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INTEROPERABILITY BETWEEN HEALTH INFORMATION SYSTEMS IN THE HOSPITAL CONTEXT

João Gabriel Fernandes

Master's in Management of Services and Technology

Supervisor:
PhD Carlos Hernandez Jerónimo, Invited Assistant Professor, Iscte Business School

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BUSINESS
SCHOOL

Department of Marketing, Strategy and Operations

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ABSTRACT

The information systems had a positive effect on the health service by reducing the physical documentation, more available information to monitor the patient and safer data storage. On the other hand, there was a negative impact due to an increase of diverse systems operating which demanded more training and support to hospitals structure aligned with the lack of interoperability standards that promote the patient´s data sharing between them. Therefore, this dissertation focused on analysing the existent interoperability between information systems in the Portuguese health service, determine the key aspects to establish communication among them, and the consequences it has on the healthcare professional´s routines. Interviews were conducted with healthcare professionals and hospital suppliers to collect their experience on interacting with this technology, their opinion about the influence it has on the hospital´s routine, and the potential measures to improve the current situation. This research concluded that the lack of interoperability and an unfriendly interface generates a complex use of the systems with a high number of clicks and slower navigation to execute the tasks that can cause loss of time for healthcare professionals. Besides, the public hospital demonstrated to have a higher number of IS suppliers and lower levels of integration between systems compared with private hospitals. Lastly, it was demonstrated that an organisational culture oriented to the technology change and a strategic plan to adapt to the hospital's approach is necessary to a successful implementation of health information systems.

Keywords: Interoperability; Health Information Systems; Portuguese National Health System

JEL Classification: I19; O33

RESUMO

Os sistemas de informação tiveram um efeito positivo no serviço de saúde com redução na documentação em papel, maior disponibilidade de informação sobre o paciente e segurança no armazenamento de dados. Por outro lado, houve um impacto negativo devido ao aumento na diversidade de sistemas a operar, que exigiram mais treino e apoio à estrutura hospitalar, associado à falta de padrões de interoperabilidade que promovam a partilha de dados do paciente. Assim, esta dissertação centra-se na análise da interoperabilidade existente entre os sistemas de informação no serviço de saúde português, em determinar os aspetos fundamentais para estabelecer a comunicação entre os mesmos e as consequências que têm na rotina do profissional de saúde. Foram realizadas entrevistas com profissionais da área e fornecedores hospitalares para recolher informação sobre a experiência na interação com esta tecnologia, a opinião sobre a influência que ela exerce na rotina hospitalar e as possíveis medidas para melhorar a atual situação. Esta investigação concluiu que a falta de interoperabilidade e uma interface pouco apelativo determinam um uso complexo destes sistemas com um elevado número de cliques e uma navegação mais lenta para executar as tarefas, que podem causar perda de tempo aos profissionais de saúde. Além disso, os hospitais públicos demonstram ter um maior número de fornecedores e menores níveis de integração entre os sistemas em comparação com os privados. Por fim, expõem-se que uma cultura organizacional direcionada para a mudança tecnológica e um plano estratégico de adaptação são necessários para o sucesso da implantação destes sistemas.

Palavras-chave: Interoperability; Health Information Systems; Portuguese National Health System

JEL Classification: I19 ; O33

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LIST OF ABBREVIATIONS

CIS - Central Information Systems

DBLINK – *Database Links*

EHR – Electronic Health Record

EMR – Electronic Medical Record

EMRAM – *Electronic Medical Record Adoption Model*

HIMSS – *Healthcare Information and Management Systems Society*

HIS – Health Information Systems

HIT – Health Information Technology

ICT – Information and Communications Technology

IoT – Internet of Things

IS – Information Systems

IT – Information Technology

NHS – National Health System

MoH – Ministry of Health

PDS – *Plataforma de Dados de Saúde*

SPMS – *Serviços Partilhados do Ministério da Saúde*

SoIS – Systems-of-Information Systems

SONHO – *Sistema Integrado de Informação Hospitalar*

RNU – *Registo Nacional de Utentes*

1. INTRODUCTION

In the health system, the adoption of Informatic and Communications Technologies (ICTs) are becoming visible and with that more heterogeneity and interoperability between Information Systems (IS) and medical data. The technological revolution enhances interoperability between Health Information Systems (HIS) as a new challenge in this sector (Aceto, Persgico, & Pescapé, 2018). This new challenge for the healthcare agents highlights the hospitals that need to adapt their way of operating with ICTs from the healthcare professionals 'routines to executive decisions.

There is already international research into the impact that HIS had in the hospital´s routine and more recently the focus has been on the intercommunication between the systems inside a hospital and in a network of healthcare units. The technology is evolving faster every day in health and this is visible to the patient, healthcare professionals, hospital board, IS suppliers, and government entities. Some countries are following this change and others are lagging, so it is important to understand and analyse what has been done and what is necessary to improve. For a country like Portugal which is a developed country, it is essential to have a clear strategy to support the use of technologies in healthcare units. To guarantee that the efficient use of information systems provides better healthcare treatments and results.

Concerning the mentioned challenge, it is important to study and discuss the positive and negative impact that information systems bring to health services, especially in a situation where there is a diversity of software operating and is necessary to establish interconnection standards between them. The technology is now part of the daily life of a hospital and is necessary to guarantee its optimized use since it has an impact on the treatments given to the patients' and organisations' workflow.

The dissertation's main objective is to analyse the interoperability between the health information systems in the Portuguese context. Therefore, it is defined to explore the approach that national hospitals are defined to face this new challenge plus identify the key aspects to establish interoperability between systems.

The technology is evolving rapidly and so that is necessary to explore the current context to sustain future measures to adapt to the health service. The results of this research can be

important to support future investigations, projects, or strategic plans on the Portuguese healthcare system regarding the interoperability of health information systems.

The present dissertation is structured by five major chapters. In the next chapter, the theoretical framework is reviewed with the objective of characterized the evolution of the ICTs in the healthcare sector and identify relevant scientific arguments about the benefits and challenges of heterogeneity and interoperability between HIT. Besides that, it also explored the Portuguese context over this topic to understand the scenario in the health service. After this, there is the methodology chapter where is explored the objectives and questions for this research and then define the approach and procedures to guide the data collection. For this dissertation, it was conducted interviews with a select sample presented in the methodology followed by a section that analyses in detail the data collected from this procedure. Finally, the discussion of the results that promote the creation of knowledge based on the scientific arguments and data collected ending with a chapter with the conclusions of this dissertation.

2. LITERATURE REVIEW

2.1 Information and Communication Technologies

Information and Communication Technologies (ICT) have changed the way people communicate, work, and operate in everyday life. There is a notable impact on the quality of life of the population with an increase in social contact but also positive consequences in economic activities, including health care and education services (Nevado-Peña *et al*., 2019). The ICTs demonstrate to have a positive impact on corporate performance with more significance in competitive environments. For this, the managers must be completely involved in the ICT adoption and updating processes and more important the employees must be trained to use it (Barba-Sánchez *et al*., 2018).

The Internet of Things (IoT) integrates different technologies and new information systems appear frequently which obligates users to possess the necessary skills to be comfortable when using the new IT. This is one of the challenges in the ICTs paradigm, most users are not well prepared to use the technology and feels a lack of trust when exposed to it. (Elsbach & Stigliani, 2019). Another relevant challenge that Information Systems face is the heterogeneity of technologies operating in the same subjects which require a new design that allows the coexistence between then and an intercommunication platform. These barriers are visible in services where they operate with objects that are digital and stored in multiple platforms (Atzori *et al*., 2017).

Although it reveals to have a positive impact on the socioeconomic patterns, the reality is that it can also damage the less developed companies. Since there is more social connection between entities, it benefits the development and consolidation of operations when they are connected but it can promote fragmentation with least technologically developed organisations (Roztocki & Weistroffer, 2016). With the current technological paradigm, public authorities play a key role to achieve the innovation by eliminating the barriers between the information and data produced by a public and private entity. Even though some data stored is confidential, in some situations can be relevant to create a common informative base for share freely and on a higher scale the source of information, for example in the health and education system. (Atzori *et al*., 2017).

2.2 Interoperability between Information Systems

The concept of interoperability is been discussed since the 1970s and the main conclusions gathered at the beginning of the 20th century were that the information exchange between computing infrastructures or applications follow a *"set of common rules and concepts that define a common understanding of the information and operations available in every cooperating system*"(Andrej Vckovski, 1999).

The modernization of ICTs in business processes has generated a heterogeneity of Information Systems (IS) operating at the same time to achieve a common business objective. Hence, a new concept emerged Systems-of-Information Systems (SoIS) that result from a combination of independent software-intensive Information Systems (IS) interoperating to accomplish an inter-organisational mission. (Saleh *et al*., 2016; Vicente *et al*., 2018). According to (Teixeira & Lopes, 2019), a SoIS *" is a specific class of Systems of Systems oriented to business processes in which constituent systems include information systems that interoperate between themselves and belong to different organisations".*

The information systems are autonomous since they have their mission and heterogeneous regarding their architecture and content. Therefore, their interoperability occurs when successfully the IS can exchange, use, and cooperate with the information shared. The effectiveness of the cooperation depends on the way they develop together different interactions and to measure it is necessary to evaluate the degree of connection between information systems. The evaluation should focus on the interaction and identify the activities repercussion and overlapping actions that occur with the interoperability. Although measuring the effectiveness of an existent interoperation relationship between IS is fundamental to control the process, it becomes essential to analyse a priori the potential of possible cooperation between systems (Panetto *et al*., 2016). When successfully explored the interoperability between systems, it becomes an opportunity for enterprises to exploit market opportunities, study their strengths and weakness in cooperation with the current partners but also define the actions to improve (Guédria *et al*., 2015).

According to (Zdravković *et al*., 2017), there are three situations of interoperability regarding the type of communication and receiving information between the IS. (1) In the subsumption situation, the communication entity is responsible to send in a fully understandable way the message to the receiving entity which occurs when two parties agree to interoperate. (2) The intersection case where the systems operate with a common language because they have the

same domain. (3) Finally, the disjointness of the perceptual sets represents the systems that interoperate even though they have different domains of interests and language, as an example the interoperation between an ERP system and an energy planning system to evaluate the impact of energy cost in the total manufacturing cost.

Regarding the technical interoperability is necessary to ensure data exchange between IS by communication channels and protocols plus the syntactic aspect that structures and specifies the data exchange, such as an XML document, and supported by international health IT standards like Health Level Seven International (HL7). On the other hand, semantic interoperability establishes a domain of medical concepts that can be shared across IS providing a common language that can be understandable for humans and machines and is also necessary to involve organizational aspects since it requires common business processes that enable healthcare treatments between institutions, policies between stakeholders to maximize interoperability and if necessary legal regulations (Lehne *et al.*, 2019).

The idea of mapping semantic mechanisms to share, convert, and translate information between heterogeneous platforms stimulates more efficient and innovative processes in areas like manufacturing processes and product development (Szejka *et al.*, 2017). Information sharing and innovation orientedness have a positive effect on organisation performance aligned with management capability (Celtekligil & Adiguzel, 2019), and interoperability can be an important tool to support innovation management inside an organisation to achieve business competitiveness (Rigoni et al., 2017). Activities related to Artificial Intelligence and the Internet of Things depend on solid data sharing framework that is provided by technical gateways like Application Programming Interfaces and enables interoperability between private and public activities (Borgogno & Colangelo, 2019). The definition of standards ensures the interoperability between different networks in industries such as information and communication technology and coordinates innovation of new systems technologies such as 4G/5G mobile communications, computer operating systems, and integration of computers. Interoperability allows different manufactures to share products or services in networks, for example, mobile communication that provides economies of scale in production and use plus larger infrastructures. The importance of interoperability and innovation depends on the technology and industry since for some organisations the products and services benefit from connectivity or to invest in R&D is more valuable to coordinate technological development with other developers (Grindley *et al*., 2017).

2.3 Health Information Technologies

Since the digital revolution started there have been changes in the medical processes which become more digital. For that reason, the World Health Organisation created the term *eHealth* that " involve a broad group of activities that use electronic means to deliver health-related information, resources and services: it is the use of information and communication technologies (ICT) for health" (World Health Organisation, 2016). The eHealth has different domains that involve healthcare administration and support, education, healthcare delivery, and research. These domains are included the Clinical Information Systems that englobes the electronic medical records, decision support, and monitoring of health systems practices (Cowie *et al*., 2013). The member states of the European Union are committed to including Information Systems that concentrate on the patient´s medical status to create new channels of health information sharing between diverse providers and to monitor the health system performance (Andriukaitis, 2017).

