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**How to improve Healthcare outcomes through interoperability - a further step
into Health digitalization**

Ricardo Jorge Cabrita Gaspar

Master in Business Administration

Advisors:

Professor Generosa do Nascimento, PhD, ISCTE – Instituto Universitário de Lisboa

Professor Filipa Fixe, PhD, Supervisor Board Member at EITHEALTH - Innostars

Outubro 2023



**BUSINESS
SCHOOL**

Management

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Inscription

To my wife, Rosário, and my daughter, Leonor, my strength and inspiration to keep pushing myself further.

“Gosto daquilo que me desafia. O fácil nunca me interessou. Já o obviamente impossível sempre me atraiu – e muito.”

Clarice Lispector

Acknowledgement

A master thesis is a long and hard road, full of ups and downs. But, like any trip, it doesn't have to be done alone. This thesis was a big challenge that made me push myself, but it is in the face of adversity that we strengthen and reinvent ourselves. I started humble and inexperienced but finished healthier and stronger. Alongside me, many were those who followed my journey that I would like to thank for everything they did for me.

First, I would like to thank my advisor, Professor Generosa do Nascimento, for all her support and help. Always humble and patient to listen to my problems, to keep me focused and motivated.

I want to thank my co-advisor, Professor Filipa Fixe, for inspiring me and help me explore a subject that made me get out of my comfort zone and expand my knowledge and perspective. Always ready to support and advise me in this long journey.

I want to thank ISCTE for welcoming me and accompanying me in this journey. It is an excellent college that made me grow and enriched me.

I want to thank my wife Rosário and my daughter Leonor for the unconditional love and support. Always with me in my best and worst moments to warm my heart.

To my family, for always supporting my personal projects and wishes, for never letting me down when I most needed and for all the love and kindness.

I want to thank my friends, for all the jokes and pranks that made me laugh and cheer up when the day seemed irredeemable.

Resumo

Nos cuidados de saúde primários em Portugal, os exames solicitados pelos médicos de família não são introduzidos automaticamente no registo de saúde eletrónico do doente (RSE) – existindo apenas alguns pilotos a decorrer com a integração direta dos valores/relatórios na ficha clínica do doente –, implicando um grande dispendio do tempo destes para introduzi-los no sistema.

A revisão da literatura revelou dados bastantes significativos relativamente à perda de tempo que os médicos enfrentam devido aos sistemas informáticos. Embora não seja o único, a pressão que os sistemas informáticos exercem sobre os médicos é um factor que contribui para o desgaste, frustração e cansaço destes, podendo levar a diferentes consequências, nomeadamente, reforma antecipada, depressão e problemas conjugais e pessoais.

Neste sentido, decidiu-se perceber de que modo os sistemas de informação na saúde poderiam ser melhorados para colmatar este flagelo, optando-se por estudar a interoperabilidade semântica.

De modo a comparar com os dados internacionais e a obter dados concretos sobre interoperabilidade, foram entrevistados 10 médicos e 2 profissionais da área da informática médica. Os resultados dos médicos foram consistentes com os dados internacionais. O tempo perdido e o desgaste causado pelos sistemas informáticos foram significativos. As entrevistas com os peritos em informática médica foram bastante claras relativamente à relevância da terminologia SNOMED e do seu impacto na interoperabilidade semântica.

A importância da semântica foi, aqui, revelada, incluindo a obtenção de dados de confiança e com maior valor, tirar partido dos sistemas de informação e a melhoria da interoperabilidade e dos resultados em saúde.

Palavras-chave: Registo de Saúde Electrónico, *Burnout*, Interoperabilidade, Semântica.

Classificação JEL: H51, I10, I18

Abstract

In primary healthcare in Portugal, the tests requested by GP's are not automatically entered into the patient's electronic health record (EHR) - with only a few ongoing pilots integrating test values/reports directly into the patient's medical record - resulting in a significant expenditure of their time to input them into the system.

