Abstract – The existence, on a European level, of a context that supports the use of information and communication technologies (ICT) in the healthcare field led to the implementation in Portugal of efforts and initiatives in the National Healthcare Service (Serviço Nacional de Saúde – SNS), which were extended to other healthcare systems such as the Military Healthcare Service (Serviço de Saúde Militar – SSM), in order to comply with initiatives to make the eHealth concept operational. Consequently, the specification of innovative healthcare services that promote preventive action in monitoring the status of chronic patients and the patient’s accountability for his/her health condition.

While the implemented changes have contributed to expedite the administrative and clinical processes, there are still some remaining constraints and inefficiencies to the use of ICT as an agent for changing and modifying unhealthy habits. This situation is aggravated if we consider the use of ICT in collaborative settings for the sharing of information and for supporting the decision process.

The contribution offered in this thesis seeks to meet this challenge. It brings forth a methodology for collecting clinical parameter values, differentiating between measurements performed in formal and non-formal environments. This approach allows healthcare professionals to have a reliable knowledge base on the evolution of the patient’s health condition, focusing the sharing of information on synthesis data from the patient’s clinical process. In technological terms, the offered solution is based upon the use of a process management web platform, with rules and alert management mechanisms. This methodology will be tested in the “Unidade Hospital da Estrela” which belongs to the “Hospital das Forças Armadas” (Armed Forces Hospital).

Keywords: Electronic Health Record, Sharing of Information, Patient Clinical Synthesis, Monitoring Plan.
I. INTRODUCTION

The SSM operates with military and civilian healthcare professionals, featuring a set of specific healthcare services for the military that differentiate it from the SNS, e.g.: Pre-deployment medical support, i.e., medical observation, complementary exams and vaccination prior to Detached National Armed Forces (Forças Nacionais Destacadas – FND) missions, the assessment of military-related illnesses and/or sequelae of injury.  

Asides from these healthcare services, the SSM also includes hospital care and primary care for military relatives and dependents, security forces such as the Guarda Nacional Republicana and the Policia de Segurança Pública, and in special cases, for civil servants - Direcção Geral de Protecção Social aos Funcionários e Agentes da Administração Pública (ADSE).  

While the changes caused by the SSM restructuring have contributed to expedite some administrative processes, the use of ICT as an agent for changing and modifying unhealthy habits is very limited and inefficient, with remaining inefficiencies in the sharing of information that can be rectified.  

Information access needs from healthcare professionals and patients have been addressed through the use of Electronic Health Records (EHR), which are but a view of the pertinent patient information [1], corroborating the Collaborative Decision Making (CDM) concept [2] in collaborative settings for the sharing of information and for supporting the decision process, as is the case of the clinical environment.  

The collaborative actions, Figure 1, among health professionals with lesser and greater differentiation, allow, according to [3], the treatment of a greater volume of information with direct influence on the quality of the decision, particularly regarding diagnosis and treatment.

![Figure 1 - Agents involved in the medical collaborative acts](image)

The outlined purpose is to conceptualize a new service that can promote interaction between patient and healthcare professionals, while providing for the patient’s active participation in his/her own treatment. Following the Design Science Research methodology for information systems, our main challenge was to find ways of implementing such a service.  

Case Study Research (CSR) [4] has allowed the definition of a work plan with an approach to the stakeholders based on focused interviews, making it possible to interact with them in the design of the offered solution. Thus, the artifacts produced address typologies of issues specific to critical environments (e.g., Unidade Hospitalar da Estrela at HFAR), which require sharing of information and collaborative work.
Among the problems encountered in the SSM, this thesis aims to address two main issues:

- Identifying which information shall comprise the patient’s health condition synthesis, accessible to all healthcare professionals;
- Increasing patient interaction to make him/her more accountable for his/her health condition and habits.

Solving these issues implies establishing an innovative Information System (IS) usage architecture that ensures standardization and access to the patient’s EHR synthesis data, placing the patient at the center of the healthcare system, and at the same time promoting the sharing of information (CDM) among healthcare professionals and empowering the patient through his/her involvement and active participation.