Health Information Technologies (HIT) are informatic hardware and software used by health professionals to support patient care. They are responsible to create, maintain, analyse, or receive information to support the diagnosis, cure, treatments, and prevention of health diseases. (Sirintrapun & Artz, 2016). From this group of technologies it stands out the *Electronic Health Records* (EHR), also designated as electronic medical/patient record, is a digital platform that stores clinical data of patient registered by healthcare providers, such as medical appointments, medication prescription, imageology reports or other medical information's from the patient health (Chakravorty *et al*., 2019)(Lamy *et al*., 2019). The EHR can be a set of multiple *Electronic Medical Records* (EMR) across multiple healthcare organisations that are capable of exchange data with each other following interoperability standards, such as the HL7 for messaging (Jacob, 2019).

Regarding the HIT systems, the *Information Value Chains* is present in the electronic health records and depends on the system design and use. In the case of the Shared Electronic Health Records, the value chain starts with the interaction of the healthcare professionals with the recorded program, collecting information to decide and then initiate the following procedure, that can order a medical exam or prescribe a medicine. The stages on the system are dependent on each other's and the progress in the value chain is variable with the context and situation. Figure 1 represents a model of *Information Value Chain* of a simple casual model connecting record system use and clinical outcomes (Bowden & Coiera, 2017).

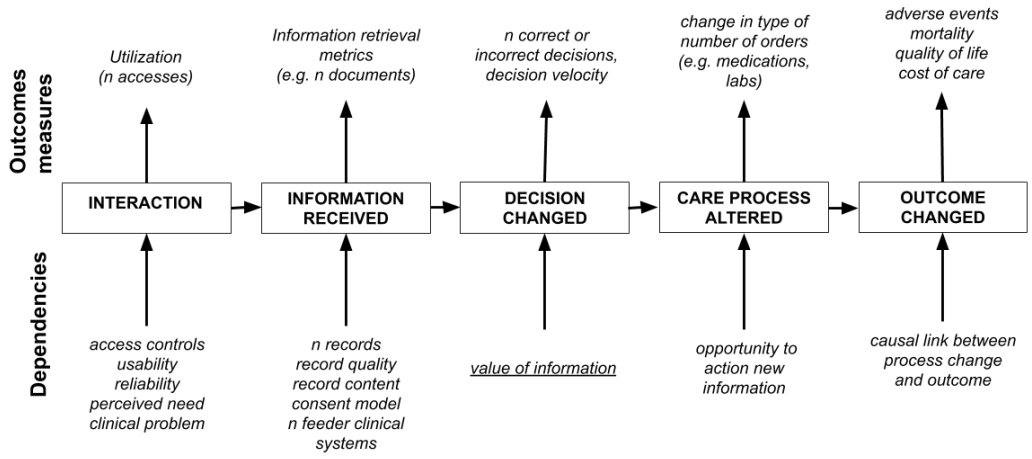

Figure 1 Information Value Chain (Adapted from Colera,2015, Chapter 11)

Figure 2 describes the Clinical Information Systems as a "*wide range of networking technology*, *clinical databases*, *electronic medical records*" and other information systems. The information provided by this IS is then stored in an Electronic Medical Record with a Patient Information database. Finally, the documentation, clinical reports, and other information will be used in medical decision-making and for quality control (Poly *et al*., 2018).

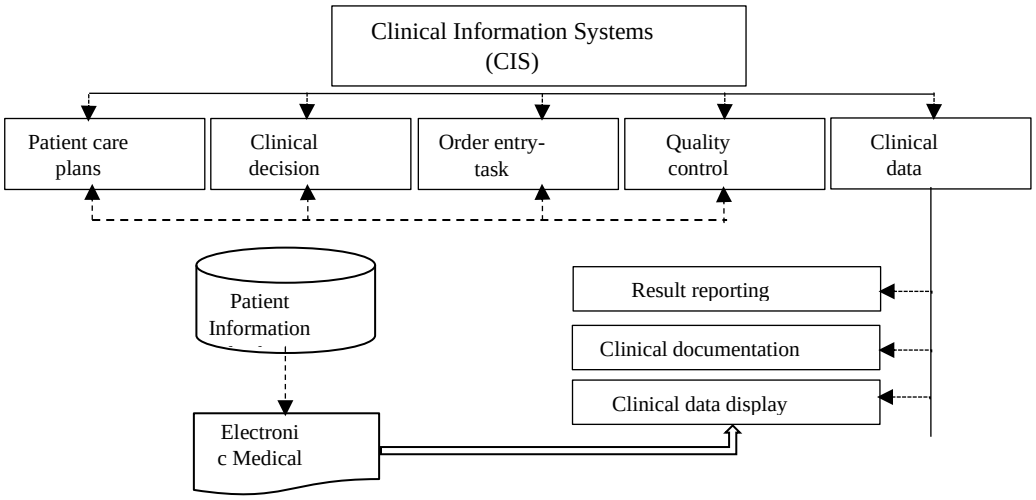

Figure 2 Infrastructure and flows in Clinical Information Systems) from Poly et al., 2018)

2.3.1 Benefits of EHR

HIT allowed to make significant advances in the monitor and control of healthcare treatments becoming more trustworthy, transparent, and accessible to the patients (Sirintrapun & Artz, 2016). Focusing on EHR systems, the primary use is centred on the patient care from their health information to the management of their treatment, but also on supporting the financial

and administrative functions and decisions. Also, the EHR has a secondary use related to providing data to public health policies and research, the existence of patient´s record that allows their self-care education and the big data generated creates the tools to the continuity of care both to the individual and to the population (Reza *et al*., 2020).

The optimization of this HIS use has a related impact on the safety and quality of healthcare (EW & Grove D, 2016), then should improve the efficiency of the processes by reducing the documentation processes (Bailas, 2016). Besides, the successful implementation of EHR can increase productivity in hospitals by establishing more efficient procedures and processes but also an increase in the quality of data management (Kruse *et al*., 2018). This technology enables more precise data collection which improves the quality of patient records, such as the pain and nutritional status evaluation, that influences the quality-of-care management at the admission of patients. Hence, promotes more safety by improving care treatment like medical treatment (Stavert-dobson & Risk, 2018).

Concerning health professionals' use, a study developed by (EW & Grove D, 2016) enhanced that the physicians with more EHR experience have more positive feedback about the use of this technology then believe it supports better patient care and benefits for their practices. This HIT has a key role in enabling information sharing and values along with them (Dobrzykowski & Tarafdar, 2017), plus the potential to simplify communication between healthcare providers and enables their access to an encyclopaedic knowledge of medicine (Stavert-dobson & Risk, 2018). More than this represents a reduction in handwriting procedures of health professionals combined with available tools to monitor and alert the users of patient´s vital statistics and drug interaction which diminishes prescription errors that came from printed records and manual methods (Reza *et al*., 2020).

2.3.2 Implementation Challenges

In a long and complex process of implementation of a new EHR, it is not just a technological and procedural change but also a human and social change that must be managed by the hospital, regulatory authorities, and suppliers. The main issue is related to change and inherent resistance and so that is necessary for the capability of creating motivation and involve employees during the process change (Marto, 2017). Another obstacle faced on the EHR implementation is the lack of organisational resources that hospitals present and the high investments needed to operate with these systems (Adler-Milstein *et al.*, 2017). According to (Plantier *et al.*, 2017) research, the proportion of the investment made in the extent of this

technology adoption in the hospital has a positive influence on the success of the EHR adoption.

Regarding the impact of healthcare providers on this process, is necessary that the EHR be perceived as useful, user-friendly, compatible with the existent work practices and their values to be used and satisfactory (Maillet *et al*., 2015). One key aspect is establishing a healthcare provider -hospital relationship based on shared values to the EMR use can be effective by improving the healthcare professional's performance and the information-sharing practices inside the hospital (Dobrzykowski & Tarafdar, 2017). The main difficulties are to integrate discipline and sufficient educations resources to the healthcare providers and stimulate the integration between administrative and operational staff. (Stavert-dobson & Risk, 2018). Initially, there is a loss of productivity because it is necessary to teach users to work with the system, adapt to data entry requirements representing a time consuming, and took users away from other duties in the service (Kruse *et al*., 2018). If there is regular support from co-workers, the behaviour of health providers changes since it will not be required so much mental effort to become more appealing and intuitive to use the systems (Martins *et al*., 2019).

2.3.3 Heterogeneity of HIS

Health Information Systems (HIS) are widely implemented by diverse manufactures with different architectures, databases, and infrastructures which has a negative impact by the incompatibles languages that difficulties the access to each data storage (Raghupathi & Raghupathi, 2014), increase the documentation process time and reduced flexibility in reporting (Dobrzykowski & Tarafdar, 2015). The heterogeneity of HIS has a higher impact if there is a high number of these systems operating in the same hospital since it increases the complexity to access and analyse the information stored in diverse databases. Hence, decreases the effectiveness of the analysis and decision-making of health professionals but also the irrational and undue use of resources (Peterson *et al*., 2016)(Jardim & Martins, 2016). The actual health scenario demonstrates that there are very disjointed data formats in IS that block the introduction of new opportunities generated by these technologies (Aceto *et al*., 2018).

The absence of interoperability standards to establish a communication flow between EHRs, patients, and hospitals is creating a barrier to effective Information Technology (IT) intervention in healthcare treatments. (Samal *et al*., 2016) (Kruse *et al*., 2018). Even that the HIT provided a structure that allows consistent data capture, the issue persists since the

healthcare data tends to be in different formats and stored in multiple platforms (LeSueur, 2017). The healthcare framework is complex since the data used is rarely standardizes, normally fragmented, and operates with IT that have incompatible structures. Aligned with the reduced ICTs skills that the health providers have to operate with these technologies. (Aceto *et al*., 2018).

Concerning the negative impact of deficient communication between systems, it blocks the opportunity to create an efficient flow of information about the patients and new knowledge processes to obtain patient´s clinical data (Fan *et al*., 2018). The lack of technical and organisational interoperability generates also loss of time in the clerical processes of the health providers (Samal *et al*., 2016), an obstacle in data access from decentralized IS with no uniformity in data records (Dlodlo & Systems, 2017) and clinical errors, such as medication and diagnostics lapses (Poly *et al*., 2018). Due to the poor user interface design, it leads to errors in data input and comprehension since the system may have different methods of presenting the patients identifying information which forces the users to constantly switch mental models to interact with the EHR increasing the probability for error (Sittig *et al*., 2020).

2.4 Health Information Technologies Interoperability

Interoperability can only be achieved when the Information System creators are willing to create an open source of shared services where healthcare organisations have a pivotal role in stimulating these collaborations. To achieve this transformation and create a large program of information and control sharing service, is necessary to: *"(1) define a set of mission threads that cross the systems boundaries and (2) define a set of capabilities and features and a logical flow of information and controls that require the integration either very tightly or in a more loose fashion."* (Dodd, 2017). There are also interoperable systems that allow the exchange of health information from one system to another by point-to-point capabilities of EHR or through specialized technologies managed by different suppliers (Frisse, 2017). As an example, the EHR adoption aligned with Enterprise Resource Planning (ERP) systems contributes positively to achieve interoperability in healthcare units (Chakravorty *et al*., 2019).

The interoperability between HIS facilitated the medical data sharing between healthcare and research organisations and enabled a faster and more reliable exchange of information (Longo, Dan L.; Drazen, 2016). The ability to share relevant information among diverse healthcare

systems and provide consistent data across them will help to improve patient safety and reduce the costs of treatments (Oemig & Snelick, 2016). Hence, the possibility of increase clinical research and healthcare effectiveness since healthcare organisations have access to the information provided by patients (Peterson *et al*., 2016). The improvement of the electronic medical information systems and the establishment of technologies architectures to stimulate interoperation, such as Blockchain, can provide effective resources to solve medical issues, more reliable information, and smooth clinical decision-making process (Chen *et al*., 2018)(Jiang *et al*., 2018).

The main constraint in the creation of interoperable health information systems is the requirement of sharing personal and medical information between different agents since the health data implies privacy, security, and patient consent to be used (Balamurugan, A.M.; Sivasubramanian, A; Parvathavarhini, 2017). More than an ethical responsibility of the institution that possess this information is the legal regulations that ensure that only authorized entities can access to HIS data stored to secure the confidentiality of the patient (Fan *et al*., 2018) (Peterson *et al.*, 2016). Technological architecture, such as the cloud environment, is not fully reliable to guarantee the security of personal and medical records of patients which acknowledge the obstacles in establishing a network of shared information(Jiang *et al.*, 2018).

2.4.1 HL7 Standards

The International Standards Organisations (ISO) defined standard as a document that must establish by consensus that provides rules, guidelines, or characteristics for activities or their results and is approved by a recognized entity. From the membership list of ISO evidence the HL7 International that is an organisation focus on developing standards for healthcare interoperability (Benson & Grieve, 2016). The Health Level Seven International (HL7) is a non-profit organisation that provides standards for the exchange, integration, sharing, and retrieval of electronic health information. Those standards define how the information is packaged and communicated from one system to another, setting the language, structure, and data types required (HL7, 2020). The institution develops standards that are free of charge and have the specifications needed for making healthcare systems interoperable in domains like administrative and clinical data. More than this they provide educational programs to support healthcare institutions on establishing their standards since their goal is to minimize the barriers and allow a worldwide adoption of HL7 standards (Benson & Grieve, 2016).

