date and time and national patient number. Thus, exist a direct and unique relation between the picture and the wound characteristics.

The mULCER application creates ulcer records associated to a patient in the current date and time, regardless of the administrative episode. Such independence allows the mULCER application to remain usable when patient is discharged from hospital, the “episode” ends but the treatments may continue at patient home.

The patient is identified via a national health number called in Portugal “número de utente”. This number is under a national database that contains patients relevant information of all registered patients in Portugal. The application synchronizes the data automatically or manually, by user order. In the automatic way, just the information of the current patient data is copied to the local system. This avoids the mULCER database overload because just the needed information is copied. Manually, is possible to select the information to be copied. Those options would be better explained and illustrated at chapter 5.



**Fig. 23 - Mobile device synchronization with main mULCER Database.**

Figure 23 shows how to make more trustful and real the data registered in the databases, in mobile application mULCER or main system. This makes

possible that all mULCER applications share the same date and time. All mULCER applications should have date and time synchronized with the Lisbon Astronomical Observatory (OAL). That institution has the statutory responsibility to maintain and distribute the official time in Portugal. Under these powers the OAL offers the service with Legal Time synchronization through the protocol NTP (Network Time Protocol). To use this functionality is required rooted device because Android system doesn't allow user application to change system time.

In deeper analysis to the "synchronization with main system" functionality, it is verified that the application may synchronize automatically data in two situations. First, the patient to treat does not exist at the local application database. In this case after search and patient selection from the central system, are copied all patient related data to the local database. In the second case, the patient to treat already exists in the local database. When is selected the patient to treat it is not clear if the local database is updated with the last patient related information. It is necessary to check for new registers of selected patient in the mULCER main database. In the case that there are new patient registers in the central system and does not exists locally, those are copied to the local device database.

On a manual way it would be possible to synchronize different kind of data as alerts for tasks, protocol information, treatments, Braden scale evaluations, wound pictures, patients, and episodes. Like this all of this information would be the same in both systems.

### 3.4. System Architecture

The mULCER application may be described considering the following main four blocks: the synchronization block, the application management block, the graphic user interface block (GUI), and Database block. Briefly, the GUI module allows the user to interact easily with the system. According to this interaction the Application Management module uses the Database module to store data. In the main system the file repository module and EHR system are updated by the synchronization Module with files or records respectively.

The synchronization module is composed by an Application Programming Interface (API) to assist in two main functions. First, to synchronize ulcer records existing on the mobile device with the EHR System. Secondly, to post and get ulcer monitoring pictures from file repository. On mULCER application, the database module may be defined as a database system. There are stored all records that are involved in the classification, treatment and wounds monitoring, and an API to interact with the database. At Figure 24 it is shown the architecture of the application.

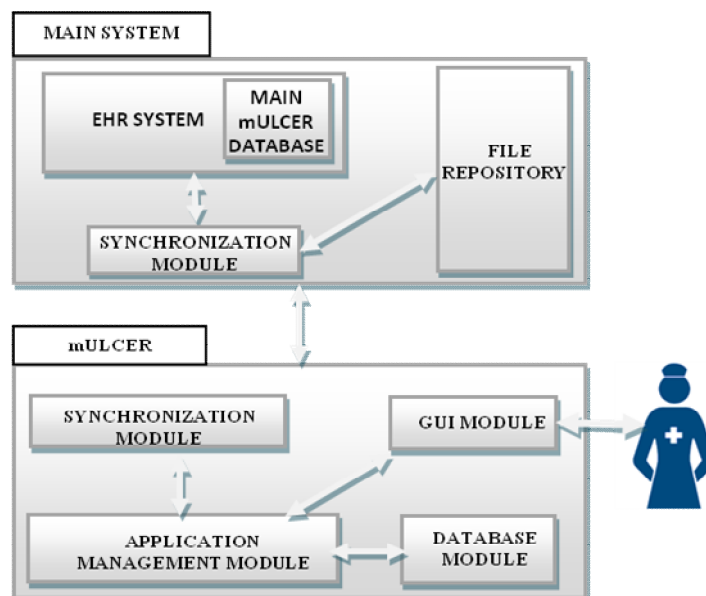


Fig. 24 - Application architecture.

As explained before, the file repository is where are kept all synchronized wound images. Considering the limited storage space of a mobile device, it is fundamental to assume the usage of any kind of a File system in order to improve the solution. This concept permits that just ulcer records and copy images are stored locally, allowing the ulcer records access without wireless connection. The GUI module defines the methods that are available for interaction between the users and application. Finally, the application management module coordinates and manages the interactions between all modules. Each action made by the user is evaluated by this module and assure that the correct module respond to the request. The mULCER application allows users to work at areas with any wireless connection interacting with a user-friendly interface. The application should be installed in each mobile device. The system is able to display the contents that are saved locally. Thus, it is assumed that Smartphone or PDA (personal digital assistant) may work in standalone mode independently of wireless connection. In summary, the main features of the application are illustrated in Figure 5, and would be explained later on.

The next chapter presents the technologies used to develop the mULCER system and the purpose of their choice.



# Chapter 4 - Used Technologies

## 4.1. Android framework

The mULCER application is designed for Smartphones with Android mobile operating system. The version developed is to run on Android 2.2. The applications for Android are created using an API similar to java developed by Google and Open Handset Alliance. The Android operating system uses Dalvik virtual machine that provides a platform-independent programming which allows the application to be executed in the same way on any platform, independently of hardware and operating system. The Figure 25 illustrates the Android Architecture and the different layers and components that make up the Android Stack.

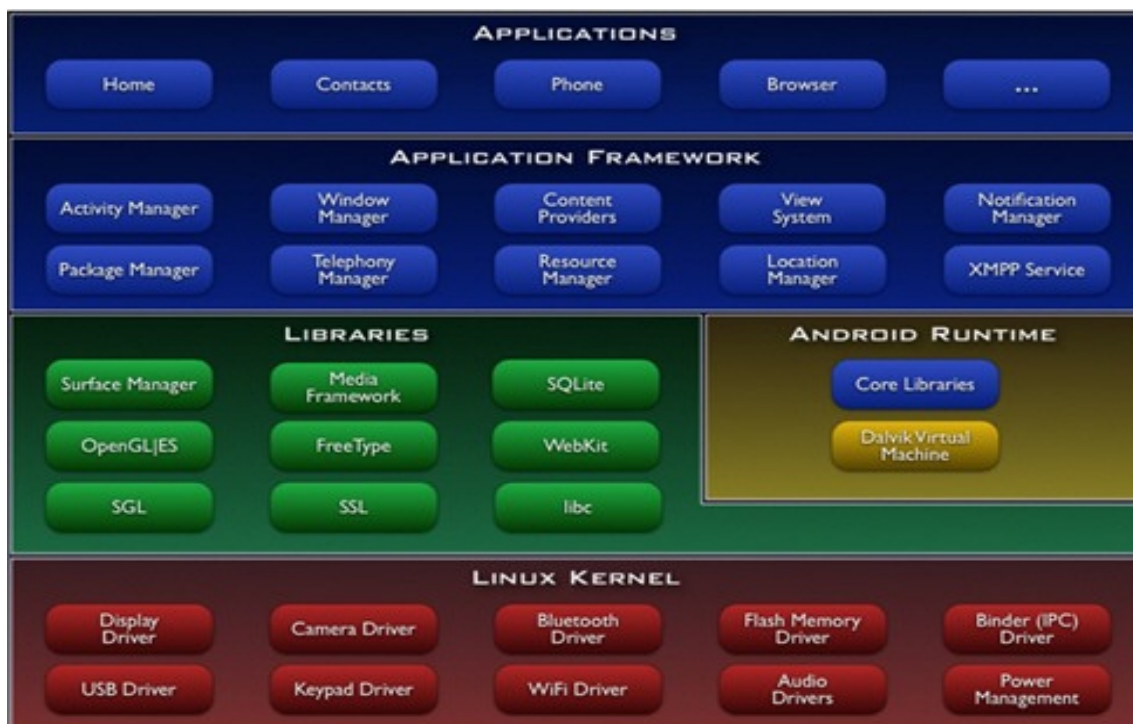


Fig. 25 - Android Architecture layers [35].