II. RELATED WORK

The purpose of the latest initiative to make the eHealth concept operational in Europe, project EPSOS¹ (Smart Open Services for European Patients), is to make patient synthesis information (e.g. allergies and surgeries performed) and drug prescription information available. The 2012-2016 Portuguese healthcare plan [5] describes a set of healthcare-related services such as the healthcare virtual library, the Healthcare Portal, the Electronic Health Record and online access to services like: RNU (national patient record), SIGIC (integrated system for managing surgery candidates), eAgenda (online clinical scheduling system).

Although studies on the usability and impact of eHealth services in Portugal, such as the EHR in primary care units [6], point to a degradation of the doctor-patient relationship, Portugal maintains initiatives in this area by participating in the EPSOS project with the Healthcare Data Platform (Plataforma de Dados da Saúde – PDS)². PDS is an access mechanism to patient information that makes it possible to show data to healthcare professionals in several SNS spots (hospitals, emergency units, primary care), where a doctor or nurse is able to access information but not modify or damage it.

All of these initiatives are based on the dematerialization of the clinical process and in a technical and semantic interoperability capacity guaranteed by standards like HL7 [7].

More relevant to this thesis is HL7 CDA – Clinical Document Architecture, offering a standard for organizing documents produced within the provision of healthcare services Figure 2.

¹ http://www.epsos.eu/home.html

² Direcção-Geral de Saúde (Health Authority) – http://www.dgs.pt/?cr=22490
Since the problem is not technical interoperability, i.e. the ability to move data from system A to a system B without considering the significance of the exchanged information, the real challenge is semantic interoperability, i.e. ensuring that system A and system B interpret the exchanged information in the same way [8].

The use of Workflow, which consists in the total or partial automatization of a business process during which information and/or tasks are passed on among participants: people and applications, according to a set of established rules [9], in healthcare is also a reality, namely to offset the lack of tools to support medical decisions in EHR software [10]. Other initiatives with very specific goals, such as the implementation of guidelines for managing cerebral stroke cases [11], were also developed based on workflow systems.

The contribution of this thesis differs from previous approaches in the sense that it is a collaboration model that will address the problem of division among the existing IS and information islands and it will facilitate the definition of a supported service catalogue in a workflow platform, as well as solving the following issues:

- Unique identification of SSM patients that makes it possible to articulate information within and outside the SSM;
- Defining the set of information that will comprise the patient’s health condition synthesis through the formalization of the data structure that characterizes his/her profile;
- Designing a new healthcare service that encourages an increased patient interaction;
- Supporting a patient’s performance analysis against a sample universe.

The main challenges arising from these issues concern the formalization of the data structure that will characterize the clinical profile, the design of the new service that encourages patient interaction to make him/her more accountable for his/her health condition and habits through the formalization of the data structure to support monitoring plans and make them available, and also the support to performance analysis through the definition of

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the variables that allow the identification of the sample and parameters working as indicators.

III. COLLABORATION MODEL

The design of the new service raises the need to implement a collaboration model, Figure 3, whose main goals are to expedite the information flow among healthcare professionals and provide access to EHR synthesis data to healthcare professionals and patients alike; besides accessing the information, patients can also contribute according to a set of rules and corresponding access permissions.

In technological terms, the model is based upon the use of a process management platform with workflow mechanisms, rule management, and a management component of indicators linked to alert mechanisms for an effective support to the healthcare professional’s work. Specifically, it is important to separate this model’s multiple components in order to detail them. Consequently, we have a SaaS (Software as a Service) component consisting in a web platform to be made available that, depending
on the different processes, will either work synchronously or asynchronously, i.e. using a service-oriented architecture (SOA) along with an event-driven architecture (EDA). The entire component of connectors to the existing vertical systems and the user authentication, developed in the SOA environment, will use web services, and the entire component of monitoring plans and alerts will be developed following EDA logic. The storage of the information collected from the existing vertical systems and generated by doctors and patients will be dealt with a central repository solution.

Information concerning the patient and his/her clinical follow-up, defined in terms of metadata, is organized into three sections:

- The first section consists of the patient clinical synthesis or ID which shall be subdivided into two subsections: the patient’s identification subsection and the patient’s clinical profile subsection;
- The second section contains information referring to the patient’s list of inter-occurrences / episodes with the healthcare system;
- Finally, we have the indicator section with the corresponding monitoring and follow-up plans, which facilitates the setting of patient follow-up clinical indicators and the definition of alerts linked to the parameters and performed measurements.