According to (Oemig & Snelick, 2016), this organisation is worldwide known for designing the HL7 version 2.x and HL7 Version 3.0 standards for exchange messages of patient-related with administrative and clinical data within hospitals, between providers and hospitals, and between hospitals and registries. Those standards are responsible for the definition of a set of messages that specifies the requirements between communicating applications and that allow healthcare information swap, such as sending a laboratory result or admitting a patient. Normally, the application interface specifications may not match so their differences must be addressed when developing the data exchange connection. The ones that use the HL7 version 2.x standards connect in two ways:

(1) Via point-to-point that involves connecting each pair of systems directly to each other independently of others.
(2) Via middleware, such as the Communication server approach, that characterizes a connection between all applications to a central message broker instead of directly to each other.

Considering the Communication server approach, if two Health Information Systems pretend to share information there will be a messaging broker/bus which provides a common point of communication between the systems engaged. Here the message structured standards like the owns provided by HL7 are defined to request, respond, and submit the information exchange between the systems. Each HIS just needs to focus on covert its data to the standard message structure and send to the messaging broker (Kuo & Kuo, 2017).

The *message broker* or integration broker is the system centrepiece since facilities information movement between two or more heterogeneous systems. An integration broker is a software hub that is capable of various functions, such as understanding the format of all messages transmitted among information systems and even trigger events or alerts (Kale, 2014).

Finally, is important to understand that the messaging between HIT systems data provided by the HL7 standards are vulnerable so is important that HIT databases be constantly on maintenance and applied robust design measures. This way will be possible to track and identify potential changes in clinical information stored in the EHR systems (Stavert.Dobson, 2016).

2.4.2 EMRAM

To evaluate the EMR capabilities installed in the healthcare centres, it was developed the Electronic Medical Record Adoption Model (EMRAM) by Healthcare Information and Management Systems Society (HIMSS) Analytics. This methodology divides the adoption and utilization of EMRs functions into eight stages that start with "Stage 0" until "Stage 7". The lowest stage considers that the organisations do not have any EMR installed in the department systems (laboratory, pharmacy, and radiology) and the highest stage represents the institutions that consolidated the EMR adoption (HIMSS, 2017). Table 1 describes the stages of the EMRAM:

Stage	Electronic Medical Record Adoption Model
7	Complete EMR; external health information exchange; data analytics, governance, disaster recovery, privacy, and security
6	Technology-enabled medication, blood products, and human mil administration; risk reporting; full clinical decision support
5	Physician documentation using structured templates; intrusion/device protection
4	Computerized physician order entry with clinical decision support; nursing and allied health documentation; basic business continuity
3	Nursing and allied health documentation; eMAR; role-based security
2	Clinical data repository; internal interoperability; basic security
1	All three ancillary information systems installed; picture archiving and communication system; non-Digital Imaging and Communications in Medicine image management;
0	Lab; pharmacy and radiology/cardiology information systems not installed

Table 1 Summary of Electronic Medical Record Adoption Model (EMRAM) stages

According to HIMSS annual EMRAM survey from US Hospitals, most of them have difficulties to reach Stage 6 since it requires higher costs, and all the organisation committed in full adopting the Clinical Decision Support (CDS) systems across the entire institution (Kharrazi *et al*., 2018). A study related to EMRAM model adoption conducted by (Martins *et al*., 2019) in a Portuguese hospital concluded that the success of an information system depends on the users and, so that is crucial a good formation and support the healthcare providers in the use of EHR. More than this, the success of EMRAM adoption depends also on the IT workforce qualified in the healthcare sector (Hersh *et al.*, 2018).

The nurses are the healthcare providers that typically spend more time operating with the EMRS and the implementation of Stage 7 results in the optimization of the HIS which represents more efficient nurse processes and make patients safer (Furukawa & Pollack, 2020). Even though the hospitals struggle to reach this stage, the ones that conquer this objective are characterized by having more healthcare providers satisfied and better in data sharing within a nd outside the organisation (Davis, 2019). The adoption of the HIMSS Model also allows to reduce the healthcare costs and upgrade standards of care (Jordan, 2018).

Taking into consideration the university hospital of Hamburg-Eppendorf and the hospital Marina Salud de Dénia that were the first two to achieve stage 7 in Europe is possible to deduce that the integration and interoperability of health information systems (HIS) achieved allowed to become paperless hospitals. Few processes escaped the integration of HIS and the digitalization improved the quality and accessibility of healthcare along with a reduction in the number of hospital complaints plus the support system for intelligent clinical decision allows quicker decisions from healthcare providers(Salomi & Maciel, 2017). Finally, a study elaborated in specific Netherlands hospitals concluded that the higher the stage the less length of stay from patients in the hospital units *(*van Poelgeest *et al.*, 2017).

In Portugal, just two private hospitals have reached the highest stages of EMRAM which are the Hospital Lusíadas Lisboa (Stage 6) and Hospital de Cascais Doutor José de Almeida (Stage 7) (HIMSS, 2020).

2.5 Portuguese National Health System

In Portugal, the Ministry of Health (MoH) owns and operates in hospitals and community-based clinics but there is also the private sector that is active in health delivery. The national policy focus on a tax-funded system that tends to provide equal access to all citizens to this service although there is a minority that holds voluntary health insurance (de Almeida Simoes, Augusto, Fronteira, & Hernandez -Quevedo, 2017).

The MoH designated the *Serviços Partilhados do Ministério de Saúde,* E.P.E. (SPMS) has the entity responsible for the development, maintenance, and operate of the several integrated health information systems in the public sector (Decreto-Lei Nº 108/2011 Do Ministério Da Saúde, 2011). The strategy for eHealth in Portugal is based on a vision where the TIC will promote and simplify access to the health system and interconnect professionals and patients

(SPMS, 2015).SPMS has been involved in the documents dematerialization process taking as an example of the contribution given to developing electronic receipts (Portaria n.º 284-A/2016, 2016). From 2013, this entity was responsible for the implementation and maintenance of *Sistema Integrado de Informação Hospitalar* (SONHO) in the Portuguese public hospitals (Despacho Nº 12071/2013 Do Ministério Da Saúde, 2013).

In addition to SPMS, there is a private company collaborating with MoH and operating with products and services in most of the national public and private hospitals. Glintt-Healthcare Solutions (Glintt-HS) is a specialized technology company that provides services and products to healthcare units, such as hospital software, adapted to the client's requirements (Cordeiro, 2016). Despite this, (Sousa, 2017) emphasizes a complete dependence on the MoH over decades regarding the evolution and development of IS which results in few local *players* operating in this market with a lack of resources for innovation and the absence of global HIS manufactures. According to the same author, MoH service has centralization of responsibility for the most relevant process (administrative and healthcare activities) that enhances a political risk preventing the elaboration of a rational and clear analysis of these systems operating in Portuguese healthcare units plus difficulties in innovating.

2.5.1 HIT in Portuguese hospitals

The HIT systems operating across the country´s hospitals are not the same, even though there are systems to record information with common aspect some problems appear in effectively connect the hospital data with vertical data collections, institutional databases, such as *SClínico*, and other data sources (de Almeida Simoes *et al.*, 2017). The *Plataforma de Dados da Saúde* (PDS) is the health data platform that stores all the information received from several other systems about a patient and allows them to be consulted by remote systems (Jardim & Martins, 2016). The PDS database allows to record information about the patients, such as medical, nursing, and social evaluations, physical autonomy analysis, and other healthcare indicators. However, not all the information on the patients can be easily followed because the hospital and primary care systems have different systems with different data modules (de Almeida Simoes *et al.*, 2017). To overcome the previous issues, it was developed a project named *Registo Nacional de Utentes* (RNU) – Patient National Registry but only solves the problem for the applications developed by the SPMS. One of the major difficulties faced by the Portuguese NHS is the lack of a common unique identifier for each patient and the absence of an integration mechanism for non-Government applications (Jardim & Martins, 2016).

In the decade of the 90s, the Information System SONHO was created to support the administrative services of hospitals, ensuring the hospital activities management and invoicing operations along with the promotion of information to healthcare indicators. This is a system available in the majority of the public hospitals and is being replaced by *SONHO V2*. This new version is more aligned with the generality of the applications available on the market, developed a new integration layer (*service-oriented),* available database to support the export of information for metrics, data, and management reports besides new functionalities to identify the patient by the use of citizen card[4]. This integration layer is the interoperability platform *Local Interoperability Gateway For Healthcare* (LIGHT) that is characterized by an integration broker that manages the information exchange between SPMS applications and external suppliers and follows an *opensource* solution based on the standards HL7 v2.5. Furthermore, the evolution will allow us to decrease the integrations based on DBLINK available with *SONHO V1* that was hard to maintain since it was necessary to develop individual schemes of integration for each hospital (Marto, 2017). Regarding the communication with other systems, the SONHO V1 is known to apply the *Database Links* (DBLINK) connection that is characterized by a one-way communication path. The user connected to a local database, as an example from SONHO, has a link stored there that allows access information in another HIS database server but a user connected to the other database cannot use the same link to access on SONHO´s database. In this case, is necessary to have a link stored in the data dictionary of the other HIS database (Oracle, 2020).

On the subject of another important system operating in the public sector, *SClínico* is a HIS developed by SPMS to promote a single and common application to all healthcare providers that allow access, use, and share of clinical records. This system is only available on the National Health Service with a hospital version, *SClínico Hospitalar*, and for the primary care units, *SClínico Cuidados de Saúde Primárias*. The goal is to standardize the practices and information collected at the national level, contributing to improve the performance of health professionals, extract more information to health indicatory analysis and this way improve the quality of care provided (SPMS,2020).

The system works based on profiles of health professionals and changes the information visible depending on the user´s profile, even though there is clinical user information shared between them. *SClínico* definitions allow the optimization of clinical information, contribute to support the user´s experience, and provide a more effective and efficient performance of healthcare providers (da Silva, 2017). According to (Jardim & Martins, 2016), the major difficulty is the

lack of good and standardized interoperability among information systems in Portuguese healthcare units.

At the Nursing level, *SClínico* allowed to improve the diagnostic and intervention activity but at the same time, it demonstrates the inadequacy of the parameterized content for specificities in healthcare services. There is a perception from nurses of slowness navigation, an unfriendly structure increases the number of steps plus the need of investing in training and adapt the content of each clinical context (Vieira, 2018). According to a research developed by (Bailas, 2016) focused on the time spent on the use of this EHR and other computerized information systems, the nurses consider that spend on average 33,5% of their total working time in the use of *SClínico* and it was also visible the impact on the perception when the nurses had a training process to use this information system. Although it is evidenced some weaknesses in the performance of the SPMS´s system in nurses' routines, it has integrated the International Classifacaitons for the Practice of Nursing which supports their nursing diagnoses and intervention plans (Ribeiro *et al*., 2018).

About private suppliers, *Globalcare* is a unique and integrated health software to healthcare that belongs to Glintt-HS. (Cordeiro, 2016). The Glintt´s software has different services that depend on the client´s needs but is related to (1) Hospital Management Systems; (2) Clinical; (3) MCDT; (4) Pharma & Logistics; (5) Interoperability; (6) Patient Engagement. This offer includes administrative and billing software, clinical records systems, imageology applications, and other systems related to the mentioned areas, but the systems integrated into the healthcare unit will be determined according to the client. From the hospitals where Glintt-HS is operating, it stands out the Hospital de Cascais Doutor José de Almeida that reached Stage 7 from HIMSS certification (Glintt,2020).

3. METHODOLOGY

According to (Fortin, 2009), the methodology is*" a set of methods and techniques that guide the preparation of the scientific research process".* This chapter is divided into four subchapters starting with an explanation of the research objectives and then presented the research questions. Furthermore, it is described as the research approach selected and the data collection procedures.

3.1 Research objectives and questions

The definition of the objectives is the first step in the preparation of the research process and then determined the research questions that will support the investigation. Therefore, the objectives were based on the important issues considered in the literature review and the gaps founded on this previous study.

After the literature review analyses are recognized the lack of knowledge on the state of interoperability between HIS in Portuguese hospitals so that will be a topic of this investigation. Even though the studied authors mentioned the main benefits and constraints from the implementation and use of the IS and their intercommunication, it will be a research objective to explore the influence that this phenomenon has on the healthcare processes in the Portuguese context. Finally, there is general knowledge that mentions some difficulties faced in the interoperability between HIS which evidence the need to clarify what is the key aspect of improving the technological approach of hospitals. Hence, it was formulated the following research question to be explored in this dissertation:

What is the influence that the interoperability between information systems generates in healthcare?

Therefore, it was defined three sub-objectives to have a clear and more complete answer for the research question:

i. Explore the level of interoperability existent in Portuguese hospitals;
ii. Identify the key aspects to establish interconnection between HIS;
iii. Understand the influence of interoperability or absence has on the healthcare professional's routine in Portugal.