In a quick analyze to the previous figure, make us understand that the mULCER application would live nearby the other applications, as well as understand the place of Android Native Libraries. The development environment to create the mobile application has the Android software development kit, the Eclipse IDE with ADT. The tests to the application are made using the mobile device emulator that is available at ADT as well as LG P500 to feel the real device reaction to the user orders. Thus it is possible to test the basic features during the application development. This application is built on Java [36]. The data records on the mobile device are stored under SQLite database. The role of cryptography in database security is an aspect that is being discarded at this application development stage. However, the synchronization method brings also a security issue on the communication between the mULCER application and the main system. Data encryption on wireless synchronization or SSL over HTTP is planned on future work. Nowadays the Android layouts definition is made using xml. To ensure that visually the application may be used in any mobile screen size are used relative layouts. During the application development one of the issues concerning the table definition was the use of a identifier “\_id” for primary key of each table because some of several android functions rely on this standard. The main database is created over a SQL SERVER 2008 R2 and those tables script definition are described on Appendix V. Nextly are explained Web service characteristics, connections over Web services and the reasons for such implementation choices.

## 4.2. Web services

The mULCER system as the necessity to synchronize the data registered on the device mULCER application to the main database. This makes possible the data sharing over the diverse mobile device applications and it is made in both directions, from and to the main system.

Using Web services any application may publish a functionality or message to the rest of the world. With Web services it is possible to exchange data between different applications and different platforms. At this system are used Web services in order to respond to the synchronization issues with the main database. The three most common web services styles of use are the RPC, SOA and REST [37]. Nextly are concisely explained each one. Firstly, RPC allows a computer program to cause procedure or sub-routine to execute in another address/computer on a shared network without coding the details for such remote interaction. Essentially the subroutine is coded as it would be executed locally. When the software in question uses object-oriented principles, RPC is called remote invocation or remote method invocation. At a Microsoft .NET environment maybe identified .NET Remoting that makes possible RPC communication. This limited way just allows a consuming application in .NET platform over the protocols HTTP, TCP and SMTP. This was superseded by WCF that would be explained latter in this chapter.

Before pass to the next item is being introduced the Simple Object Access Protocol (SOAP). This protocol allows the messages exchange at a distributed platform. The messages are structured information and are designated as Extensible Markup Language (XML) messages. This SOAP messages allows the information exchange between different environments without concerning about conversion matters. An example that uses this kind of protocol may be the ASP.NET Web services. This exists for building applications that send and receive messages using the SOAP (Simple Object Access Protocol) over HTTP (get/response). In this case the structure of the messages is defined using an XML (Extensible Markup Language) that relies on the concept of rule, specifying tags. These tags identify elements and also contain attributes about these elements, so XML use a tag processing application that knows how to deal with this tags. ASP.NET enables to create custom Web services or to use built-in application services and to call these services from any client application. After create the Web service, to get access a Web service the

client application locates, references and uses the functionality that is contained in the Web service. In this case the client of an XML Web service is typically an application. This application can send, receive, and process messages to and from the Web service. More technically, these Web services may invoke a Stored Procedure in the destiny that for example puts or gets data from any database.

Secondly the Service-oriented architecture (SOA) that as the main principle to make the application functionalities available in the way of services. This services normally offer interfaces or contracts that are accessible throw web services or in other way of communication between applications. It uses the request/reply paradigm to establish the connection between client systems and the system that implements the services. It is required that the provider and consumer have the same context that is referenced between the provider and consumer messages. Normally is often used the XML to interface with SOA services, though this is not strictly required. Also may be used JSON that is becoming increasingly common. Architectures may operate independently of specific technologies. The developers may implement SOA using a wide range of technologies. SOA Web services may be developed using Windows Communication Foundation (WCF) from the .NET framework. This is used to build service-oriented applications. Using WCF makes possible to send data as asynchronous messages from one service endpoint to another. A service endpoint may be part of a continuously available service hosted by IIS, or it can be a service hosted in an application. An endpoint can be a client of a service that requests data from a service endpoint. Under configuration the messages may be as simple as a single character or word sent for example as standard XML, not wrapped in SOAP or JSON. WCF service after deployment may expose a collection of endpoints. Each endpoint may have the properties Address that is a location that defines where messages may be sent. Binding describes how messages should be sent and Contract that is a set of messages that can be sent/received at that

location. This makes the WCF more flexible and simplifies future development changes [38].

Third, Representational State Transfer (REST) is a software engineering technique to distributed systems. This appears on 2000 in a PHD thesis of Roy Fielding one of the main authors of HTTP protocol specification [39]. At REST each address URL identifies a resource. For a correct use of REST the interaction with the resources should be used and implemented using the GET, PUT, POST e DELETE HTTP pattern methods correctly. Each one represents a CRUD operation. The method GET may retrieve a member or members of the collection, PUT may replace entire collection or if does not exist create it, POST creates a new entry collection, and DELETE that may delete one entire collection or a specific member of the collection. The services implemented using HTTP and based on REST follows the most significant set of operations supported and the other REST characteristics are called Restful.

Nextly are being described the different variables that impacts any system solution performance. When applying directly the traditional models into mobile solutions may decrease the system performance. The decoding and encoding of XML consumes important resources and may decrease also the performance. The mobile devices are arrested to mobile connections as Wi-Fi and 3G/GSM normally with limited speed, mobile limited storage space, limited memory, and limited battery time. The REST defenders refer that the existing protocols and methodologies are enough to create with HTTP, XML and JSON robust web services solutions. The REST methodology normally is known to use invocations throw URI. This allows a reduced time to test a GET web service, to develop and make quick changes. It is just needed a browser and not special tools as to invoke via SOAP. REST requests and responses are shorter unlike SOAP that requires a XML wrapper on the request and response. Normally REST response has ten times less bytes to represent the same answer on SOAP. On REST calls is possible to know the kind of intent request however in SOAP is needed to open the envelope to know the real request intent. On

REST are used the methods GET, PUT, POST e DELETE and shows what operation is pretended. Despite everything that was mentioned earlier the REST is not the perfect solution for each web service. Safe data must not be passed over the URI parameters and in case of huge data it may pass the URI limits however this may be configured. Sometimes a simple need may be treated over a REST call and not over a heavy SOAP request. On [40-41] are demonstrated the differences referred between SOAP and REST response time, message size and which solution is more suitable for mobile environments.

According to everything referred and analyzed on [40] normally should be considerate the REST methodology and lastly the SOAP to develop a good, flexible, and with lower overhead solution. In a different analysis may be analyzed the messages and languages involved, the XML and JSON. JSON is widely used in portable data transfer and it can be parsed by many languages according to its origin that is JavaScript. However XML has some advantages as XPath and XSLT that offers simple ways to filter data and convert it to other formats. Also is possible to create rich set of data structures and read complex objects with a huge set of existing tools. XML disadvantages seem to be the large XML data records, and the parsers tend to heavy especially when it relates to mobile applications and XML. Concerning to JSON can be said that is simple and already well defined, it can be easily parsed in many different languages and the parsers are very simple without a lot of code. Also it does not require parsing libraries as XML however it is not so widespread as XML and not so powerful in namespaces. However the most important issue is the bandwidth aspect. Under a mobile network connection it is relevant to think that JSON takes almost half of the bandwidth then XML. Thereby concerning the mobile devices limitations JSON seems to present a valid alternative, with a lighter data interchange over restricted bandwidths and totally independent from the language.

After the characteristics evaluations explained before, and tending in consideration the final system to develop, was choose the RESTful

methodology to communicate to services. The use of JSON to send and receive the messages was the choice. Nextly are explained the technologies and some important characteristics taken in consideration.

WCF is a part of the .NET Framework that provides a unified programming model for building service-oriented applications that communicate across the web and the enterprise. Exists some differences between ASP.NET Web services and WCF, however concerning to the protocol is being used the same SOAP. About the messages can be in any format, and conveyed by using any transport protocol, so the messages are not forced to use HTTP to send or receive the messages. WCF is more usual, practical and complete than ASP.Net Web services. The characteristics explained before drive to choice the use of WCF web services on the mULCER system.

The WCF system Web services were developed at Microsoft Visual Studio 2010 IDE, under programming language C# with the target .NET framework 4. There were created diverse web services in order to synchronize registered data. The main developed web services goals were to get all patients identification, get patients identification by name, set patient identification data, get patient episodes, set episode data, get all patient treatments, set patient treatment, get all Braden scale patient evaluations, set Braden scale patient evaluation, get protocol information, set tasks, and get tasks.