A literature review revealed quite significant data regarding the time doctors lose due to information systems. Although it is not the only factor, the pressure exerted by information systems on doctors is a factor contributing to their exhaustion, frustration, and fatigue, which can lead to various consequences, including early retirement, depression, and personal and marital problems.

In this context, it was decided to understand how healthcare information systems could be improved to address this issue, choosing to study semantic interoperability.

To compare with international data and obtain concrete information on interoperability, 10 doctors and 2 professionals in the field of medical informatics were interviewed. The results from doctors were consistent with international data. The time lost and the wear and tear caused by information systems were significant. Interviews with experts in medical informatics were quite clear regarding the relevance of SNOMED terminology and its impact on semantic interoperability.

The importance of semantics was revealed here, including obtaining reliable and valuable data, leveraging information systems, and improving interoperability and healthcare outcomes.

Keywords: Electronic Health Records, Burnout, Interoperability, Semantic.

JEL classification: H51, I10, I18

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Abbreviations Index

ADMS – the Asset Description Metadata Schema.

AHRQ – Agency for Healthcare Research and Quality.

AMA – American Medical Association.

APA – American Psychiatric Association.

ATC – Anatomical Therapeutic Chemical.

CEO – Chief Executive Office.

CMA – Canadian Medical Association.

COVID-19 – Coronavirus Disease 2019.

CPAL – Catálogo Português de Análises de Laboratório.

CPT – Current Procedural Terminology.

CSP – Cuidados de Saúde Primários.

DIF(s) – Domain-specific Interoperability Frameworks.

DSM-5 – Diagnostic and Statistical Manual of Mental Disorders, 5th edition.

FACCT – Foundation for Accountability.

EC – European Commission.

EIF – European Interoperability Framework.

EIRA – The Interoperability Action Plan and the European interoperability architecture.

EHR – Electronic Health Record(s).

EML – Election Markup Language.

EMR – Electronic Medical Record.

EPR – Electronic Patient Record.

EU – European Union.

FHIR – Fast Healthcare Interoperability Resources.

GO – General Objective.

GP – General Practitioner (also known as, Family Medicine Practitioner).

HIT – Health Information Technologies.

HL7 – Health Level 7.

HL7-FHIR – Health Level 7 - Fast Healthcare Interoperability Resources.

ICD-10 – International Classification of Diseases, version 10.

ICD-11 – International Classification of Diseases, version 11.

ICPC-2 – International Classification of Primary Care, 2nd edition.

ICT – Information and Communication Technologies.

IEP – Information Exchange Package.

INFARMED – Instituto Nacional da Farmácia e do Medicamento.

ISA – Interoperability Solutions for European Public Administration.

ISO – International Organization for Standardization.

IT – Information technology.

LOINC – Logical Observation Identifiers Names and Codes.

MBI - Maslach Burnout Inventory.

MedRA – Medical Dictionary for Regulatory Activities.

MRI – Magnetic Resonance Imaging.

NHS – National Health Service.

NIEM – National Information Exchange Model.

NIF(s) - National Interoperability Frameworks.

NIST – National Institute of Standards and Technology.

NLM – National Library of Medicine.

OASIS – The Organization for the Advancement of Structured Information Standards.

ONC – The Office of the National Coordinator for Health Information Technology.

PACS – Picture Archiving and Communication System.

PEM – Prescrição Eletrónica do Medicamento.

RadLex – Radiology Lexicon.

RSE – Registo de Saúde Eletrónico.

RSNA – Radiological Society of North America.

RxNorm – Medical prescription normalized medical prescription.

SPMS – Serviços Partilhados do Ministério da Saúde.

SNOMED CT – Systemized Nomenclature of Medicine – Clinical Terms.

SNS – Serviço Nacional de Saúde.

SO – Specific Objectives.

TC – Computurized Tomography.

ULS – Unidade Local de Saúde.

URAP – Unidade de Recursos Assistenciais Partilhados.