To answer this central question is necessary for the creation of sub research questions that will support the investigation. These questions were based on the research objectives and the literature review authors as the following Table 2 demonstrates:

Research Objectives	Sub Research Questions	Literature Review authors
Explore the level of interoperability existent in Portuguese hospitals	How do Portuguese hospitals are organized to operate with HIS?	(Sousa, 2017);(de Almeida Simoes *et al.*, 2017);(Jardim & Martins, 2016).
Identify the key aspects to establish interconnection between HIS	Which are the key elements to achieve interoperability between HIS?	(Furukawa & Pollack, 2020);(Davis, 2019); (Jordan, 2018); (Marto, 2017); (Adler-Milstein *et al.*, 2017);(Plantier *et al.*, 2017); (Martins *et al.*, 2019);(Hersh *et al.*, 2018);(Dobrzykowski & Tarafdar, 2017);(Stavert-dobson & Risk, 2018).
Understand the influence of interoperability or absence has in the healthcare routine	How IS and their intercommunication influences the healthcare routines?	**Positive Impact:** (Reza *et al.*, 2020); (Kruse *et al.*, 2018); (Stavert-dobson & Risk, 2018); (Dobrzykowski & Tarafdar, 2017); (Longo, Dan L.; Drazen, 2016); (Oemig & Snelick, 2016);; (Chen *et al.*, 2018);(Jiang *et al.*, 2018). **Negative impact:** (Fan *et al.*, 2018);(Samal *et al.*, 2016);(Dlodlo & Systems, 2017);(Poly *et al.*, 2018);(Sittig *et al.*, 2020).; (Dobrzykowski & Tarafdar, 2015); (Peterson *et al.*, 2016);(Jardim & Martins, 2016); (Vieira, 2018);(Bailas, 2016);(Ribeiro *et al.*, 2018).

Table 2 Relating Research objectives, Sub Questions, and Literature Review authors (Elaborated by the author)

3.2 Research approach

Considering the research objectives and questions is necessary to understand the opinions, behaviours, and interactions of people that are or were involved with health information systems. So, the most efficient approach to collect this data is a qualitative research that is characterized by representing the views and perspectives about real-life events of the participants in the study (Yin, 2016). More than this allows us to study the context of participants, focus on a single phenomenon, and create an agenda for a change (Creswell, 2014).

Qualitative research tends to collect data in the field where the participants experience the problem under study, but since this investigation is taken during the COVID-19 pandemic done this research in health facilities is not possible to accomplish this requirement. Hence, the methods that are chosen will not include any physical interaction with the participants to follow the government rules and so that the digital platforms will be essential to gather information for the research.

Although the previous constraints, the researcher represents a key instrument to gather and review multiple forms of data that must select the central personalities and review many official documents about the problematic studied and determine whether is needed to collect additional data to confirm the collected one (Yin, 2016). The researcher's role involves also studying the contextual conditions of the institutions and participants that cooperate in the investigation, explore the processes and activities that are influenced by the studied theme, and generate weighted conclusions from the data collected (Creswell, 2014).

The qualitative technique that was used to collect the primary data was semi-structured Interviews which is characterized by assuming a conversational mode to reconstruct the participants' experiences and reality in their expressions. Therefore, the researcher will have to create a healthy conversation going by demonstrating interest in the other person´s responses, avoid that the answers be “yes/no”, feel the participant comfortable to follow their sequence and perspective about the theme (Yin, 2016). Although the researcher does not have all the data necessary, it is important to have a significant domain of scientific knowledge on the subject under study, control over the emotional skills as an interviewer to be prepared to make unpredictable questions in the appropriate moment (Britto Júnior & Feres Júnior, 2011).

3.3 Data collection procedures

Regarding the research goals, it was important to create an adapted interview script since there are interviewed persons that prefer a more informal approach and others maintain a formal approach (Beaud & Weber, 2007). The interview protocol created to guide the conversation promoted a more efficient data collection since the interviews had pre-defined questions to avoid that the conversation diverges from the main theme and if that happens to easily reconstruct the context of the interview. About the interview´s guide, it contains questions of an open answer to explore the knowledge and life experience of the interviewee about HIS and therefore the guidelines are adapted to participants' functions and experience with this technology. (Appendix 9.1) can be found the interview scripts used for the different types of interviewed persons since there were some different questions chosen because of the person´s profile.

The selected sample contains 16 interviews which were considered an acceptable number, even though the results of this research should be taken with caution. The persons interviewed were selected based on their functions in the healthcare sector, their experience, and expertise in HIS. In terms of geography, the sample is limited to Portugal and mainly interviews from public hospitals so that should be avoided generalizations. About the search for people was planned according to the previous indicators and the approach was to look for persons that were referenced in their functions for their knowledge about HIS or that interacted intensively with this technology. Most of the persons interviewed were mentioned by a third party that worked with them and the remaining individuals were pointed during the interviews. In all the cases, the person received the first-person contact to ask for their interest in participating and with a contextualization of the research.

Concerning the interview methods, they were conducted via video conference and phone call, participants accepted being recorded with the guarantee that it would only be used for information transcription but also concealing information that was not authorized by the companies and hospitals where they work. The interview's average duration was 45 minutes and occurred during May and June 2020.

Sample characterization

The interviewed persons are characterized by their function and the organisation where they work. For this research participated 7 healthcare professionals from four different hospitals and 9 members of four hospital´s IT and process suppliers can be seen in detail in Table 3. The name of the organisations and interviewed persons will not be shared on the dissertation, instead, it will be made a description of their organisation and functions.

Number	Organisation	Function
1	Company I	Head of Healthcare & Life Sciences
2	Company I	Head of Market
3	Company I	Healthcare Senior Consultant
4	Company II	Health Care Systems Unit Coordinator
5	Company II	Consultant
6	Company III	Healthcare Solutions Consultant
7	Company III	Healthcare Solutions Consultant
8	Company III	Healthcare Solutions Consultant
9	Company IV	Founder
10	Hospital I	Doctor at Internal Medicine Service
11	Hospital I	Nurse at the Psychiatry Service and Member of Hospital computerisation committee
12	Hospital I	Nurse in the intensive care service and Member of the Hospital nurse committee
13	Hospital II	Anaesthetist
14	Hospital II	Head of Department of Gastroenterology and Hepatology
15	Hospital III	Nurse in the emergency department
16	Hospital IV	Radiologist

Table 3 Characterization of the sample of participants in the interviews (Source: Elaborated by the author)

Regarding the healthcare professionals involved in the research, there were 3 physicians, 3 nurses, and 1 radiologist. As mentioned in Table 3, these healthcare providers operate in four different hospitals that will be featured later and each one has different functions on the unit where they work. Their interviews were organized to retract their hospital procedures that involve the use of Information Systems, the feedback that comes from their interaction, and

the measures that consider essential to improve the current paradigm. The three types of healthcare providers interviewed have different types of interaction with the HIS, such as the dependency on it to execute daily routines or the type of tasks they must execute there.

On the suppliers interviewed, there were members of four companies involved and some of them with similar functions inside the company. In *Company III*, all the persons interviewed are Healthcare Solutions Consultant but in different hospitals which allowed having a broader perspective over the Portuguese context. Even though some members of the four companies operated in the same hospitals, they had different perspectives and insights to offer on the research analysis.

Organisation	Description
Company I	A consulting company with projects in Portuguese Hospitals.
Company II	The entity is responsible for the development, maintenance, and operation of several integrated HIS in public hospitals. Their most used technologies are the administrative system used in the hospitals and the central information system for clinical procedures.
Company III	A private company operating in consultancy and technological services in Health and with a high number of HIS in public and private healthcare units. The portfolio of services offered by the company allowed Hospital III to reach the highest level of the EMRAM scale in Portugal.
Company IV	IT company with services related to the development, support, and maintenance of software. From their services portfolio, they have a cardiology information system operating in public and private healthcare units.
Hospital I	This hospital is in the health region of the Centre of Portugal. According to the NHS information, the entity has an average of 321 available beds during 2019.
Hospital II	The healthcare unit integrates the “Lisboa e Vale do Tejo” region and belongs to one of the region's hospital centres. According to the previous source, in 2019 this hospital centre had an average of 1 058 available beds.

Hospital III	From a partnership between the NHS and private groups, the hospital provides public service translated on governmental investment in the budget. This institution is the most advanced in terms of technology conquering level 7 of the EMRAM scale and in 2019 had available an average of 258 beds. The HIS used to result from an agreement with a private supplier that supported an advanced integration on the hospital services.
Hospital IV	The hospital belongs to a private group that manages the healthcare services and the major HIS supplier is Company II. This unit has 186 available beds according to the entity information.
Hospital V	Healthcare unit with 28 beds available and located in the centre region of Portugal. This is a public hospital that operates with systems from Company II.
Hospital VI	Oncology unit with an average of 379 beds and located in the centre region of Portugal. In terms of HIS, the hospital has a huge diversity of systems and recently started using the MoH systems.
Hospital VII	Located in the North of Portugal, this healthcare unit has 143 available beds and operates with the principal IS from Company II.
Hospital VIII	This local unity of Health has different healthcare units and services with a capacity of 347 beds. For this research, it only is considered as one of the departments from the hospital.

Table 4 Characterization of the organisations mentioned in the research (Source: Elaborated by the author with information from ACSS Ministério da Saúde Benchmarking)

About the organisations involved in the research, Company I have been involved in hospital projects to support the implementation and modifications of HIS on the healthcare routine. The interviewed persons from this company contributed with their perspective about the hospital management, relationship with IS suppliers, and other stakeholders of these entities. On the other hand, members of Company II, Company III, and Company IV contributed to understand the IS supplier's perspective about the hospital dynamic but also to understand how they

interact between them. Each one of this three companies has a different approach to healthcare service, Company II is a public entity and has a large presence in NHS hospitals, Company III is the private entity with a higher market share in Portuguese hospitals, and lastly, Company IV is a smaller company that focuses on developing a more simple EMR compared with the other two suppliers.

Finally, the hospitals listed were the healthcare units that the research gathered more information about the hospital´s management of HIS and the experience that they have on operating with this informatic tool. Even though the interviews mentioned other hospitals that will be referred to in the next chapter, most of the persons answer the questions based on the experiences in these institutions. The eight hospitals mentioned have different structures percentage of public investment and the number of beds available for healthcare treatments which allow having a more detailed and diversified data collection.

3.4 Qualitative data analysis approach

The interview records were transcript to the Microsoft Office Word program in separate documents and then combined in one scheme divided into three columns (HIS experience, feedback, and improvement proposals) to facilitate the data analysis. After that, the data collected was introduced in the MAXQDA program that was allowed to track the keywords, expressions, and descriptions mentioned during the interviews.

The first phase of data analysis was as mentioned to compile the collected data into a structured document that allowed to initiate the second phase of qualitative data analysis, the coding procedure. Taking into consideration qualitative data analysis from (Yin, 2016), the original text will be analysed and organized into a database with specific items, such as specific opinions, explanations, and other views expressed by the interviewees. Using the MAXQDA program, there was created the first level of codes that allowed to join in a database similar items to the same code followed by check and recheck process of the items that were combined in this code level. Posteriorly, the next level of category codes was created based on the specific details mentioned in the selected items from the interviews named as the category code. Furthermore, it was also selected specific explanations that characterized the HIS operating in the healthcare units and their interaction during their daily routines which allowed to make a contextualization of the hospital’s context.

After the coding process, there is the reassembling procedure that consists of recombining generated from the list of codes generated and facilitates the creation of tables and graphics to establish a data analysis narrative. Therefore, it comes to the fourth phase dedicated to the interpretation of the reassembled data and then finishes with the concluding phase that will draw the conclusions taken from the research.

4. DATA ANALYSIS

Firstly, it will be done description of the organisations mentioned in Table 4 based on the interviewee´s testimonies. For this contextualization, the main goal is to understand the interoperability level existent in this healthcare unit and then proceed to a more detailed analysis according to the list of codes created.

For the code's analysis, it will be presented graphics to support and facilitates the narrative of the study. The bar graphics allow an easy interpretation of the results and are also supported by a more detailed description of the codes presented.

4.1 Hospitals context

Hospital I

In Hospital I, the program responsible for the clinical record is *SClínico Hospitalar* and the administrative system is *SONHO Hospital* apart from emergency service that has an isolated IS denominated *ALERT* responsible to manage the patient occurrence. For the imageology exams, clinical analyses, and pharmaceutical tasks there are specifics EMRs from different suppliers but also a smaller IS from Company II for specific diseases or to provide receipts for patients. Attending to the interviewees' explanation it´s evident the lack of integration between the HIS in the hospital because of an absence of a global strategy to upgrade the actual situation and focusing on short-term solutions.