### 4.3. Network Time Protocol - NTP

The Network Time Protocol (NTP) allows the clock time synchronization between computers in a network. It was developed by David Mills at Delaware University. Nowadays, NTP is a standard and works under Coordinated Universal Time (UTC) to synchronize the computer times to a millisecond or sometimes to a fraction of it. The precision time under any network may be important and sometimes small differences of seconds may create huge problems. In a network where some procedures should be made at a precise time and must follow a specific order should have some coordinate time

dependency. This may be used for example at security mechanisms dependent on time, File system updates carried by different computers dependent on synchronized clocks, air traffic control systems that precisely controls the aircraft exact time and flight path at a specific moment and many other quotidian's tasks. This UTC time may be get by radio, satellite, and telephone modem to hundreds of primary time servers then via NTP spreads to millions of secondaries servers and clients increasing Stratum levels. There are specialized receivers for specific reasons as Global Positioning system (GPS) or some governments needs for example, but attending to their cost it is not practical to equip each computer with such receivers. Therefore, the NTP is defined under a layered design. There are primary time servers with specialized receivers computers that then use protocol as NTP to synchronize the clocks over the network. These different computers are separated in degrees from the UTC source. These degrees are defined as strata. A radio clock that receives the real time from a specialized receiver or Satellite Navigation System is at Stratum 0. Then a computer that is connected to the radio clock is at stratum 1 and so on in the various layers. The figure 26 illustrates this layered NTP design.

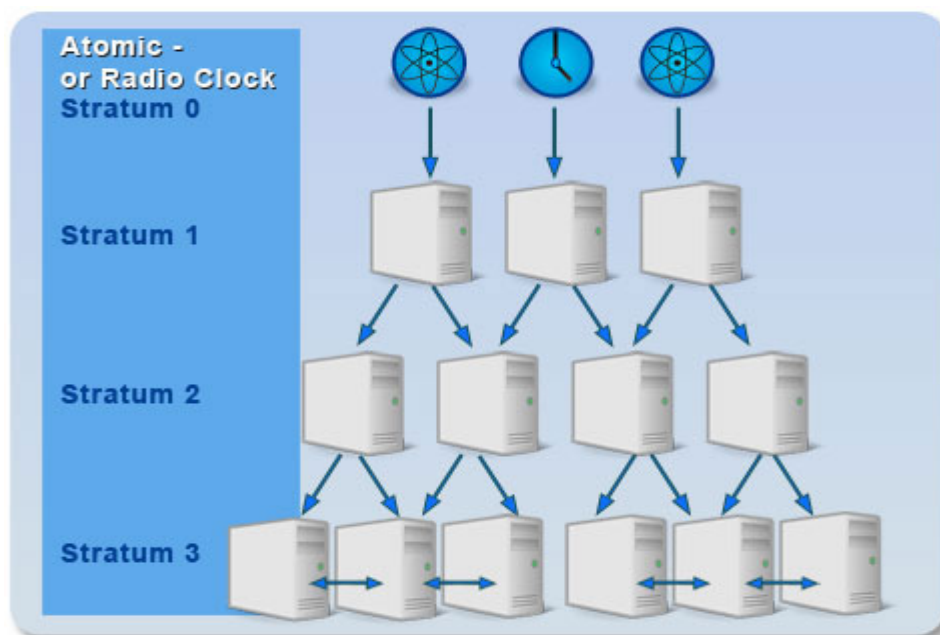


Fig. 26 - NTP stratum [42].

Basically the NTP client requests to NTP server a time exchange and with the result the NTP client calculates the link delay, its local offset and sets the local computer clock. In client/server synchronization point of view to correctly achieve the first synchronization is needed to make six exchanges during a period of five to ten minutes, then the requests are only made each 10 minutes. Normally are used redundant servers and different networks in order to ensure accuracy and reliability. NTP is designed to be scalable and highly fault tolerance allowing also the broadcast synchronization of the peer computer clocks. It provides accuracies in the range of 0.1 ms at Local Area Networks and up to some dozens of milliseconds over intercontinental connections. This makes the NTP services available in diverse countries, on every continent, and also in the space, and on the sea floor. This is used in personal workstations, supercomputers and has estimated supported population of 25 millions of computers. At Portugal the OAL offers these services at the addresses "ntp02.oal.ul.pt" and "ntp04.oal.ul.pt" [43-44].

In the next chapter is presented the system evaluation and how the nurses can use mULCER on their daily work. In order to mount all mULCER system there are some steps that are needed to make. First it is needed to deploy the Web services in a machine with IIS. The configure it to work with .NET framework version 4. Then install mULCER *apk* application file at the mobile device with android OS version 2.2 and at the application configure the FTP server location, and IIS location. Lastly is needed to create a database named mULCER at a SQLSERVER 2008 R2 instance and execute the SQL script illustrated on APPENDIX V.



# Chapter 5 - System Evaluation and Validation

In this chapter the mULCER system is being demonstrated, evaluated, and validated from a technical perspective through an example (case study). First of all it is ensured a customization and integration in order to interact with a Hospital EHR system. Within mULCER application it is possible to record and include in the EHR photos and data of nursing work at classification, treatment and monitoring of ulcer care. The application may works at standalone mode independently of wireless connection or any system. Hereafter, are demonstrated general application functionalities and users experience in the mULCER application during validation process. The main usage functionalities of the application system can be described as follows. Left part of Figure 27 presents a screenshot of the Login Window. Following Figure 27, "1" the user starts the interaction with the application and appears this window. At "2", the user enters the login name to access the system, and on "3" corresponding password. When pressed the button shown in "4", it is validated on the mULCER local database the username and password from the selected system. After successfully login, the application opens Main Menu shown in the right part of Figure 27, marked as "5".

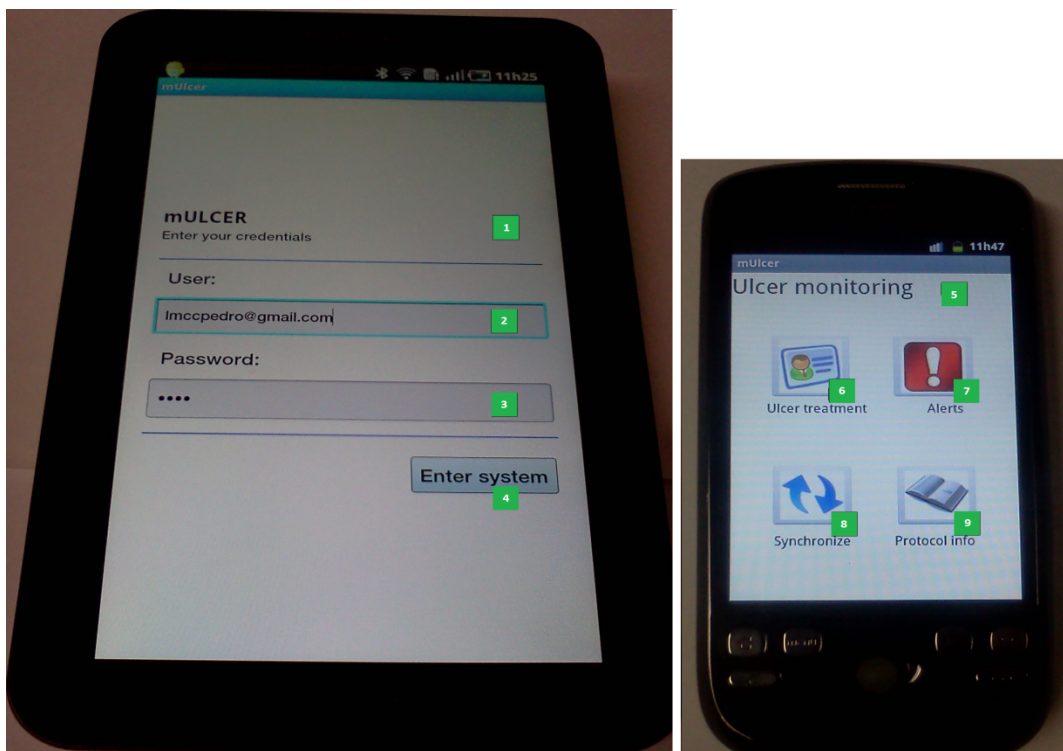


Fig.27 - Login Window and Main Menu.

In this main menu there are four buttons. At the button "7" on main menu, the user presses the alerts button in order to see the pending tasks. The opened window is illustrated in Figure 28.