USA – United States of America.

WHO – World Health Organization.

WONCA – World Organization of Family Doctors.

Introduction

In Portugal, most doctors in the National Health Service (NHS; in Portuguese, Serviço Nacional de Saúde – SNS), including Primary and Secondary Healthcare Sectors (in Portuguese, Cuidados de Saúde Primários e Secundários) works with SClínico (despite the existence of other software like MedicineOne and Glintt, Sclinico is, by far, the most used). SClínico is the program where each doctor register, in his daily routine, the patient's clinical information. This means that a Family Medicine/General Practitioner (GP) works with the Primary Healthcare Sclinico (in Portuguese, SClínico CSP – Cuidados de Saúde Primários) while a Secondary Healthcare practitioner (hospital speciality physician) works with the Hospital's SClínico (in Portuguese, Sclinico Hospitalar). Each one of these programs is connected with RSE (Portuguese acronym for Registo Eletrónico de Saúde), which is the program that gathers all the clinical history and information produced by public healthcare entities and foresees, in the future, the collection of all clinical data from the public, private and third sectors. In other words, RSE is the patient's electronic health record (EHR). That link between SClínico and RSE means that any physician in SNS can access RSE (or the patient's EHR) through Sclinico, allowing him to consult all the necessary medical information for his clinical practice. In greater detail and as an example, if a GP needs to know the new updates about his patient's latest appointment at the hospital with his Cardiologist, he consults RSE through Sclinico CSP and can see all the new information that the Cardiologist registered (like clinical status, medication, imaging and/or laboratory tests results, etc.).

Nonetheless, the interoperability among healthcare systems is not homogenous neither perfect. For instance, the majority of exams/tests requested by a hospital physician is done in the hospital. This means that if the physician requests, for example, a computerized tomography (TC) for his patient, the latest has to go to the imaging room service in that hospital to do the imaging test and then the TC scan result/report is uploaded into PACS (Picture Archiving and Communication System), a software used for archiving imaging tests results. The same happens with laboratory tests, which are uploaded into a software for archiving and sharing laboratory results (as, for example, Clinidata® software, one of the most common software used in Portuguese hospitals). These results can be consulted by any physician in the Hospital. Even a GP or a physician from another hospital can consult those tests results through RSE. However, if a patient has to do a specific exam that it isn't available in the hospital as, for example, a Magnetic Resonance Imaging (MRI), and has to go to a Healthcare service outside the NHS (like a private imaging service), the result of that MRI will not be available in the patient's EHR, since there is no interoperability between RSE and private sector software's. So, the result is delivered in paper to the physician who requested the MRI, which leads, among other problems, to an increased risk of misplacement and loss of the results and can generate privacy police issues. This is the reality

for most of imaging and laboratory tests requested by GPs in the Primary Healthcare Service. Most tests must be done in the private sector, which means that patients have to deliver their tests results to their GP in paper since, as mentioned before, there is no interoperability between RSE (patient's EHR available in SNS) and private sectors systems. However, in some specific cases, like in ULS (Portuguese acronym for Unidade Local de Saúde, a structural organization with more collaboration between primary healthcare centers and the reference Hospital), some exams requested by GPs can be done in the Hospital and the results are shared with the primary healthcare centers. Still, this is not the case for the majority of primary healthcare centers. This means that tests results are not uploaded automatically into patient's EHR. Thus, to maintain a documentation and registry of all patients' clinical data, GP's must transcribe every imaging and laboratory tests results into SClínico CSP, to making it available in RSE for future consultation by any physician attending the patients. In other words, to keep a patient's EHR updated, GP's must spend time during the appointment or after-hours transcribing the tests results. And the fact is that, in the Primary Healthcare Sector, there is a large volume of complementary diagnostic exams (laboratory and imaging tests) that are requested in the daily routine of a GP, which means that a large amount of time is lost in this process of transcribing the tests results and reports. Still in regard of the time consumption of tests results transcription, on the 17th day of September of 2019, it was released a Portuguese Decree-law by the Portuguese legally responsible entity (in Portuguese, Diário da República) that establishes the standard time of medical appointments by specialty (Ordem dos Médicos, 2019). In this document, it is described that, for Family Medicine (or GP) specialty, there is an expected time of 5 to 15 minutes for the evaluation of previously requested auxiliary diagnostic exams without the patient's presence. This is apart from face-to-face physician-patient appointment. That work multiplied by all tests from all patients means that the process of evaluating and transcribing all patient's tests results and reports in a single workday significantly impacts the 20 minutes appointments' schedules, representing a significant extension of the appointments' time or after-hours' time.