Taking an example of a patient´s hospitalization that comes from emergency service. In this process is necessary to extract manually the information to create a complete clinical record for the physician that will receive the patient in a specific hospital unit. Access to ALERT is limited to the unit where the healthcare provider operates, so if the emergency doctor does not extract the patient´s record is impossible for the other to access the information from emergency service. The physician interviewed affirms that "*To hospitalize three patients, I can lose about half an hour only in bureaucratic processes"*, such as discharge the patient's information in the system, wait for the approval on SONHO system to transfer for *SClínico*, and then sent all the clinical data for this platform, including the medicines prescribed. Regarding the imageology exams done in the hospital, the interface between *SClínico* and the specific EMR is based on DBLINK connection since the exam report is stored in that platform. In the case of clinical analyses requirement, the users can access the EMR from *SClínico* with the same connection standards. Then, the user can execute the clinical analysis tasks and when

the exam is concluded it is possible to download the PDF report, but for more information is necessary to go back to the EMR. More than this, it is enhanced that the clinical data is not all in the *SClínico* and so that the platform will not notify the nurses if the patient´s doctor has scheduled an exam being aware of this when they receive the results. A similar process occurs in the pharmaceutical software, physicians can prescribe, and nurses consult the medication schedule for the patient on it, once again the connection between HIS is based on DBLINK standards. According to the same physician, doctors have limited information from medicines in *SClínico* that is limited to the last prescription made for the patient outside the hospital stay or if the previous colleague left information on the patient´s clinical record.

This hospital has a workgroup that is composed of nurses responsible for track and monitors the implementation of IS in all of the healthcare services, trains the new service´s colleagues, and guarantee continuous formations when new functionality or a new system is installed. More than that the workgroup meets frequently to discuss proposals for improvement and problem resolutions based on the feedback collected on routine meetings with the nurses from the hospital units. This group was created for the implementation of Company II systems and then continued to other medical record systems that arrived, according to the interviews it allowed to establish a close relation whit this company since receives their feedback to upgrade and adapt the IS to their needs. The group is committed to providing a close assistant to the nurses because is they believe that training is necessary to guarantee efficient healthcare professionals. The interviewees also mentioned a hospital commission created by law requirement for the computerisation of the organisation is composed of a member of the administration, informatics department, and other hospitals ‘services.

Hospital II

This is a public hospital where the central information system is from a private supplier, Glintt, instead of using the Company II solution. The system allows the user to access the other EMR operating in the hospital, such as *ALERT* present in the Emergency service, Imageology platform for exams, or the clinical analysis application. Currently, the healthcare institution is in a transaction process from an obsolete IS to a new Company´s III system which generates an increased difficulty for medical staff since they have to use simultaneously both platforms. For example, it was described that some physicians use the old IS to schedule appointments and the new one for the patient´s admission process which was described as a chaotic situation since it forces them to continue to use both platforms. More than that the communication

between IS is based on DBLINK resulting in a high number of "clicks" to execute digital tasks, especially in ordering imageology exams and clinical analysis. According to a doctor, "*The information from the imageology platform is not shared with the central system, only accessible by a weblink and when requested an exam is necessary to order on the platform and also deliver a physical sheet"*. Regarding the intercommunication between *ALERT* and the central information system (CIS), if a patient is hospitalized in the emergency service and then transferred to another hospital unit, it is necessary to manually copy the available patient´s information for CIS. On the other hand, pharmacy management IS, and CIS have a complete interface that allows information transmission by a specific translation of the nomenclatorial. Finally, the interviews mentioned that the size of the hospital has a huge influence on the supplier's approach, IT department efficiency in problem-solving, and in the healthcare professionals training.

Hospital III

The central information system of this hospital allows the user to access all the information stored on the other IS operating there without leaving the platform. According to the interviewee´s testimony, "*From the central registration system, I can access the patient´s daily therapy, the needed medication and also register the procedures done to the patient"*. Even if the patient was hospitalized in the emergency service, the user can access to the entire clinical record, such as previous examinations or even medication. In the experience of the interviewee, this is a case of a high-level interconnection between systems that facilitates the daily routine even that occasionally the systems speed slow down because of updates. In detail referred that each nurse has a Personal Digital Assistant (PDA) during the shift that allows healthcare professionals to register more information/indicators supported by the fast data processing on the PDA than desktop computers. The interviewed nurse mentioned that "*it allows to make a nursing record next to the patients that have a bar code associated with their clinical record scanned by the PDA code reader".* Ultimately, the IT department has a close relationship with the healthcare professionals collecting heir feedback to implement new functionalities to improve their productivity and providing on-the-job training when are uploaded new program features.

Hospital IV

This private hospital is characterized by to use of systems of Company III. On the Imageology service, it operates essentially with a specific IS due to the characteristics of the medical exams and clinical record platform that stores the patient´s information and the imageology exam. On this service, there is a reduced number of clicks since the process is simple and intuitive. The healthcare professional interviewed from this unit explained that "*When I do an imageology exam, it is saved in the machine storage and after the verification process, I send it to a specific IS that will send automatically to another program that is used by doctors"*. This communication flow is adapted when occurs updates on the systems. This action forces the creation of an alternative flow to storage the exams resulting in more time consume and extra healthcare providers' support. Finally, was mention the need for more training time to learn new functionalities of the platforms without slowing down the rhythm of the hospital unit.

Hospital V

The hospital has a huge number of Information Systems (IS) with different web services and databases that resulted in lower paper registration. Even though the technologies improved the service, it persists the loss of information since healthcare professionals have to fill manually the records in the IS with their common language which translates in difficulties to examine standardize indicators, such as a specific disease like HIV or COVID-19. As a public hospital, it operates with Company II systems but also with platforms from private suppliers. The purchase department tries to select IS suppliers that can establish a communication flow with the Company II systems, even though they have limited budgets to invest. The financial limitations to invest in expensive equipment and systems do not allow the hospital to expand.

Hospital VI

In the gynaecology service of this hospital, it was described that *SClínico Hospitalar* was insufficient for the needs of that unit. The program allowed the user to write the patient´s therapy in "open fields" which did not permit the data extraction and analysis. Therefore, another EMR came as support to provide a more structured data collection and improved data analysis. According to the interviewed person that operated in this hospital, *"the programs did not migrate automatically the information from one to another if the healthcare professionals had to do it"*.

Hospital VII

The healthcare unit presents a big delay in terms of computerisation development, it still has a high number of paper processes and inadequate informatics systems. Some hospital units have developed their informatic systems based on Microsoft platforms without any level of interoperability with other HIS operating there. Described by an interviewee, "*One of the services had an Access database that was responsible for the patient´s data and the number of beds available management without communicating with the central registration system of the hospital. The central system only received information from the day the patient arrived and when get out of the unit".* The main reason for the development of this homemade solution is the low budget that the public hospital presents to improve the computerisation of processes. As consequence these programs do not communicate with the administrative system of the Hospital and so that there is little patient data in the system but also no security standards to prevent access to private information on these systems. At the time of this research, the hospital had recently installed the *SClínico* that faced difficulties in the implementation process because some private IS suppliers were not prepared to interoperate with the system. The solution found was to establish interoperability standards based on DBLINK with these IS but the hospital continued to operate with the homemade solutions.

Hospital VIII

In this hospital, the department for Complementary Diagnostic and Therapeutic Means has an internal autonomy. Even though the independent management, there isn´t a clear strategy for IS management which results in a high number of IS programs operating and constant purchase of new ones for specific functions instead of a global solution. As consequence is evident the lack of interoperability and low interaction between the HIS, the DBLINK standards are the only used between the Company´s II clinical system and the most used imageology program in the department. This means that a user can access the imageology program from *SClínico* but there is no information transferred to the patient´s clinical record on that EMR which translates in a paper flow to access some specifications needed to do an exam. According to the interviewee, *"The doctor enters the imageology platform to request an exam for the patient which then has to be printed because the information transmitted to the central system is insufficient for the technicians to execute the imageology exam. The number of tasks in this process increases without adding value and creating a materialization flow due to the paper printing".*

4.2 IS supplier's characterization

Company II

According to Health Care Systems Unit Coordinator, " *SONHO and SClínico platforms are implemented in around 90% of public hospitals that benefit from a free service provided"*. The company had a key role in the development of IS in Portugal by creating these two major programs that facilitated the hospital management and reduction of the paper processes on healthcare centres with the computerisation of medical prescriptions and other HIS that allowed to centralize the information at a national level. Even though the contribution to the NHS evolution, some interviewees mentioned that the developing and updating process of the systems is slow, the relationship with some public hospitals is turbulent and the private suppliers evolve faster in the gaps generated in this market. The lack of interface between their systems and the other generates, in some situations, the creation of double patient record which translate in more time-consuming in administrative processes. Another issue related is the fact that some patients do not have an NHS number which can result in each HIS generates is own patient´s process meaning scattered information.

Regarding the operation level of HIS, the members of the company mention that the interoperability with other IS depends on the hospital's conditions and the IS suppliers. The company has two scenarios to establish communication between their systems and the other. In the best scenario, they establish interoperability between programs following the HL7 standards but in some circumstances, they prioritize the DBLINK method that is the easiest and fastest solution for hospitals that are unprepared for the other method. Most of the public hospitals are already computerized and the company strategy is to replace existing programs, but it is still difficult to manage the change among the members of the board, IT Department, and health professionals. To manage the difficulties faced in the hospitals, the company created a strategy when implementing a new IS tool. Starting with an internal analysis of the hospital's technologies, meetings with the hospital stakeholders, create training moments for healthcare professionals and IT department, and then migration of data from the obsolete program to their system. The company has an active presence on the previous week before the hospital initiates the use of the HIS and after that evaluates the program´s performance but always trying to guarantee that the IT department is autonomous on this process.

Company III

As mentioned in Table 4, this company was a key element to Hospital III reach Level 7 of the EMRAM scale. In this healthcare unit, there are some nursing EMRs that are owned by other IS suppliers but they are handled to establish a high level of interoperability that allows full integration with the central registration system even that HIS has distinct database storage. The institution has an internal team that verifies the IT services provided in the hospital and a supportive team on the company office that develops the program and makes the first test to quality there. The HIS is maintained by these teams that support and monitor the database and when the customer wants a new IS or functionality, the company intervenes and delivers to the hospital.

Regarding other hospital facilities, there is a private hospital that has multiple EMRs operating simultaneously but the database is from this company, and when a new patient enters it will be registered on their software. More than that this information appears on the systems of the other suppliers plus the same occurs with the information registered on this specific IS. Also, there are meetings between HIS suppliers and the IT department to find global solutions for the interconnection or discuss the influences that a new project will influence the existing programs. The negative side is that suppliers wrestle to keep secrets about their product´s specifications which can delay the hospital´s progress.

About the public hospitals, the company III has a portfolio of clients such as Hospital II. In this hospital, the company has a program operating at the pharmacy unit that faces difficulties in establishing an interface among various IS since the pharmaceutical technical language is different from the languages used on the other healthcare services. Furthermore, the dimension of the facilities interferes with the contact that the company´s members have with the healthcare professionals and work more closely with the IT department that struggles to maintain an intermediate role between all the IS suppliers. According to the company´s members operating in this hospital, "*only when is implemented new functionalities or a new system, there is a contact with a select number of health professionals that will be trained and follow-up them in the experimental phase"*.

Company IV

The cardiology IS owned by the company is focused on a certain area and has several specifications that other programs cannot solve. Therefore, is regular to establish

interoperability standards with the central registration system of hospitals and machines software related to this area (e.g. ECG machines). The IS is prepared to automatically integrate the clinical exams made on the machines, transfer the billing data to the administrative software, and allow the exam results to be imported. In some situations, the medical staff uses the imageology program, and the information is stored in the cardiology IS but there are also occasions that the user works directly from their system. In both scenarios, the clinical record is done on this company software and then communicated to the hospital central system.

4.3 Information Systems on the hospital context

General Considerations

After each interviewee described their experience with HIS in their professional experience, it was asked the impact that computerisation brought to their routine. The answers were divided into three codes which two are considered disadvantage (Inadaptation of the hospital structure; Complex use and loss time with HIS) and one as an improvement on their workflow (Dematerialization of processes).