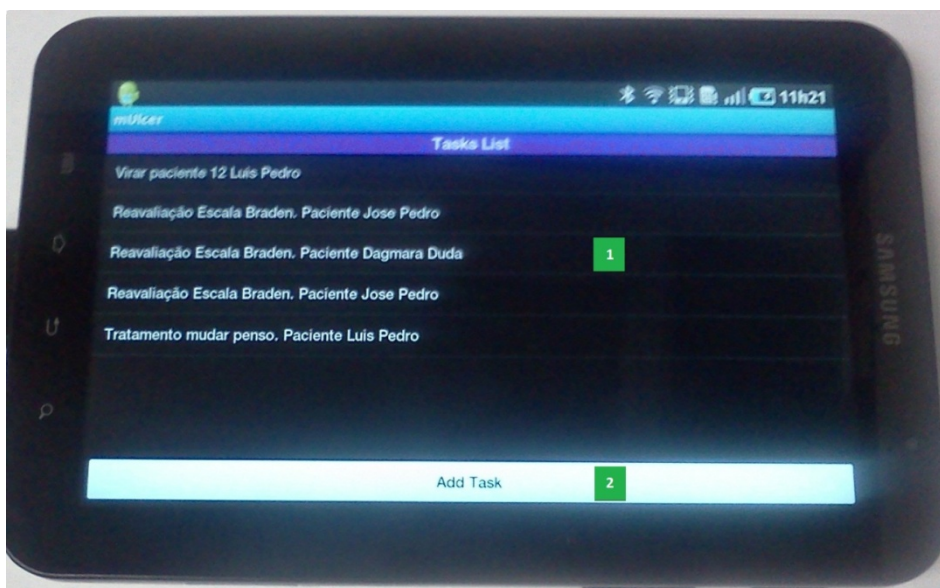
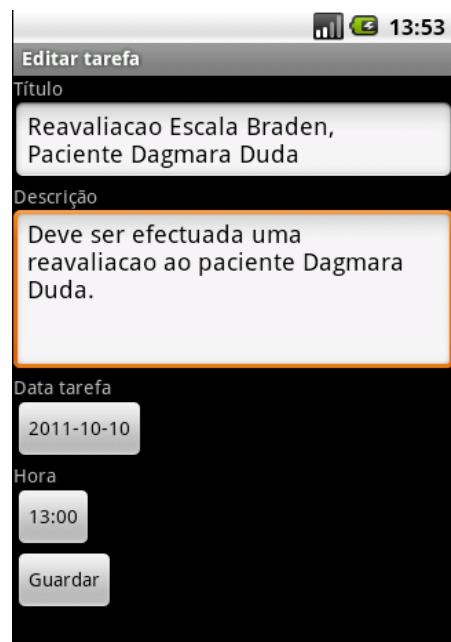


Fig. 28 - Task list window.

In the task list window after being pressed one of the lines with task short description marked as "1", it is open a window that shows the task details as illustrated at figure 29. At this window is allowed to edit and save the task fields or the task time.



**Fig. 29 - Task details.**

The device alerting system warns and advises the user on the next steps and patient observations. There are three kinds of alerts defined. First, during the Braden Scale register, the user fills the date to next re-evaluation. Second, at ulcer treatment the user can specify the time of the next observation or treatment. The third one is generated automatically in the end of each treatment, according to the protocol time defined to turn around the patient. All three alerts types add to the schedule the date and time to alert, the task description and resumed patient details information. In the case of user necessity, in order to create a new alarm, the application gives this possibility in this menu. Pressing "2" is showing a window, illustrated at Figure 29 that makes possible manual task creation.

Coming back to Main Menu window, the option marked as "8" permits the user to synchronize manually the local data records to the central system. This

synchronization is unidirectional to avoid local system overload with unnecessary data and avoiding also excess network traffic. Therefore, all options selected to synchronize, like Images, Patients, Episodes, Braden evaluations, Treatments and Alerts would be synchronized to the central system. Those options can be selected at Figure 30 at button marked as "2". To start synchronizing data is needed first to activate the permission for synchronization at button marked as "1", and secondly the start up button "3". At "4" is showing a waiting message informing user that is occurring the synchronization process. At "5" shows the result message with current synchronization status.



Fig. 30 - Synchronization process.

The button "9", on main menu permits the user to search protocol information or medical relevant information topics. This window has a search bar, illustrated at image 31, marked as "1" where user writes the searching word. After that, pressing the button marked as "2" starts the database search and retrieves the list of results marked as "3". This information normally exists in paper but it is not available on the action environment near patient.



Fig. 31 - Protocol information search.

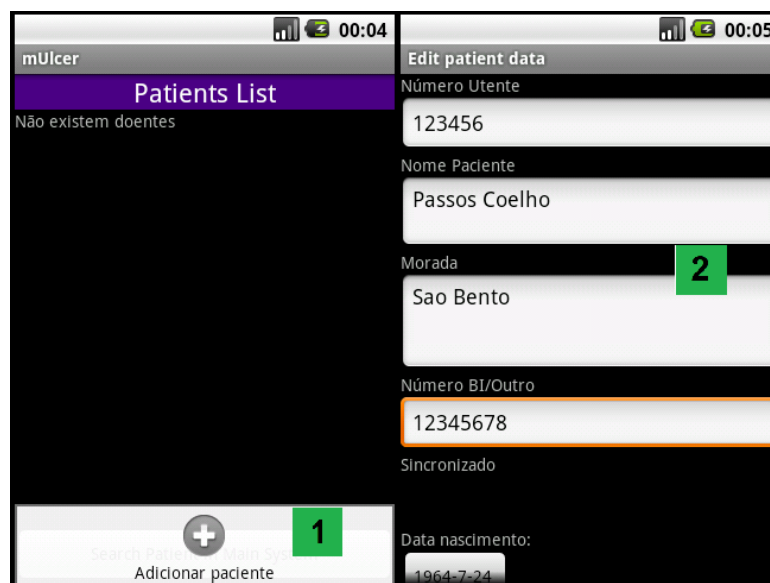


Fig. 32 - Patient create/edit window.

Coming back to Main Menu, at "6" in the option "Ulcer Treatment" the user selects which patient is under treating. Afterwards, if it is the first patient evaluation, the user may create a patient record pressing the device menu button. Like this appears the option marked as "1" on the Figure 32. After that, user may insert patient personal information such as national

health number, name, address, national identification number, and date of birth in order to create a patient record, marked as "2" on Figure 32.



**Fig. 33 - Patient search result.**

Supposing that mULCER is wirelessly connected with the central system it is possible to search a patient in the mULCER main database. This research is based on patient's name. After being retrieved the data it is shown a list of patients that is matching with the search. The Figure 33 illustrates this window with the patient's result list. Selecting and pressing a patient from the list, for example as shown as "1", are copied all information of selected patient from main database to the local one.

Coming back to patients list already appears the copied patient. Pressing the patient name it jumps to the Episode's list illustrated in the right part of Figure 34. This list represents the patient diverse episodes. Each line is represented by the date and time of all patient episodes. In case of continuity of an older wound treatment should be selected the first episode from the list, that is the most recent episode. In case of new patient episode,

pressing on "2" creates a new patient episode with the current time. After the previous steps, appears the window marked as "1", Patient Record Menu, at Figure 35.