In matter of fact, this is such an important subject to address that, during the preparation of this dissertation, SPMS (Portuguese acronym for Serviços Partilhados do Ministério da Saúde, the public entity responsible for, among other duties, the provision of shared services regarding information and communication systems and technologies) was, and still is, working in solutions to improve EHR. This includes some interoperability technical specifications to standardize the communication between health information systems, independently of its origin (SNS or private sector). These interoperability specifications include the use of HL7-FHIR and of SNOMED-CT standards (Serviços Partilhados do Ministério da Saúde, 2023). This is a project with the aim of working on Digital Health Transition.

Clinical data is a vital asset that should be maintained, protected and securely shared. Clinical data is crucial to provide patients the best health care and produce the best medical evidence and,

consequently, improve healthcare quality and delivery. That is why it is so important to preserve and maintain health data. So, since there's a jeopardized interoperability between health systems, it becomes crucial to manually register clinical data, despite being a time-consuming process that impairs physicians' efficiency and productivity. Otherwise, there is no archiving and tracking of these important clinical data. In matter of fact, empirically, some possible problems that can arise from this lack of interoperability between systems (leading to the need of transcribing tests reports and results) include: 1. extension of the appointment time; 2. loss of productivity; 3. Increased risk of errors; 4. Ecological problems – since all of the tests results and reports are printed and delivered in paper to the GP; 5. Duplication of exams – since there is a lack of interoperability between systems, a great amount of tests, especially those that are done in the private sector, are not uploaded directly into RSE, leading to misinformation between physicians attending the patient (physicians are not aware of the exams requested by each other, leading to an unnecessary duplication of tests); 6. Risk of harm and side effects – since there is a greater risk of duplication of tests, sometimes it means that the patient is submitted to higher doses of radiation (for example); 7. Risk of privacy policy issues – if the patient has to bring the tests results in paper to his physician, there is a risk of misplacement, exchange of reports, etc.; 8. Loss of healthcare delivery quality; and 9. Negative impact on physician-patient relationship.

Then, it becomes clear that the lack of interoperability between systems in Healthcare Services, more specifically between the patient's EHR and laboratory and imaging sectors outside SNS, creates an important management problem. Indeed, organizational, technical and logistical issues are as important as clinical practice to improve healthcare's quality, delivery and productivity. This fact makes interoperability such an important objective to achieve.

Furthermore, according to the EU 2016/679 European Parliament and Council's Regulation concerning the protection of natural persons regarding the processing of personal data and the free movement of these data and which repeals Directive 95/46/EC (General Regulation on the Data Protection), "those responsible for data processing should be encouraged to develop interoperable formats that allow data portability" (Parlamento Europeu e o Conselho da União Europeia, 2016).

After some research, it became clear that interoperability is a vast topic with many possible pathways for improvements. Semantic interoperability is one of interoperability's layers that it is still new and with a great potential for exploration and improvement. So, this dissertation arises as a problem-driven study with the purpose to give some solutions to this organizational problem using the management scope. The aim is to clarify the Portuguese reality of Primary Healthcare Sector regarding semantic interoperability, although a review of interoperability in general is considered. Many questions arise, namely, what is interoperability? What is Portuguese GPs' perception about interoperability and what is their experience with current available systems? What are the practical and effective consequences of lack of interoperability? Do GP's experience difficulties associated with

impaired interoperability? If so, what kind of difficulties do GP's experience in their daily routine? What is healthcare systems experts' perception about interoperability? What kind of solutions can be done or are in motion to improve systems' semantic interoperability?