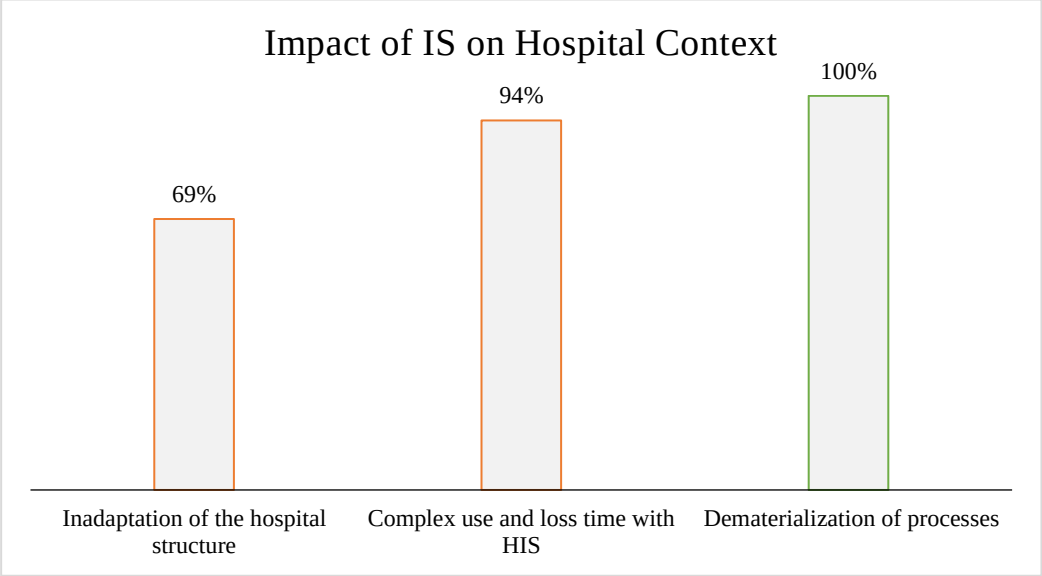

Figure 3. Impact of IS on Hospital Context (Elaborated by the author)

The analysis of Figure 3 concludes that all the interviewed persons consider that HIS implementation resulted in a positive move to the dematerialization of processes in hospitals which can be analysed in-depth in Figure 4. Although the positive side enhanced, 94% of the participants characterized the use of HIS as complex and a cause of lost time in their routine and is even enhanced by 64% that hospital structured is not prepared for the computerisation transformation.

Dematerialization of Processes

Regarding the consequences generated by the Dematerialization of processes (Figure 4), the major advantages pointed by the interviewees were the **increase of information access and an efficient analysis from the data storage** and was also reported the **active support gave to the healthcare professionals when interacting with HIS**. Even though it was not considering

the most significant consequence of the computerisation processes, the reduction of paper flow was referred from 44% of the participants as a positive change in their daily routine.

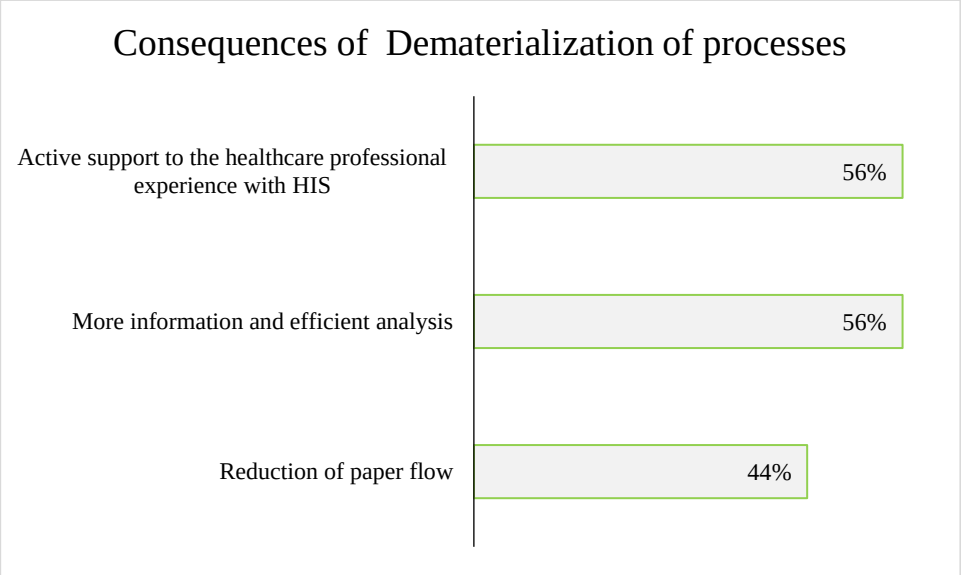

Figure 4. Consequences of Dematerialization of processes (Elaborated by the author)

Active support to the healthcare professionals experience with HIS

Regarding the active support given to the healthcare professionals, it is essential to refer that this code includes the interviewees that referred to the proper formation and training services provided on their hospital, the efficient work relationship established between HIS suppliers, and the hospital's IT departments. In this topic, it is also important to have into consideration the support gave by Company III on the private sector where they have a stable relationship with the other HIS suppliers and the IT department who are well prepared to be intermediate on negotiations processes or on problem-solving. One member of Company II referred that "*some hospitals put the new health professionals into intensive training and when a new IS is implemented especially the private organisations"* which reveals higher support gave by the private organizations. Company IV member also pointed out that " *hospitals with good IT departments obligate the suppliers to adapt their IS dynamic in a way that adapts to the information flow existent there"* which results in better performance of the systems. Despite the previous considerations, it was mentioned one example of a public hospital that provides active support for healthcare professionals. which is the. As mentioned before the Hospital I has a group dedicated on offer the right tools for the formation and training of nurses but the physician interviewed also referred that medical staff receives support when a new program or functionality is implemented.

More information and efficient analysis & Reduction of Paper Flow

The improvement in the information available, more efficient data analyses, and the reduction in paper flow were mentioned for most of the healthcare providers interviewed. They pointed that there is a more detailed and strict record of patient´s clinical data which enables more efficient analysis of the patient´s health condition, facilitates access to hospitals indicators (e.g.: Number of empty beds on service), and reduces the loss of information promoted by the paper flow. According to members of Company I and Company II, IS had an important contribution to this process plus the introduction of digital medication prescription with a significant impact on reduction paper flow in the hospital.

Inadaptation of the Hospital structure

According to Figure 5, 91% of the participants referred that the hospital structure was not adapted to the computerisation process on the daily routines of these services. In a more in-depth analysis, it was verified that the main cause of this problem comes from the **resistance of the healthcare providers** to this transformation on their work routines. Besides, 45% of these eleven interviewees feel that the actual **strategy from the hospital board is ineffective** to manage the workflow generated by IS.

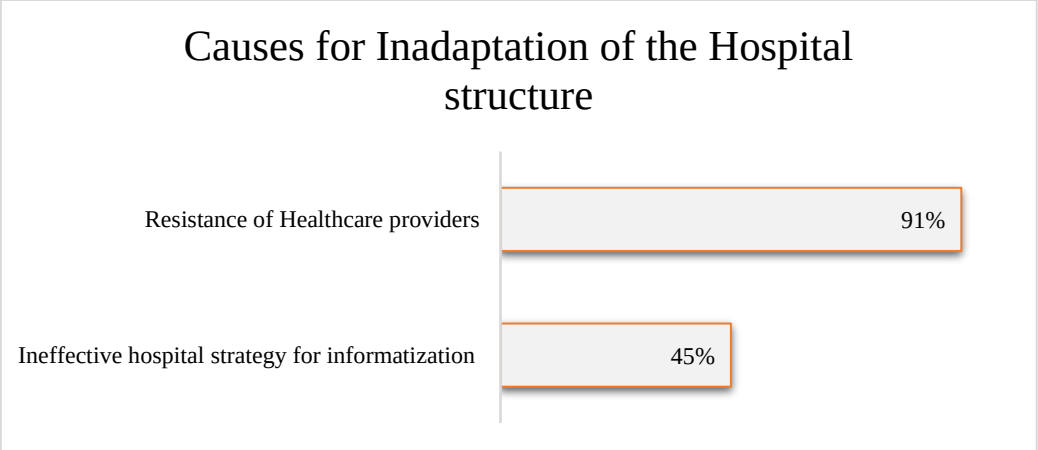

Figure 5. Causes for Inadaptation of the hospital structure (Elaborated by the author)

The resistance of Healthcare providers

This code englobes all the research participants' feedback that reflected the difficulties faced by them on using or accepting the HIS in their daily routine. One of the supplier´s member referred that "*healthcare professionals tend to be resistant to change, so is necessary to drag them among the changing process"*, it demonstrates that is crucial to involve them in the HIS implementation process. This statement is the reflex of the majority of the interviewed that describes difficulties from healthcare providers in adapting to the digital transformation. According to an interviewed person, " *the reason for resistance is that doctors did not study to register information in IS, they studied to take care of the patients This is a trouble since they have to use and register information in a high number of platforms"*. This statement is aligned with was mentioned in other interviews related to the fact that older doctors are the more sceptical professionals on accepting this change since they have more difficulty in using digital equipment and there were not prepared during their entire career to working with these technologies. The doctors interviewed express the difficulty faced by their colleagues and the support that younger medics give to them and on the experience of the physicians from Hospital I there is some medical staff that let incomplete reports on HIS and finish their task using paper. According to a nurse from this hospital, the professionals do not see value in working with HIS due to the overload of tasks to perform and difficulties faced on the use of programs. In an external view of the hospital dynamic, the healthcare senior consultant from Company I characterizes the change management has " *a complex issue in the public sector where the majority of the members are not willing to change due to the comfort level and do not see the change as a common objective in the hospital"*. He also mentioned that *"the older the health professionals, the more resistant they are. But are the administrative workers and nurses that feel more when there is a change process due to IS since at an operation level they interact more with the technology"*.

Ineffective hospital strategy for Computerisation

This code reflects the low-efficient performance from the public hospitals in dealing with the computerisation of the processes focusing on the weak management from the Board and the inefficient IT department role with suppliers. An interviewee pointed out that in public hospitals " *there is no hospital strategy, they have a vast number of IS suppliers and constantly purchasing new systems just for specific functionalities"*. A supplier´s member refers that " *some hospitals have not constituted a local computerisation commission (…), there are*

hospitals that have a lot of processes that are not charted, and then when during the IS implementation they find out that more programs are being used in the services". From the perspective of certain supplier´s members, the IT departments in public hospitals are not prepared to assume the intermediate role between suppliers which is visible in a problem-solving situation where the suppliers must communicate directly to find a solution.

Complex use and loss time with HIS

The main problem identified from the use of IS in the hospital context was the complex use and loss of time generated by these systems on the healthcare provider's procedures. After this feedback, it was investigated the causes for this discomfort and 91% of the persons complain about the **lack of integration between HIS** among healthcare providers, IS suppliers, and external consulting managers. More than this 64% of the feedback answers refer that HIS layout **is not user-friendly and not intuitive** and **insufficient support from the suppliers and IT department from the hospital**. Even though just 24% of interviewee refers that hospitals need investment in IT services, is important to express that their testimony enhanced as a problem faced on the hospital from the public sector.

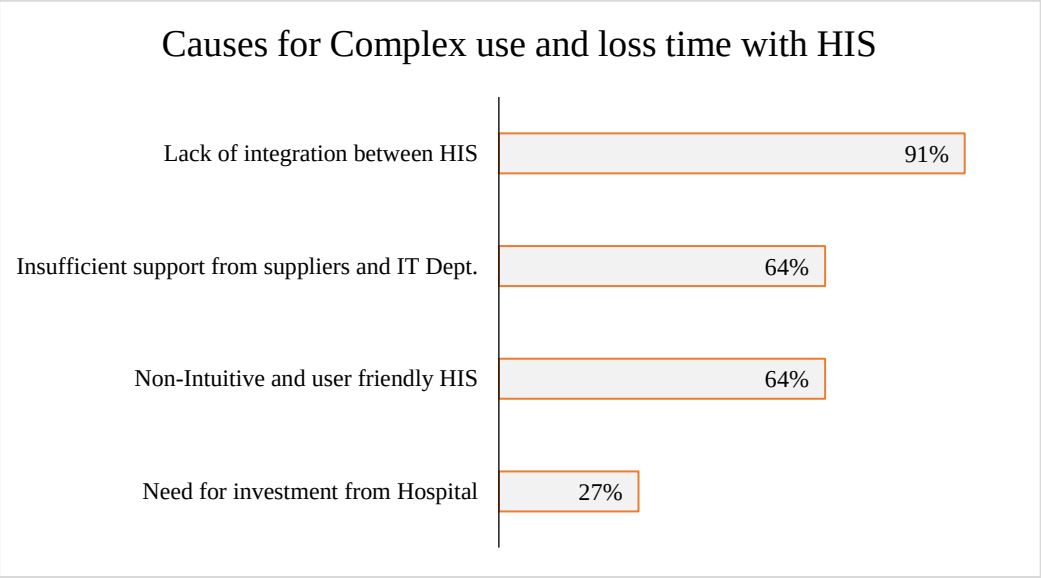

Figure 6. Causes for Complex use and loss time with HIS (Elaborated by the author)

Lack of integration between HIS

This code is mentioned as the main cause of labelling HIS as a complex tool. On the healthcare provider's routine, there is an information system that is the central storage and manages the information flow between the different platforms which in the majority of the public hospital is the *SClínico* from Company II and in Hospital II is EPR that faces the same problems. These programs are described by the interviewees as synonyms of a high number of clicks causing a slower performance of the programs. The healthcare professionals interviewed explained that for simple tasks as schedule an exam they have to do a high number of steps in the platforms. According to a Company´s II member, these situations occur since "*in some systems still occurs a partial integration by DBLINKS because the others IS are not prepared to HL7 standards or our programs did not yet develop mechanisms for a determined hospital section.* Some interviewees explained that in DBLINKS connection, the central registration system seeks information from another HIS by a Webservice since the data is not stored in the program and that means consulting multiple servers in an old-fashioned computer which slows down the process.