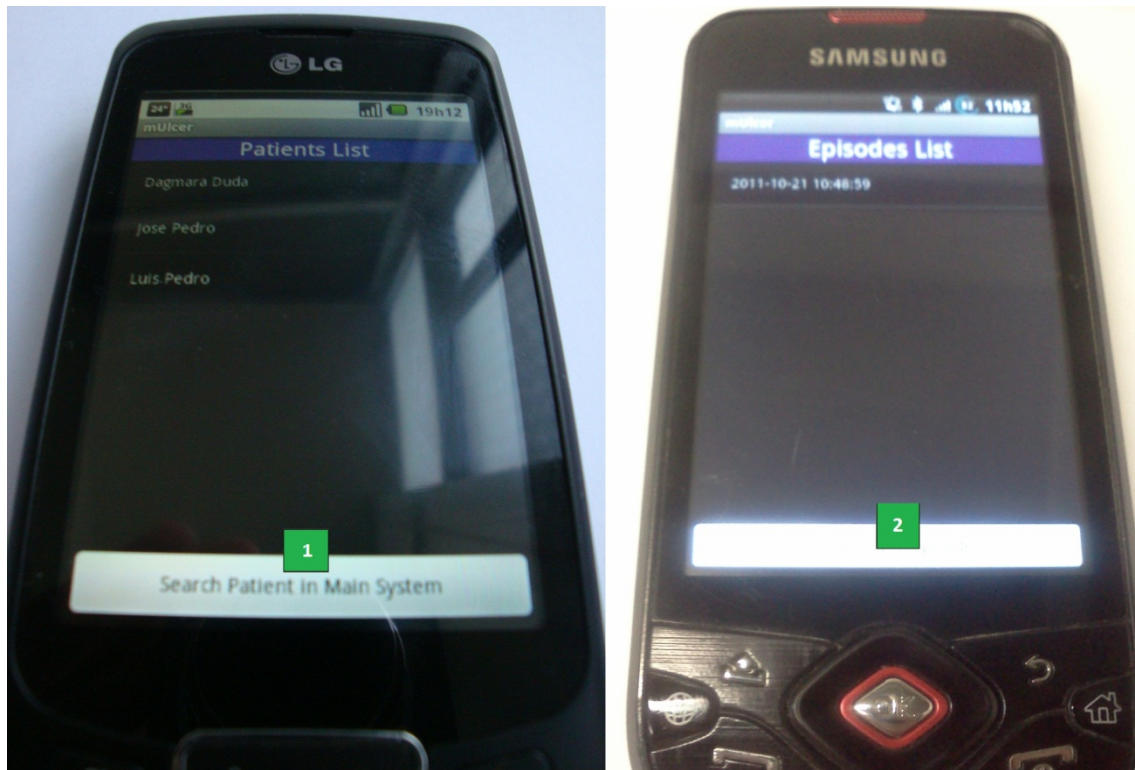


Fig. 34 - Patient's list Window and Episode list Window.

On "2" at Figure 35 is possible to register Braden Scale observation. The button marked as "3" shows to user a treatment suggestion for the wound. On "4", allows the registry of wound characteristics and treatment applied to the patient ulcers. To read the registered information at the current patient episode, may be pressed "5". On "6" it is detailed the patient name and initial episode time.

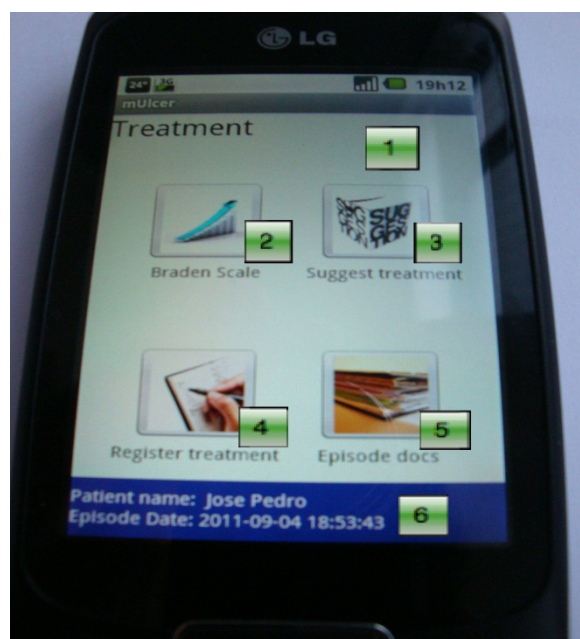


Fig. 35 - Patient Record Menu Window.

Coming back to Patient Record Menu window to the Braden Scale functionality the user may press on "2". The process is illustrated on Figure 36.

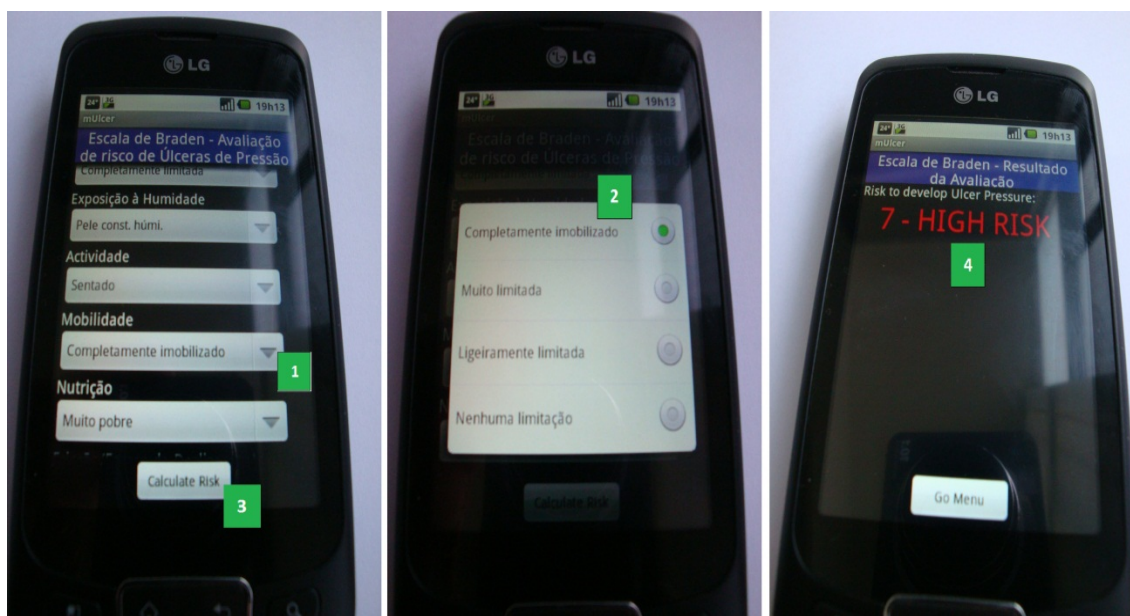
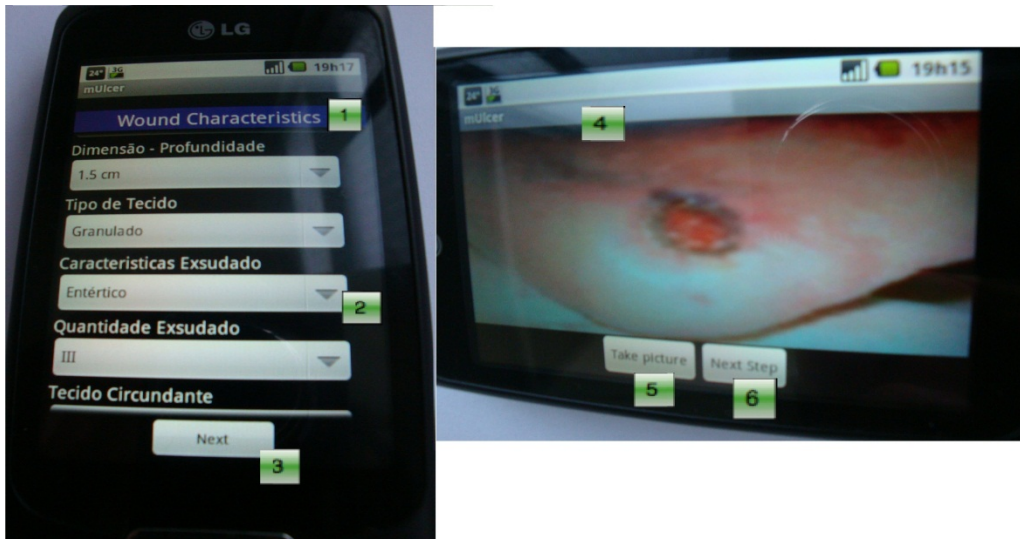


Fig. 36 - Braden Scale Evaluation Windows.