So, it is in this context that this dissertation's general objective (GO) is to identify the main issues regarding semantic interoperability. In addition, specific objectives (SO) were also defined and include the analyse of international and national practices that improve patients' clinical data access and record (SO1), the identification of Family Medicine doctors' needs (SO2) and the offer of a solution to semantic interoperability (SO3).

This work was developed with the following structure: chapter 1 is the literature review which is divided into 4 subchapters. Subchapter 1 is meant for explaining electronic health records, its definition, characteristics, limitations, advantages and disadvantages, its impact on efficiency, productivity and communication and the associated burden; subchapter 2 reviews, in greater detail, the literature concerning the association between electronic health records, lack of interoperability and providers' Burnout; subchapter 3 is dedicated to possible solutions mentioned in the literature; and subchapter 4 is specifically dedicated to interoperability, its definition, its layers, Europe's work and solutions to improve interoperability and data portability, ending with some more detailed information about semantic interoperability. Chapter 2 includes information about the research methods used for the development of this work. Chapter 3 is destined for the diagnosis, findings, results, and analysis while Chapter 4 includes the conclusion. At the end of this work, all the references used for the development of this dissertation and some appendices are included.

Chapter 1: Literature Review

1.1. Electronic Health Records

To improve Healthcare delivery, it is crucial to take advantage from information management (Chassin & Galvin, 1998). According to the National Institute of Standards and Technology (NIST), having access to complete patient health information is fundamental to reduce health costs, to decrease medical errors and to increase clinical care (National Institute of Standards and Technology, n.d.). However, management of information based on paper has limitations (Chaudhry et al., 2006; Ornstein et al., 1992). That is why, according to many studies, it is considered that Health Information Technologies (HIT), where Electronic Health Records (EHRs) are included, are fundamental to revolutionize the Healthcare industry (Institute of Medicine, 2000; Institute of Medicine, 2001; Thompson & Brailer, 2004; Asch et al., 2004; Epstein et al., 2004; Smith, 2004; FACCT: Foundation for Accountability, 2003), since it has shown benefits related to the improvement of Healthcare's quality (Chaudhry et al., 2006).

But, what are EHRs? EHRs are digitalized clinical data supported and held by health information systems (Black et al., 2011) and, since the advent of this technology, many terms have been used to represent its concept (Hoerbst & Ammenwerth, 2010). Nowadays, the most common and used name is "Electronic Health Record" (EHR) but it is important to be aware of the existence of the other terms (Hoerbst & Ammenwerth, 2010).

The International Organization for Standardization (ISO) defines "Electronic Medical Record" (EMR) as an "electronic record of an individual in a physician's office or clinic, which is typically in one setting and is provider-centric" while "Electronic Patient Record" (EPR) is an "electronic record of an individual in a hospital or health care facility, which is typically in one organization and is facility-centric" (International Organization for Standardization, 2012).

So, according to ISO, EHR is defined as "Information relevant to the wellness, health and healthcare of an individual, in computer-processable form and represented according to a standardized information model, or the longitudinal electronic record of an individual that contains or virtually interlines to data in multiple EMRs and EPRs, which is to be shared and/or interoperable across healthcare settings and is patient-centric" (International Organization for Standardization, 2012).

However, there are other definitions of EHRs. The US' National Institute of Standards and Technology (NIST) defines EHR as "a longitudinal collection of patient-centric health care information available across providers, care settings, and time. It is a central component of an integrated health information system" (National Institute of Standards and Technology, n.d.). On the other hand, according to the Office of the National Coordinator for Health Information Technology (ONC), EHRs are "a digital version of a patient's paper chart" capable of providing "real time, patient-centered record

that makes information available instantly and securely to authorized users” (The Office of the National Coordinator for Health Information Technology, n.d.a).