Insufficient support from suppliers and IT Department

From the perspective of the external managers of Company I, the hospital relationship with suppliers is difficult especially with Company II since the HIS implementation or a problem-solving process is slow, and both parts have responsibilities on that. From the perspective of the Company´s II members, they struggle to collaborate with some private suppliers who are very reticent in accepting their presence and it complicates find collective. On the other side, healthcare professionals complained about the lack of proper training when it is implemented a new functionality, or a new program is implemented in their unit.

Non-intuitive and user-friendly HIS

The suppliers assumed that the main complaints they receive are related to the difficulties on the usability of the programs, not related to the interaction with other HIS on the system but to the fact that systems are not adapted to their *Modus Operands.* In the words of one of the interviewed doctors, the "*patients complain that the doctor hardly looks at them during a medical appointment*" which is a consequence of not user-friendly layout from the HIS and this same interviewee referred that would be an improvement establish a simple layout like the one present on a smartphone. Additionally, the healthcare professionals that use the *SClínico*

characterized it has a platform with a non-intuitive layout that was a difficulty for users who spent more time interacting with it.

Need for investment from Hospital

Even though this cause was the less expressed on the feedback made by the research participants, it is important to mention the experienced lived of the external manager, the supplier member, and a healthcare provider about this topic. According to them, if the public hospital wants to improve is necessary to invest in more developed machines to collect clinical information from patients, improve the IT supportive hardware and renew the technological park of the institution. However, they identified this problem as a deeper situation since it is related to the low budget that hospitals have for investing in this segment.

Suppliers

Starting with the Supplier's improvements, 13 participants evidenced a set of proposes that were separated into five codes that are focused on the role of the supplier and the IS developed by them.

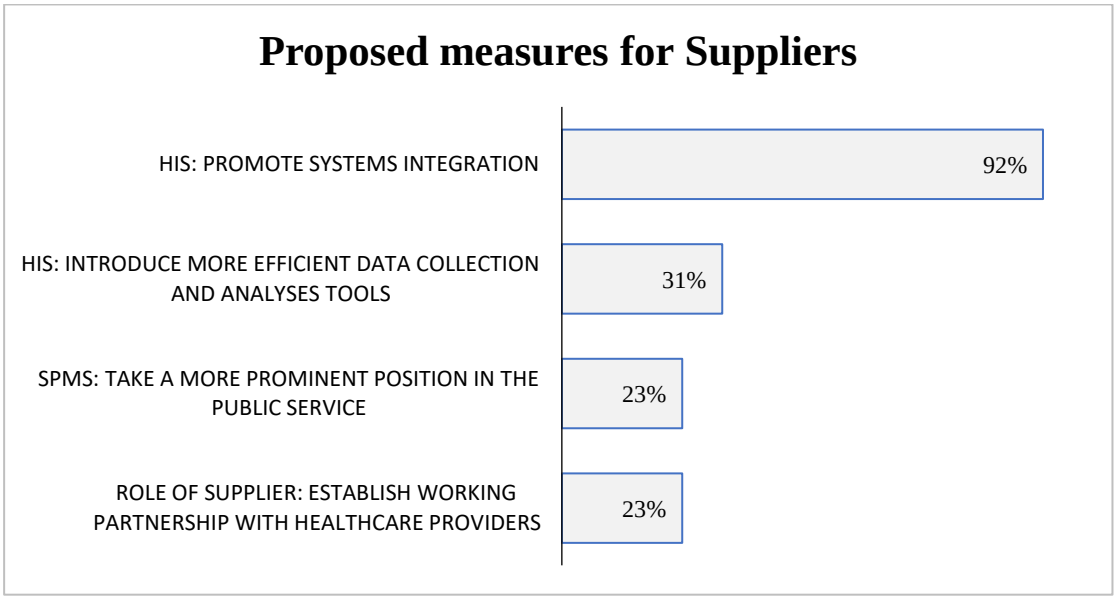

Figure 7. Proposed measures for Suppliers (Elaborated by the author)

Figure 7 reveals that the majority pretends that suppliers invest and focus on guarantee the **Systems Integration** and 31% of this population considers necessary the **introduction of more efficient data collection and analysis tools**. About 23% of the 13-interviewee focused

on the role of the supplier in the hospital context that emphasizes the **establishment of a working partnership with the healthcare providers** and a more **prominent position of Company II in the public service**.

Based on the proposed measures, the following Table has been drawn up:

Role of Supplier: Establish a working partnership with healthcare providers
• Create a work commission with the Supplier´s supportive teams, the hospital´s IT Department, and healthcare providers; • Collect the feedback from the healthcare providers to improve or implement a new HIS to consider the legal normative and the needs of their daily routine;x
SPMS: Take a more prominent position in the public service
• Creation of a certification that identified the private HIS with the standards to interoperate with SPMS programs; • In public hospitals, implement *SClínico* in the Emergency services; • Attribute more authority to SPMS in the hospitals where they have HIS implemented to guarantee the necessary interoperability standards;
HIS: Introduce more efficient data collection and analyses tools
• Creation of BI System: development of paraments, such as number of consultations, nr patients that allow reporting directly to Hospital Board;   o Adapt parameters to the services of each unit; • Data Structuring, artificial intelligence, and machine learning. (Computer able to analyse the information and through the incorporated big data to be accessible to doctor on the decision moment); • Development of a system that allows the healthcare professionals to have their credentials in Windows to access directly to personal information and fewer credentials log-ins. Even agile the number of authorizations for exams/medication orders needed in each program. • Voice recognition for medical records or scheduling appointments;
HIS: Promote Systems Integration
• Centralize information by establishing a common language to enable HIS to communicate: o Promote the use of HL7 language to translate the information of the diverse IS

○ Investment to implement an interface between the SPMS systems and the other IS on the hospital; • Guarantee the information flow between primary care and hospital centers (SPMS Objective) • Reduce the number of platforms operating in the hospital context; • Upgrade the usability and the layout design of the systems;

Table 5.Detailed information on the Measures proposed to HIS Suppliers (Elaborated by the author)

Hospitals Structure

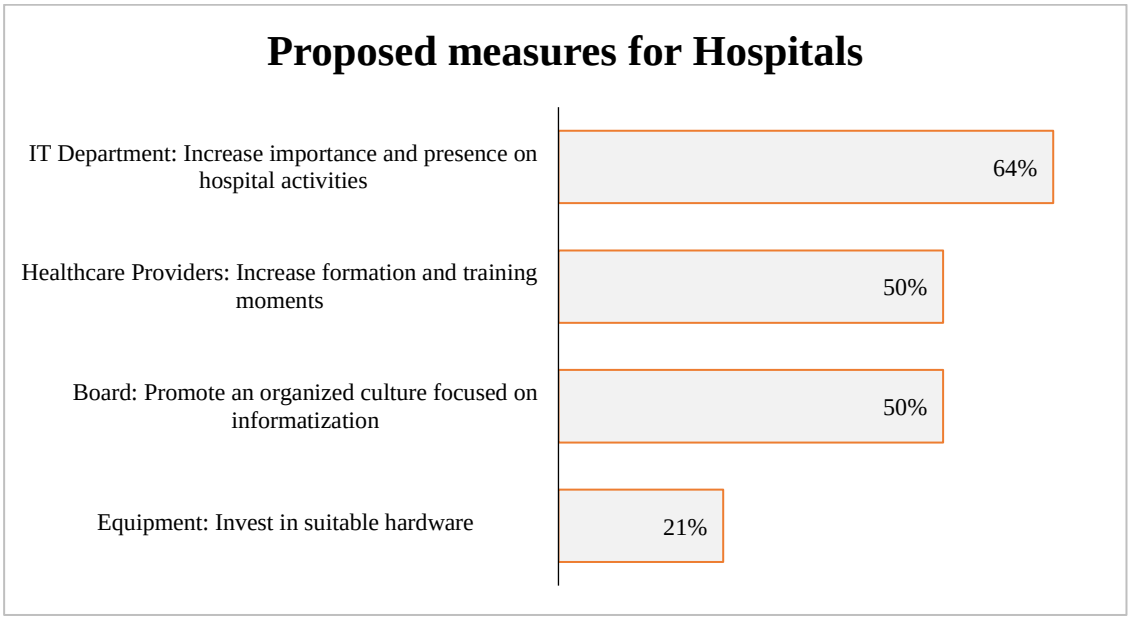

Figure 8. Proposed measures for Hospitals (Elaborated by the author)

Figure 8 presents the four groups of measures that the 14 interviewees referred to as their testimony. From the analysis of the data, it is possible to conclude that majority claim the **increase of importance and presence of the IT Department on the hospital activities**. On the other hand, half of the research participants purpose that **the hospital board must promote an organisational culture focused on computerisation** and the **increase of formation and training moments for healthcare providers.** For last is also pointed the **need for investment in adequate informatic equipment** to provide a more efficient interaction between the medical staff and the systems.

Table 6 describes in detail the measures presented by the research participants:

IT Department: Increase importance and presence of hospital activities

• Investment on more qualified IT workers to an internal department and reduce the acquisition of outsourcing companies;
• Create a global strategy for HIS operating in the hospital services;
• Closer interaction with health professionals:
  o Monitor and collect feedback from their routines;
• Improve the intermediate role with the HIS suppliers:
  o Collect their feedback;
  o Promote an efficient communication channel in problem-solving situations or implementations processes;
• Stimulate meetings between IT Department, Health professionals, and HIS suppliers;

Board: Promote an organized culture focused on computerisation
• Create a more efficient hospital chart who should define the paper of supplier, internal departments, and healthcare providers; • Hospital Overview: Reduce the number of HIS to optimize costs and more efficient IS integration; • Apply Lean Management tools (S5) to improve internal flows and standardize service areas; • Promote the hiring of managers for reorganizing the processes and the quality levels of public hospitals to achieve a national standard   o Or hiring a Management Consultant company to study the process flows to improve the IS integration and apply Lean methods to improve the organisational culture and have an external opinion of the hospital workflow;
Healthcare Providers: Increase formation and training moments
• Promote training with more simplified instructions to teach them how to operate with programs due to their lack of time: o Create tutorials and simple manuals in cloud systems available for healthcare professionals; • Stimulate special formation sessions for older healthcare providers and intensive sessions for new hospital workers; • Creation of Course Units on in Medical and Nurses Faculties:

○ Training in the academic path to promote a close relationship with IT tools; ○ Educate for the importance of clinical records in HIS;
Equipment: Invest in suitable hardware
• Acquire more computers to improve a better interface ratio per health professionals; • PDAs for Nurses that collect the info from patients and automatically communicated to IS; • Development of fingerprint log-in for authorizations;

Table 6 Detailed information on the Measures proposed to Hospital structure (Elaborated by the author)

5. DISCUSSION OF THE RESULTS

In this chapter, it is expected to be answered the research question and after analysing the interviews and their results, it is necessary to understand if they answer the defined sub-questions and the main question of this dissertation.

(1) How do healthcare units are organized to operate with HIS?

Regarding the strategy for HIS in Portuguese hospitals, 69% of the interviewed people mentioned the inadaptation of the hospital structure to deal with IS and 45% consider that the Portuguese hospitals have an ineffective strategy. More than this the research demonstrated that there is a different approach if the entity is public or private. According to the interviews, the public hospitals have a low-efficient strategy due to weak administration management, inefficient IT department performance, and the lack of investment in computer structures. The hospital structure was characterized by having IT departments that are not prepared to play the intermediate role with the suppliers and lack of workgroups for the hospital´s computerisation. On the other hand, there is the Hospital III that reached stage 7 of the EMRAM scale and the Hospital IV as good examples of a successful strategy on HIS that can bring benefits, such as the reduction of patients length of stay *(*van Poelgeest *et al.*, 2017), improvement on the quality of care management and treatments (Stavert-dobson & Risk, 2018). Both entities have a private investment with a high level of integration between the systems supported by Company III. So, is possible to understand that there is a clear strategy from the private hospitals but what about the issues described in the public hospitals?

From the public hospitals mentioned in the interview, only Hospital II did not operate with the clinical information system from MoH. As (Sousa, 2017) pointed there is a complete dependence on the MoH with centralized responsibility for the administrative and healthcare activities processes. The interviewees proved the difficulties existent to establish interconnection between the IS from MoH and the privates EMRs and the lack of a common patient´s identifier (Jardim & Martins, 2016). The sample of public hospitals that were mentioned in this research has different private IS suppliers with different specifications and that means an increase of difficulty to establish interoperability standards with the Company´s I systems. This is in agreement with the (de Almeida Simoes *et al.*, 2017) conclusions that point to the diversity of HIT systems across the Portuguese hospitals and the problems inherent to the healthcare data transmission between the systems and their data storage. The interviewees indicated that public hospitals need to improve the strategy for monitor and

support IS implementation by involving the healthcare providers in this process and improve the IT department performance.