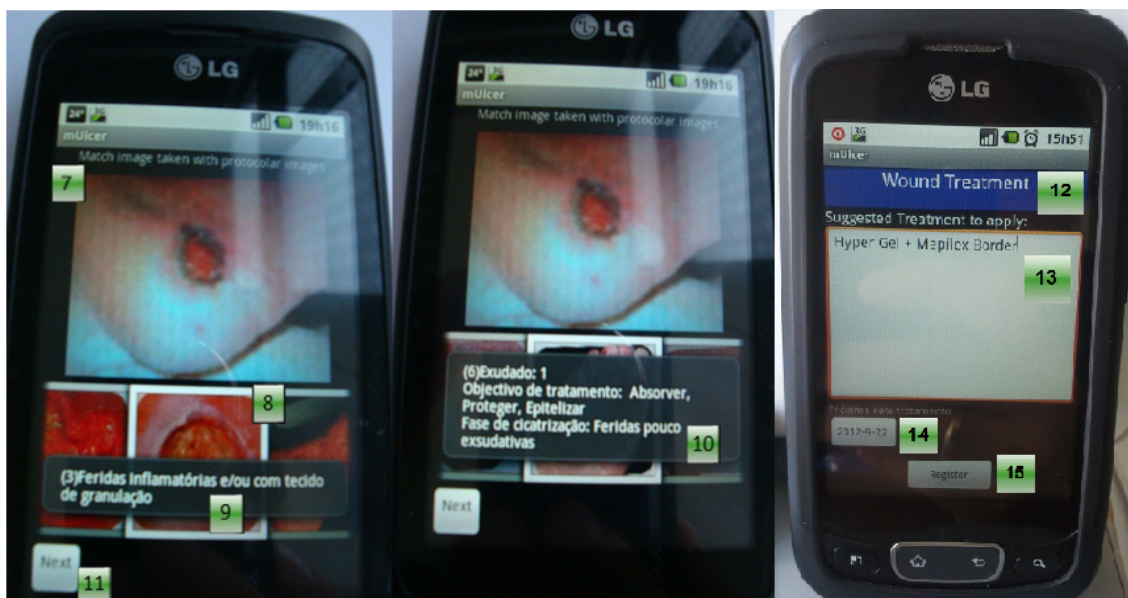
Marked as "1", are the patient characteristics that the user may fill according to the current patient conditions. During the patient characteristics filling appears a window like on "2". Those variables values are configured in the

database. Finally, pressing on "3" is calculated the patient risk in develop UP and it goes to "4". There is presented the final result already registered on the database. Automatically creates a reminder for a new time reevaluation according to protocol information. Coming back to Patient Record Menu and pressing on "4", user goes to window marked as "1" illustrated on Figure 37.



**Fig. 37 - Wound Characteristics Window and Wound Picture Window.**

The diverse fields like the one marked as "2" may be filled according to wound characteristics. Those characteristics are representative of the paper based form and are illustrated on Appendix III on "4". Pressing on "3", it goes to the next window marked with "4". At this moment user may take a picture to the wound by pressing "5". Pressing on "6" goes to window marked with "7", illustrated on Figure 38.



**Fig. 38 - Picture Matching and Suggested Treatment Windows.**

After that, on top marked as "7" appears the picture taken to wound and on down part as "8" a roller with illustrative ulcer pictures. Each picture on the roller has some extra information. Pressing it during a short time appears the ulcer short description shown as "9". Pressing it during a long period shows the respective wounds characteristics and treatment goal, illustrated on "10". On "11" goes to a new window marked as "12". Here it is described the suggested wound treatment, on "13". The user may choose the next treatment date, on "14". This generates a task reminder for this date and time. After editing or accepting the suggested treatment, user goes further pressing on "15" and it is being registered all ulcer characteristics previously selected as well as picture taken and treatment applied.

Therefore, this application does not take out nurse's responsibility and capacity to decide. This gives the essential decision environment in order to choose the appropriate wound treatment in the specific case. Coming back to Patient Record Menu Window the user may check a possible wound treatment for a specific wound. This functionality does not allow user to treatment register as on "4". Finally, on Episode Docs marked as "5" it is possible to see the diverse registers at the current patient episode.

The Figure 39 shows the compact disposal window chosen to show high quantity of information registered. At this are Braden scales evaluations, treatments applied and wound picture taken.



Fig. 39 - Episode Docs Information ( Braden Scale).

Marked as "1", represents the horizontal bar that hangs three possible types of data to visualize. Pressing the option "Escala Braden" opens the second horizontal bar marked as "2". There shows some explanation of the values that appears at "3". At "3" shows a list with all patient Braden evaluations from this episode. The data and time as well as risk calculated make part of each list row. Coming back to the bar "1" on Figure 40, pressing "Tratamentos" shows the bar marked as "2". At this bar are shown the wound locations. Pressing one location is opening the list with the wound treatments details marked as "3". Pressing the last option "Fotografias", on bar marked as "1", is opening the horizontal bar "4" with diverse wound locations. Pressing one location is opening the list marked as "5" that shows the picture taken to the wound and the treatment applied. This makes possible to see how looks like the wound and the evolution since the last treatment. Also is possible to compare the wound evolution to a specific treatment.



Fig. 40 - Episode Docs Information (Treatments).

Those pictures are kept at the sdcard device. In case that those pictures does not exists locally is being called a function that gets the image from the picture sharing server.

According to the interaction of the application and data register, it is possible to evaluate it. With the positive feedback, means the fast access to the information taking part of mobile potentialities that makes work better, faster, more near the important information and with safe and credible data records. Thus, the human error decreases, the usage and impact of protocol relevant information on ulcer treatment increases, and ends ulcer paper based registry method.

# **Chapter 6 - Conclusions and Future Work**

## **6.1. Main Conclusions**

The mULCER system was developed taking into consideration clinical relevant information needed in the context of nursing work to classify, treat and monitor patient ulcers. The proposed application helps nursing work as well as other informal careers. A registry of ulcer status, treatment and monitoring are wirelessly transferred and easily integrated with any EHR system. Summarizing, in order to aid during classification and treatment ulcer steps it is available relevant paper protocol based information, patient Braden scale evaluations, with the possibility to record ulcers/wounds characteristics, and status with a picture. Pictures are stored locally on the mobile device and posteriorly synchronized to the FTP server. The alert system was created to remember nurses on next treatments, to turn around patient task, and next Braden Scale re-evaluation according to protocol information. The mULCER application can be integrated with any EHR system and its mobility opens new perspectives, such as, the possibility for its use in a primary care setting. It allows health care providers the possibility of keeping the records about skin and ulcer care, even after hospitalization on the same platform, thus contributing to continuity of care. It offers the possibility to follow all the patient process and provide treatment according to the accepted protocols for integrative care, and also provides information about what has been made on the patient before. The idea is to make the application easily available among Health Care Facilities.

In a research perspective may be useful to analyse the images and data at each step of care. For example similar problems (ulcer types) can be studied regarding the impact of different treatments approaches. Such application may enhance ulcer care knowledge and provide better health care for patients with similar kinds of ulcers. In summary, this document describes an existent mobile health application for ulcer treatment, and patient risk evaluation in develop ulcers based on protocol information aided by pictures, and integrated with an EHR.

## 6.2. Future Work

This application may be improved with some changes, such as the ability to automatically measure the wound length, width and depth and also suggest a possible classification after taking the wound picture. Some useful functionalities could be added as it is shown on [45-46], to improve the earlier detection of pressure ulcers by enhancing digital color images.

Normally, near to the patients, there is not always assisting nurse or physician capable to evaluate the possibility to develop pressure ulcer. Each day it should be made a careful evaluation of the skin in order to detect skin redness. Any kind of redness implies the necessity of an immediate action to avoid skin breakdown. Thus, it is essential that persons who take care of those patients (caregivers or familiars) would be capable to use some application to help them to detect these important timings and calculate the risk of development of pressure ulcers. Like this, it is our intention to expand the application to other users and not just nurses, making available important information with impact in patient treatment as expressed on [17]. The availability to connect the mULCER with some main system like one existing in Portugal, called *Saúde24*, would facilitate and increase nurse's work quality at the caregiver interaction moment. This would make the decision easier to decide if to send an ambulance team to take the patient or help to make some specialized care.

Taking in consideration that all images are synchronized and are accessible by the main system is possible to run automatically some pressure ulcer detection algorithms in order to early detect them. In case of ulcer detection the system should advice over email the system *saúde24* to contact the caregiver to evaluate the real ulcer state, providing the most right procedure. This kind of system behavior would provide better patient quality of life as well as improve healthcare system budget.

The development of all functionalities would make the system faster and efficient in the sense, that users would not need to make some tasks manually and alone, accelerating the data registration process and improving the healthcare quality.

Such application may enhance ulcer care knowledge and provide better health care for patients with similar kinds of ulcers. In summary, this document describes an existent mobile health application for ulcer treatment and patient risk evaluation in develop ulcers based on protocol information aided by pictures, and integrated with an EHR.