1.1.1. EHRs Characteristics, Advantages and Benefits

EHRs have a large set of characteristics that make it a useful tool. According to Black AD and colleagues, EHRs are widely capable, including the use for digital input, storage, display, retrieval, printing, and sharing of patient’s clinical data (Black et al., 2011). Besides, EHRs are multidimensional in its functionalities, making it able to integrate images and documents and allows the management of nonclinical data (Black et al., 2011). Furthermore, we can find some other benefits associated with EHRs including legibility, sharing, preservation, accessibility, storing, manipulation, transportation and the ability to search patient’s health information (Black et al., 2011). For instance, these characteristics can be expected to improve Healthcare’s efficiency (Black et al., 2011).

The ONC lists a vast number of EHR advantages, including the ability to “provide accurate, up-to-date, and complete information about patients at the point of care”, “enable quick access to patient records for more coordinated, efficient care”, “securely share electronic information with patients and other clinicians”, “help providers more effectively diagnose patients, reduce medical errors, and provide safer care”, “improve patient and provider interaction and communication, as well as health care convenience”, “enable safer, more reliable prescribing”, “help promote legible, complete documentation and accurate, streamlined coding and billing”, “enhance privacy and security of patient data”, “help providers improve productivity and work-life balance”, “enable providers to improve efficiency and meet their business goals” and “reduce costs through decreased paperwork, improved safety, reduced duplication of testing, and improved health” (The Office of the National Coordinator for Health Information Technology, n.d.b). Alongside with the advantages, some of the mentioned benefits include “improved patient care”, “increase patient participation”, “improved care coordination”, “improved diagnostics and patient outcomes” and “practice efficiencies and cost savings” (The Office of the National Coordinator for Health Information Technology, n.d.c).

Thanks to its benefits, it is believed that EHRs are able to increase safety and quality in Healthcare (Chaudhry et al., 2006; Institute of Medicine - Committee on Data Standards for Patient Safety, 2004; Bank et al., 2013), to reduce costs (Bank et al., 2013) to improve healthcare outcomes, to hold relevant data for research and monitoring in health and to help medical decisions (National Institute of Standards and Technology, n.d.). In matter of fact, there has been a great investment (Blumenthal & Tavenner, 2010) and increased implementation (Bank et al., 2013; Bank & Gage, 2015) in EHRs in

countries like in the United States of America (USA) since it is believed that this technology improves clinical decisions and health outcomes (Blumenthal & Tavenner, 2010).

However, HIT and specifically EHRs also have some limitations (Chaudhry et al., 2006).

1.1.2. EHRs Limitations, Disadvantages and Risks

There are some risks associated with this technology, namely networks issues in respect to unsafe and non-authorized access (Black et al., 2011); until the accomplishment of full clinical data digitalization, the persistence of paper data can lead to patient safety issues (Black et al., 2011); the physician-patient relationship, interaction and dynamic can be threaten by the presence of a computer (Friedberg et al., 2014; Wachter, 2015; Girgis, 2015); and the time consumption of clinical data documentation, which can lead to inefficiency (Black et al., 2011).

Besides safety and quality, a crucial outcome to access EHRs success is efficiency and studies are showing that working with EHRs can be significantly time consuming (Makam et al., 2013). In turn, this impacts on physicians' productivity (Bank et al., 2013; Bhargava & Mishra, 2014) which is also a fundamental component of Healthcare (Bank & Gage, 2015).

The fact is that despite of its benefits, EHRs are timely demanding for physicians (Bank et al., 2013; Medical Economics EHR Study Update. 2012), making them spend less time with patients (Boonstra & Broekhuis, 2010) and more time dealing with computers (Hill et al., 2013). Furthermore, studies have shown that physicians spend too much time dealing with EHRs after clinical time or after-hours (Makam et al., 2013; Boonstra & Broekhuis, 2010).