It is then possible to conclude that there is a clear gap in the integration of HIS between the public and private hospitals exposed in this research. This conclusion has into consideration the difference in the budgets, strategy, and number of suppliers that the hospitals have. However, it should be done broader research to prove that is a reality in the Portuguese national health system.

(2) How IS and their intercommunication influences the healthcare routines?

The healthcare routines changed with the introduction of IS, all the persons interviewed considered that implementation of IS resulted in the dematerialization of processes. Most of the interviewed persons pointed out that as consequence there was an increase of information access and an efficiency analysis from the data storage plus it was also mentioned the reduction of paper flow in the healthcare routines. This is in agreement with the authors (Reza *et al*., 2020) and (Kruse *et al*., 2018) that mentioned the increase in the quality of data management, reduction in the paper process, and more available information to the public health policies and research.

In the literature review, was pointed out that a successful implementation of EHR increases the productivity in hospitals with more efficient procedures and processes. However, the testimony from the interviewees verifies that does not depend only on the implementation process. About 94% of the sample interviewed considers the use of this technology is complex and a loss of time and 91% consider that the lack of interoperability between health information systems is the cause. (Samal *et al*., 2016) also mentioned that the lack of communication between different IS caused a loss of time in the processes of the health providers. Additionally, the members of the hospital and supplier´s company pointed the fact the HIS is not intuitive and user-friendly without being adapted to the healthcare professionals' routines. Hence, a poor user interface design forces the healthcare professional to switch mental models to interact with the EHR which enhances potential errors in data input and comprehension (Sittig *et al*., 2020).

Taking into consideration the (da Silva, 2017) conclusions that mention *SClínico* has a HIS that allows the optimization of clinical information, contribute to support the user´s experience, and provide more effective and efficient performance. The data collected is not in total agreement with these conclusions since the healthcare professionals and suppliers that worked

with this platform pointed out difficulties in the use. The reason for this negative feedback is the lack of interoperability between this central registration system and the other EMRs on the hospitals as mentioned by (Jardim & Martins, 2016) as the major difficulty faced among the IS operating in Portuguese healthcare units. Further, this research proves that the interoperability is conditioned by the type of standards defined between the information systems and that the hospitals present in this study use DBLINK or HL7 standards. The hospital that operates based on HL7 standards present positive feedback and demonstrates the potential of IS and their intercommunication. On the other hand, the DBLINK is seen as a solution that facilitates the communication with platforms that are not prepared to a higher level of interoperability and the members of *SClínico* company justified that there are hospitals with a high number of IS from different suppliers which complicate the communication standardization plus some programs do not support the HL7 standards. Therefore, it would be important to make a detailed analysis of the impact on the efficiency of healthcare routines based on interoperability standards.

(3) Which are the key elements to achieve interoperability between HIS?

Healthcare professionals are a key element to have a successful implementation of HIS and the interoperability between them. They are the main users of the EMRs (Furukawa & Pollack, 2020), and a successful HIS implementation will result in healthcare professionals more satisfied (Davis, 2019). The interviews converge for this conclusion since 91% of the research sample considers the resistance of healthcare providers as a cause for the difficulty faced by the hospitals to achieve the computerisations of processes. In detail, this resistance was pointed to be more frequent in older healthcare providers, especially physicians, due to the short time they interact with this technology plus the lack of support given for their training. Certain testimonies mentioned that medical staff who are not adapted to the HIS produce incomplete reports or receive extra support from colleagues to perform the tasks. According to half of the interviewed persons, is necessary to increase formation and training moments for the platform´s users highlighting the older healthcare professionals and the new workers that arrive at the hospital.

Beyond the resistance of healthcare professionals due to the lack of training, there is a crucial moment to have them cooperating in the HIS implementation. During the interviews, it was pointed the changing process has a decisive moment to the success of a new system and therefore necessary to evolve the healthcare providers on this process. Hence, the hospital

board must have the capability of creating motivation and involve employees during the change process. (Marto, 2017). The data collected shows that is more than that as 64% of interviewed persons mentioned that is necessary an increase of the presence of the IT department and HIS suppliers in the hospital activities since their current support is insufficient. The example of hospital III and the European hospitals mentioned by (Salomi & Maciel, 2017) demonstrate that the EMRAM scale from HIMSS can be a support to guarantee that Portuguese hospitals establish a strategy oriented to the integration and intercommunication between the HIS. To conclude the key element can be summarized as the promotion of an organisational culture focused on the technological development of health services.

Finally, the main question of this dissertation:

What is the influence that the interoperability between information systems generates in healthcare?

The interviewed people were unanimous that health information systems contributed to the dematerialization of processes but 91% considered that the lack of interoperability between IS has a negative impact on the healthcare professionals' routines. Most of the hospitals presented in this research operated with a DBLINK connection between HIS that according to the Company II members is due to the difficulty of some IS to connect by HL7 standards to the *SClínico.*

According to the data collected and Samal (2016), the use of HIS is complex and translates in a loss of time due to the lack of intercommunication between the systems. It was recognized during the interviews that users complaint about the high number of clicks to execute their digital tasks and mentioned that HIS is not intuitive and user-friendly. Due to the poor interface of HIS, it hinders the healthcare professionals' daily routine and pointed by Sittig (2020) enhances potential errors. These errors can be medication and diagnosis lapses (Poly *et al*., 2018) which can potential harm or even lead to the death of the patient (Zhou et al., 2018) and be emotionally devastating to the healthcare professional (Mota, D; Moreira de Sousa, A; Ribeiro, 2020). The interview statements are also in concordance with (Vieira, 2018) since the healthcare providers especially nurses that operate with *SClínico* have the perception of slowness navigation and unfriendly structure with a high number of steps. The fact nurses are the healthcare providers that have the worst feedback over the HIS use is due to the time spent executing their daily tasks in *SClínico* and other EHRs (Bailas, 2016).

The healthcare providers create some resistance and do not see value in working with HIS since they have an overload of tasks to perform in these systems and face difficulties when using it. The younger physicians interviewed also pointed out that the difficulty in adapting to HIS result in older colleagues making incomplete reports on HIS and finish their reports in a paper. Taking into consideration the analysis of Aceto (2018) and this data, it is possible to point that the reduced technological skills of healthcare providers aligned with the lack of interoperability standards between the HIS contribute to the complex use of the healthcare platforms.

6. CONCLUSIONS

This research main purpose was to study the influence of the lack of interoperability between information systems in healthcare services. In detail, to identify the level of interoperability existent in the Portuguese hospitals, the key aspects to establish interconnection between Health Information Systems and understand the influence that it has in the healthcare professional´s routine.

Regarding the influence of the lack of interoperability between IS, the research study concluded that it translates into a complex use of the HIS with a high number of clicks and slower navigation to execute their tasks. Therefore, it has a negative impact on the healthcare professionals' routine due to the loss of time to execute their daily tasks using multiple IS. The analysis of the literature review also showed that the lack of interoperability can generate errors in data inputs and comprehension (Sittig *et al*., 2020). An error in this circumstances can be the cause of a minor error like a duplicated blood test to an incorrect or delayed treatment (Coiera *et al.*, 2016) or even a medication error (Poly *et al*., 2018) that extend from an injury to a potential death of the patient.

The Portuguese hospitals explored in this investigation demonstrated a difference between the public and private strategy to support IS and available resources to expand their technological tools. There is an inadaptation of most public hospital structures to operate with HIS aligned with an ineffective strategy for computerisation and low budgets to invest in technology. They tend to have a high number of IS suppliers which difficulties establishing interconnection with the central medical records which generate the complex use of HIS. On the other hand, private hospitals have a higher level of integration between the systems and invest more in IT structures and equipment to guarantee better performance from the systems.

The interviewees pointed out some proposals to improve the current situation of the Portuguese healthcare context. In the hospital domain, it was mentioned the need of establishing working groups with healthcare professionals to improve the HIS plus the increase of importance and support of IT departments in the healthcare activities. The research participant also proposed that the Board should promote an organisational culture focused on the continuous improvement of IS. About the IS suppliers, it was proposed that SPMS should have a more prominent position in the public service and more influence in the national strategy decisions. Additionally, is suggested that IS suppliers implement new and more efficient tools to collect

and analyse patient´s data. Even though these suggestions were not the main and secondary objectives of this research, it is included to be subject to future investigation.

Concerning the healthcare professionals that are the main users of the health information systems, it was proved that have a key role in the efficiency in the implementation and performance of this technology. This investigation also concluded that resistance of healthcare providers is one of the causes of the difficulty faced by hospitals to implement HIS which can be justified by the inexperience and lack of training of older people to operate with this equipment. Therefore, is necessary these healthcare institutions stimulate an organisational culture oriented to HIS and prepare the internal structure to support this change.

It is important to understand that the interoperability does not depend exclusively on the standards used to interconnect the information systems. Hospital structure must be prepared for this change in the healthcare routine which includes the organisational culture, trained professionals to work with these applications, and a suitable technological park. In addition, suppliers need to cooperate closely with the hospitals to guarantee more functional systems and reduce the loss of time executing tasks.

This investigation makes some contributions at a theoretical level by reinforcing the arguments of several authors and exposes new topics to be studied. The data collect exposed the main issues related to the lack of interoperability, such as the loss of time, the complex use of HIS, the high number of programs operating in a hospital, and the importance of the stable relationship between healthcare professionals and hospitals. These topics were mentioned by previous authors in other contexts and this research concludes that in the Portuguese context there are the same issues. Once that it was difficult to search for recent and updated information about the Portuguese context about this subject, it is recommended a depth study about this content and analyse the impact of the high dependence on the Ministry of Health to improve technologically the public hospitals.

Finally, the research was developed with the aim of being analysed and discussed by Hospital Board, healthcare professionals, HIS suppliers, and members of the Ministry of Health. Even though it has a small sample, the characterization of the Portuguese hospitals in this dissertation is a reality faced in other healthcare centres and so that it serves as a reminder for the hospital structures. The study focused especially on the public sector due to the difficulties it faces to adapt to the technology revolution and it is expected that these conclusions stimulate a quantitative investigation of the impact that HIT had on the hospital´s management and

routines to facilitate the creation of a national and a local strategic plan for the healthcare service.

7. LIMITATIONS

The study was limited essentially to the COVID-19 pandemic that did not allow physical observation in hospitals and limited the range of persons to participate in this research. Even though the sample allowed to create the previous conclusions and exposed new issues to be explored, it does not allow to establish general conclusions for the Portuguese national health system.

About the data collected, it is reliably since the interview people were from the different groups involved in the implementation, monitoring, and control of Health Information Systems. In the data analysis process, it was selected the information that was important to the research objectives and had validity for this purpose. Even though the interviews provided relevant information for the research, it would have enriched the study the inclusion of direct observations in the hospital context.

Furthermore, there are few research studies developed in Portugal about this topic and the main support was based on international authors. This demonstrates that is necessary to promote more investigations about information systems in the hospital context, especially in a country where the Ministry of Health has an organisation dedicated to supporting this transformation in the healthcare system.

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9. APPENDICES

9.1 Interview Guide

Interview Guide for Members of Company I

1. Were you involved or are you aware of the process of implementing and/ or monitoring an Information System in a Healthcare Unit?
2. About this same process, which Information Systems (IS) were operating in this Healthcare Unit?
3. What is the change that IS brought to the clinical routines/processes of health professionals in this unit?
4. Regarding the performance of the IS in these processes, how do you characterize the interaction between them?
5. What feedback do you have, or elements involved in interacting with these IS?
6. What would be the recommendations/measures to improve the IS interaction in this Healthcare Unit?

Interview Guide for Members of Company III and Company IV

1. What is the company's role in the implementation and monitoring of Information Systems (IS) in hospital units?
2. In the hospital units where you cooperate/cooperated, how do you characterize the existing interaction between the IS?
3. How do you describe the relationship between the company's services and the various services in hospitals?
4. What are your suggestions for improving the interaction between IS and hospital services?

Interview Guide for Members of Company II

1. Were you involved or are you aware of the process of implementing and/ or monitoring an Information System in a Healthcare Unit?
2. How does it characterize the existing collaboration between the services of your company and the IS of public hospital units?

3. How do you characterize the role of our company in improving the flow of information between IS in the National Health Service?

4. What would be your suggestions for improving the experience of IS in the National Health System?

Interview Guide for healthcare professionals:

1. In your clinical service, which IS do you interact with to perform your tasks? What are their main tasks?
2. Regarding the performance of the IS in these processes, is there an exchange of information between them or is it necessary to operate with several systems simultaneously?
3. How do you characterize the role of IS in the performance of your tasks and the health professionals you work with?
4. What are your suggestions for improving the experience you have with the computer systems of your clinical service?