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# APPENDIXES


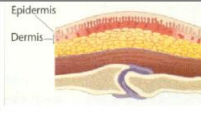

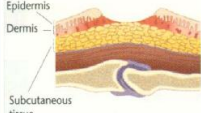

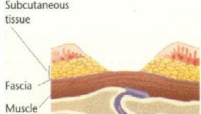
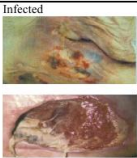
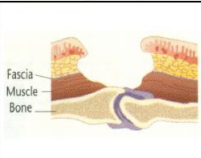



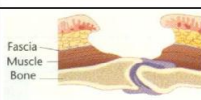


# APPENDIX I - Braden Scale Protocol adopted in Portugal

Nome do doente: _____		Nome do avaliador: _____		Data da avaliação: _____					
Serviço: _____		Cama: _____		Idade: _____					
<b>Percepção sensorial</b> Capacidade de reacção significativa ao desconforto	<b>1. Completamente limitada:</b> Não reage a estímulos dolorosos (não geme, não se retrai nem se agarra a nada) devido a um nível reduzido de consciência ou à sedação, OU capacidade limitada de sentir a dor na maior parte do seu corpo.	<b>2. Muito limitada:</b> Reage unicamente a estímulos dolorosos. Não consegue comunicar o desconforto, excepto através de gemidos ou inquietação, OU tem uma limitação sensorial que lhe reduz a capacidade de sentir dor ou desconforto em mais de metade do corpo.	<b>3. Ligeiramente limitada:</b> Obedece a instruções verbais, mas nem sempre consegue comunicar o desconforto ou a necessidade de ser mudado de posição, OU tem alguma limitação sensorial que lhe reduz a capacidade de sentir dor ou desconforto em 1 ou 2 extremidades.	<b>4. Nenhuma limitação:</b> Obedece a instruções verbais. Não apresenta défice sensorial que possa limitar a capacidade de sentir ou exprimir dor ou desconforto.					
<b>Humidade</b> Nível de exposição da pele à humidade	<b>1. Pele constantemente húmida:</b> A pele mantém-se sempre húmida devido a sudorese, urina, etc. É detectada humidade sempre que o doente é deslocado ou virado.	<b>2. Pele muito húmida:</b> A pele está frequentemente, mas nem sempre, húmida. Os lençóis têm de ser mudados pelo menos uma vez por turno.	<b>3. Pele ocasionalmente húmida:</b> A pele está por vezes húmida, exigindo uma muda adicional de lençóis aproximadamente uma vez por dia.	<b>4. Pele raramente húmida:</b> A pele está geralmente seca; os lençóis só têm de ser mudados nos intervalos habituais.					
<b>Actividade</b> Nível de actividade física	<b>1. Acamado:</b> O doente está confinado à cama.	<b>2. Sentado:</b> Capacidade de marcha gravemente limitada ou inexistente. Não pode fazer carga e/ou tem de ser ajudado a sentar-se na cadeira normal ou de rodas.	<b>3. Anda ocasionalmente:</b> Por vezes caminha durante o dia, mas apenas curtas distâncias, com ou sem ajuda. Passa a maior parte dos turnos deitado ou sentado.	<b>4. Anda frequentemente:</b> Anda fora do quarto pelo menos duas vezes por dia, e dentro do quarto pelo menos de duas em duas horas durante o período em que está acordado.					
<b>Mobilidade</b> Capacidade de alterar e controlar a posição do corpo	<b>1. Completamente imobilizado:</b> Não faz qualquer movimento com o corpo ou extremidades sem ajuda.	<b>2. Muito limitada:</b> Ocasionalmente muda ligeiramente a posição do corpo ou das extremidades, mas não é capaz de fazer mudanças frequentes ou significativas sozinho.	<b>3. Ligeiramente limitado:</b> Faz pequenas e frequentes alterações de posição do corpo e das extremidades sem ajuda.	<b>4. Nenhuma limitação:</b> Faz grandes ou frequentes alterações de posição do corpo sem ajuda.					
<b>Nutrição</b> Alimentação habitual	<b>1. Muito pobre:</b> Nunca come uma refeição completa. Raramente come mais de 1/3 da comida que lhe é oferecida. Come diariamente duas refeições, ou menos, de proteínas (carne ou lacticínios). Ingerir poucos líquidos. Não toma um suplemento dietético líquido OU está em jejum e/ou à dieta líquida ou a soros durante mais de cinco dias.	<b>2. Provavelmente inadequada:</b> Raramente come uma refeição completa e geralmente come apenas cerca de 1/2 da comida que lhe é oferecida. A ingestão de proteínas consiste unicamente em três refeições diárias de carne ou lacticínios. Ocasionalmente toma um suplemento dietético OU recebe menos do que a quantidade ideal de líquidos ou alimentos por sonda.	<b>3. Adequada:</b> Come mais de metade da maior parte das refeições. Faz quatro refeições diárias de proteínas (carne, peixe, lacticínios). Por vezes recusa uma refeição, mas toma geralmente um suplemento caso lhe seja oferecido, OU é alimentado por sonda ou num regime de nutrição parentérica total satisfazendo provavelmente a maior parte das necessidades nutricionais.	<b>4. Excelente:</b> Come a maior parte das refeições na íntegra. Nunca recusa uma refeição. Faz geralmente um total de quatro ou mais refeições (carne, peixe, lacticínios). Come ocasionalmente entre as refeições. Não requer suplementos.					
<b>Fricção e forças de deslizeamento</b>	<b>1. Problema:</b> Requer uma ajuda moderada a máxima para se movimentar. É impossível levantar o doente completamente sem deslizar contra os lençóis. Descai frequentemente na cama ou cadeira, exigindo um reposicionamento constante com ajuda máxima. Espasticidade, contraturas ou agitação leva a fricção quase constante.	<b>2. Problema potencial:</b> Movimenta-se com alguma dificuldade ou requer uma ajuda mínima. É provável que, durante uma movimentação, a pele deslize de alguma forma contra os lençóis, cadeira, apoios ou outros dispositivos. A maior parte do tempo, mantém uma posição relativamente boa na cama ou na cadeira, mas ocasionalmente descai.	<b>3. Nenhum problema:</b> Move-se na cama e na cadeira sem ajuda e tem força muscular suficiente para se levantar completamente durante uma mudança de posição. Mantém uma correcta posição na cama ou cadeira.						
Nota: Quanto mais baixa for a pontuação, maior será o potencial para desenvolver uma úlcera de pressão.						<b>Pontuação total</b>			