To determine the relevant information that should be featured in the different sections and its organization, a detailed stakeholder survey was conducted to establish the solution’s implementation model. The domain model in Figure 4 is the result of this survey.

![Figure 4 – Domain Model](image-url)
The generated parameter matrix per specialty and illness, with the corresponding reference values for each listed parameter, was also based on the stakeholder survey.

IV. CASE STUDY

When collecting information through interviews and meetings with stakeholders from Unidade Hospitalar da Estrela (UHE), namely doctors from the nephrology, cardiology, hematology, imaging, endocrinology and nutrition departments, as well as doctors who work specifically in the Homogenous Diagnostic Group coding and production area, the cardiology, endocrinology and nutrition departments were selected as those that will participate in the patient monitoring case study. This choice derives from the fact that the patients followed in these departments have a clinical profile suited to the needs of the monitoring and alerts component. They are mostly patients suffering from chronic illnesses that require control through parameter measurement and regular visits to the hospital.

From the universe of those department’s patients, Table 1, data was crosschecked based on the comorbidity associated with patients with diabetes or heart conditions, and it was found that 545 patients share these departments.

Table 1 – Patients Year 2011 – Cardiology / Endocrinology and Nutrition

<table>
<thead>
<tr>
<th>Department</th>
<th>Act Type</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiology</td>
<td>Visit</td>
<td>3,046</td>
</tr>
<tr>
<td></td>
<td>MCDTs⁴</td>
<td>7,441</td>
</tr>
<tr>
<td>Endocrinology and Nutrition</td>
<td>Endocrinology visit and Nursing</td>
<td>1,789</td>
</tr>
<tr>
<td></td>
<td>Nutrition visit</td>
<td>875</td>
</tr>
</tbody>
</table>

The application of the offered model to the patient universe in Table 1 starts with the creation of the data structure based both on the domain model and the attributes from the different entities that are part of it. The collection of information for clinical synthesis and for the list of patient-UHE inter-occurrences is done through the creation of connectors to the different clinical information systems in production at this hospital unit. These connectors are implemented using web services and through the execution of the methods associated with the multiple entities (e.g. Table 2 – Patient).

⁴ Additional means of diagnosis and therapeutic
For the monitoring plan and alert component, the parameters from the parameter matrix per specialty and illness, as well as the corresponding reference values, are loaded and made available. Monitoring plan creation, sensor attribution, and measurement record are, among others, based on the methods from the multiple entities involved (e.g. Table 3 – Monitoring Plan).

Through the implementation of the offered model, we guarantee the collection and sharing of information essential to the decision process, as well as a reliable knowledge base on the evolution of the patient’s health condition.

V. CONCLUSIONS

The offered collaboration model, particularly the sharing of information it provides, fits into the doctor’s decision process which results from the aggregation / conjugation of data from multiple sources, thus corroborating the CDM concept in the clinical environment while granting the patient a way of viewing and contributing with information.

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Matrix created based on the conducted interviews.
The contribution of this thesis to solving the identified problems is supported by a web-based collaboration model that will address the problem of division among the existing IS and information islands and facilitate a management component of indicators linked to alert mechanisms for an effective support to the healthcare professional’s work, and to solve the following issues:

- Unique identification of SSM patients;
- Defining the set of information that will comprise the patient’s health condition synthesis through the formalization of the data structure that characterizes his/her clinical profile and making the corresponding dashboard available;
- Designing a new healthcare service that encourages an increased patient interaction through the formalization of the data structure to support monitoring plans and its availability;
- Supporting a patient’s performance analysis against a sample universe through the definition of the variables that allow the identification of the sample and parameters working as indicators.

Future work would consist of the expansion of monitoring plans to other specialties / illnesses, the inclusion of healthcare centers, and solving other problems raised at the SSM that were not subject matter for this thesis such as:

- The existence of different IS in SSM institutions, along with different maturity stages;
- Interoperability difficulties between the existing IS;
- The process dematerialization stage is incipient;
- Lack of consolidated management information.

Also as future work is the possibility of implementing a pilot, based on QREN project, in a production environment at UHE, whose purpose is to apply the offered methodology. This project, which could not be implemented during the making of this thesis, features its own planning and will have to be made productive for tests for a period of at least six months, after which it will be possible to conduct result analysis, namely regarding the validation of the impact and use in the patient clinical monitoring process.

REFERENCES