# APPENDIX II - A Pressure Ulcer Management Protocol

T grade	Description	Example	Characteristics	Exudate Present	Initial Objectives	Primary Action/Recommended Dressings/Options
1	Discoloration of intact skin 	Epidermis 	Blanchable erythema or Blue/purple and black discoloration.  This may be difficult to identify in dark skinned individuals.	None	<ul style="list-style-type: none"> <li>Relieve pressure</li> <li>Prevent friction and sheering</li> <li>Protect skin from moisture</li> <li>Protect fragile skin and bony prominences</li> </ul>	<ul style="list-style-type: none"> <li>At least 2<sup>nd</sup> hourly turning. Use pressure relieving/reducing mattresses according to Patient Risk Assessment1. Pressure Ulcer Prevention Protocol</li> <li>Do not drag patient. Use correct manual handling technique and appropriate equipment</li> <li>Dermal pad, Allevyn Heel Protector</li> </ul>
2	Epithelialising 	Epidermis Dermis Subcutaneous tissue 	Non-blanching hyperaemia  Superficial granulation tissue and epidermal elements	Low to medium	<ul style="list-style-type: none"> <li>Relieve pressure</li> <li>Prevent friction and sheering</li> <li>Protect skin from moisture</li> <li>Protect and promote new tissue growth and migration to the epidermis</li> </ul>	<ul style="list-style-type: none"> <li>At least 2<sup>nd</sup> hourly turning. Use pressure relieving/reducing mattresses according to Patient Risk Assessment1. Pressure Ulcer Prevention Protocol</li> <li>Do not drag patient. Use correct manual handling technique and appropriate equipment</li> <li>Hydrocolloid, foam, film</li> </ul>
2 & 3	Granulating 	Subcutaneous tissue Fascia Muscle 	All layers of skin involved down to subcutaneous layer	Medium to high	<ul style="list-style-type: none"> <li>Relieve pressure</li> <li>Prevent friction and sheering</li> <li>Protect skin from moisture</li> <li>Remove/control exudate. Promote new tissue formation</li> </ul>	<ul style="list-style-type: none"> <li>At least 2<sup>nd</sup> hourly turning. Use pressure relieving/reducing mattresses according to Patient Risk Assessment1. Pressure Ulcer Prevention Protocol</li> <li>Do not drag patient. Use correct manual handling technique and appropriate equipment</li> <li>Alginate, hydrogel, hydrofiber, foam, film</li> <li>Warm N/saline irrigations, hydrofiber, foam, film</li> </ul>
3, 4 or 5	Infected 	Fascia Muscle Bone 	Pus may or may not be present. Antibiotic plus surgical intervention to treat infection needs to be considered.	Low/medium/high	<ul style="list-style-type: none"> <li>Relieve pressure</li> <li>Prevent friction and sheering</li> <li>Protect skin from moisture</li> <li>Treat infection and control any odour</li> <li>Conduct regular wound irrigation</li> </ul>	<ul style="list-style-type: none"> <li>At least 2<sup>nd</sup> hourly turning. Use pressure relieving/reducing mattresses according to Patient Risk Assessment1. Pressure Ulcer Prevention Protocol</li> <li>Do not drag patient. Use correct manual handling technique and appropriate equipment</li> <li>In addition to surgical debridement consider use of hydrogel, charcoal-based dressing, Iodosorb, Iodoflex, hydrofiber, foam, film</li> <li>Use warm Normal Saline, 35ml syringe and 19G needle.</li> </ul>
3, 4 or 5	Sloughy 	Fascia Muscle Bone 	Non-infected shallow sloughy cavity  Deep sloughy cavity  Fungating wounds  Tracking sinuses	Low  Medium to high  May be medium or high  Medium to high	<ul style="list-style-type: none"> <li>Deslough and protect healthy tissue</li> <li>Deslough and protect healthy tissue</li> <li>Wound irrigation, promote comfort, control exudate and /or odour</li> <li>Wound irrigation, promote comfort, control exudate</li> </ul>	<ul style="list-style-type: none"> <li>Hydrogel, film, foam</li> <li>Hydrogel, alginate, hydrofiber, Iodosorb, Iodoflex, Allevyn cavity pack, Vacuum-Assisted Closure</li> <li>Hydrogel, alginate, hydrofiber, Iodosorb, Iodoflex, Allevyn cavity pack with oral metronidazole, metranidazole gel or charcoal dressings</li> <li>Hydrogel, alginate, hydrofiber, Iodosorb, Iodoflex, Allevyn cavity pack, Vacuum- Assisted Closure</li> </ul>
3, 4 or 5	Black, necrotic 	Fascia Muscle Bone 	Surgical debridement is required for all necrotic wounds. It will depend on the size of the wound if should be attended in OT or in the clinical area	Non  Low to medium High	<ul style="list-style-type: none"> <li>Protect from further damage- Rehydrate</li> <li>Debride necrotic area</li> <li>Debride-protect healthy tissue</li> <li>Debride-absorb exudate &amp; remove from wound surface</li> </ul>	<ul style="list-style-type: none"> <li>Foam, combine pad-hydrogel</li> <li>Surgical debridement</li> <li>Surgical debridement-alginate, hydrofiber, film</li> <li>Alginate, hydrofiber, foam, film</li> </ul>

Collier, M. (1989) *Pressure Sore Development and Prevention*. Leaflet 3. Northampton Wound Care Society. 2. Torrance, C. (1990) Sleep and Wound Healing. *Surgical Nursing* 3, 3. 16-20. 3. Reid, J., Morison, M. (1994) Towards a Consensus: Classification of Pressure Sores. *Journal of Wound Care* 3, 3. 157-160. - Draft Protocol: Giselle Simmons, July 2000



# APPENDIX III - Paper Form to register Ulcers observations

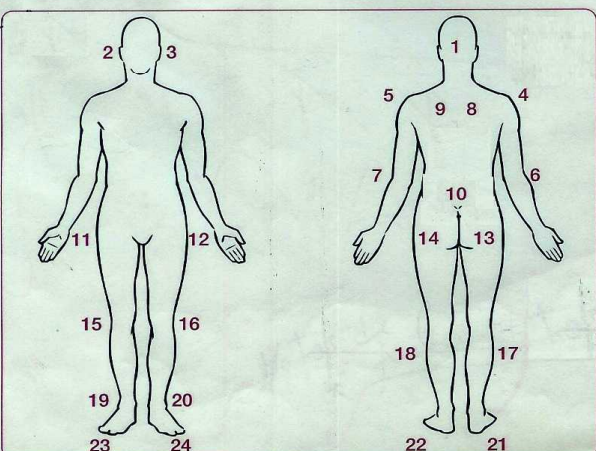

**Grupo de Prevenção e Tratamento de Feridas do HFF**  
 DIRECÇÃO DE ENFERMAGEM  
 FOLHA:  Inicial  Continuação N.º \_\_\_\_\_

Nome: \_\_\_\_\_  
1 \_\_\_\_\_  
 Idade: \_\_\_\_\_ Sexo: M  F   
 N.º Benef. \_\_\_\_\_ S.N.S.  / \_\_\_\_\_  
 N.º Processo Clínico H.F.F. \_\_\_\_\_

### INSTRUMENTO DE AVALIAÇÃO DE RISCO DE ÚLCERAS DE PRESSÃO

Serviço \_\_\_\_\_ Data Internamento \_\_\_\_/\_\_\_\_/\_\_\_\_ Proveniência:  Domicílio  Lar  Transf. \_\_\_\_\_

	Enf. _____ N. Mec. _____ ____/____/____	Enf. _____ N. Mec. _____ ____/____/____	Enf. _____ N. Mec. _____ ____/____/____
<span style="border: 1px solid red; padding: 2px;">2</span>			
<b>Percepção Sensorial</b>	1. Completamente limitada 2. Muito limitada 3. Ligeiramente limitada 4. Nenhuma limitação	1. Completamente limitada 2. Muito limitada 3. Ligeiramente limitada 4. Nenhuma limitação	1. Completamente limitada 2. Muito limitada 3. Ligeiramente limitada 4. Nenhuma limitação
<b>Exposição à Humidade</b>	1. Pele constantemente húmida 2. Pele muito húmida 3. Pele ocasionalmente húmida 4. Pele raramente húmida	1. Pele constantemente húmida 2. Pele muito húmida 3. Pele ocasionalmente húmida 4. Pele raramente húmida	1. Pele constantemente húmida 2. Pele muito húmida 3. Pele ocasionalmente húmida 4. Pele raramente húmida
<b>Actividade</b>	1. Acamado 2. Sentado 3. Anda ocasionalmente 4. Anda frequentemente	1. Acamado 2. Sentado 3. Anda ocasionalmente 4. Anda frequentemente	1. Acamado 2. Sentado 3. Anda ocasionalmente 4. Anda frequentemente
<b>Mobilidade</b>	1. Completamente imobilizado 2. Muito limitada 3. Ligeiramente limitado 4. Nenhuma limitação	1. Completamente imobilizado 2. Muito limitada 3. Ligeiramente limitado 4. Nenhuma limitação	1. Completamente imobilizado 2. Muito limitada 3. Ligeiramente limitado 4. Nenhuma limitação
<b>Nutrição</b>	1. Muito pobre 2. Provavelmente inadequada 3. Adequada 4. Excelente	1. Muito pobre 2. Provavelmente inadequada 3. Adequada 4. Excelente	1. Muito pobre 2. Provavelmente inadequada 3. Adequada 4. Excelente
<b>Fricção / Forças de Deslizamento</b>	1. Problema 2. Problema potencial 3. Nenhum problema	1. Problema 2. Problema potencial 3. Nenhum problema	1. Problema 2. Problema potencial 3. Nenhum problema
<b>Score Total</b>			
<b>Nível de Risco</b>			
<b>Data de reavaliação</b>	____/____/____	____/____/____	____/____/____



3

**Score Total** Acima de 16 → Baixo Risco  
 Menor ou igual a 16 → **ALTO RISCO**

Assinalar o local e a categoria das úlceras à entrada e saída

Ulc. Entrada		Ulc. Saída	
Local	Categoria	Local	Categoria

Data da alta \_\_\_\_/\_\_\_\_/\_\_\_\_  
 Enfermeiro \_\_\_\_\_ N. Mec. \_\_\_\_\_



# APPENDIX IV - Data Model of the Application