In Makam et al study, the authors found that almost 50% of the primary care physicians in 3 health systems in Texas spend at least one hour per day beyond of clinic time completing EHR documentation meaning that, in a week, these physicians spend more than 9 extra hours dealing with administrative EHR tasks (Makam et al., 2013). In Hill RG and colleagues' study, the authors demonstrated that physicians in an emergency department were spending more time dealing with documentation and data entry than with direct patients' interaction and caring (Hill et al., 2013). According to Arndt et al., of a roughly 11 hours' workday, GPs spend approximately 6 hours per day in EHR tasks (like documentation and data entry), of which 1,5 hours are spent after-hours (Arndt et al., 2017). These same authors stated that EHRs are more time demanding for physicians than paper-based charts (Arndt et al., 2017). Young et al also reported that family physicians spent more than 50% of their time dealing with EHRs (Young et al., 2018). According to Zallman et al. study, EHRs caused the increment in physicians' time spent in documentation, especially for GP's (Zallman et al., 2018). Another study points out that, on average, a physician spends around 50% of his workday dealing with tasks that do

not include direct contact with patients (desktop tasks) (Sinsky et al., 2016), which is similar to the results obtained by other studies (Shanafelt et al., 2016a; Tai-Seale et al., 2017). Read-Brown et al found that ophthalmologists were spending about 3.7 hours per workday using EHRs (Read-Brown et al., 2017). Similarly to the previously mentioned studies, many other studies reported identical results, with physicians spending about 6 hours per day dealing with EHRs (Oxentenko et al., 2012; Jamoom et al., 2016; Chen et al., 2016). A more recent study reported similar results regarding the time spent per day with EHRs (about 40%) (Verma et al., 2020).

This is important because studies identify factors like the excessive time spent after hours working with EHR as stress-inductors associated with EHR use (Gardner et al., 2018; Eschenroeder et al., 2021; Peccoralo et al., 2021) and, as we will see later, this has negative consequences that impact not only on care providers but also on the Healthcare system as a whole.

Considering the previous data, it becomes clear that, with the EHR's implementation, physicians became more overloaded with administrative and clerical tasks (Bossen et al., 2019), since EHRs increased the amount of time needed for documentation (Downing et al., 2018). Besides, it is crucial to be aware that despite EHRs implementation, data duplication is still an existing problem (Burns, 1993; Safran et al., 2007; Orfanidis et al., 2004).

To put in perspective, the workload associated with data documentation and EHRs is so overwhelming that the full physicians' working tasks are, at least, a two persons' job. In matter of fact, in Bank AJ et al study (Bank et al., 2013), the authors found a large and statically significant improvement in physician's productivity associated with the use of scribes, which were responsible for collection and documenting data during physicians' assists (Bank et al., 2013; Bank & Gage, 2015). This led to a decreased in the time spent in EHR documentation and administrative tasks by the physician (Bank et al., 2013; Hess et al., 2015), fulfilment of patients' visits on schedule (Bank et al., 2013), the completion of the documentation during the patients' visits (Bank et al., 2013), the abolition of after-hours work to finish documentation (Bank et al., 2013), a reduction in appointments' time (leaving more time to see more patients) (Bank et al., 2013) and an increase in time for direct interaction between physician and patient (Bank et al., 2013; Hess et al., 2015). Consequently, the use of scribes increased both physicians' and patients' satisfaction and positively influences revenue (Bastani et al., 2014; Arya et al., 2010; Heaton et al., 2016).

It is also worth to mention that time consumption of data documentation constitutes an important aspect that influences physicians' EHRs acceptance and satisfaction (Bates et al., 2003; Kuhn & Giuse, 2001; LaDuke, 2001; Leung et al., 2003; Lau et al., 1998; Tierney et al., 1993; Tierney et al., 1994). This is relevant because physicians' satisfaction influences fundamental dimensions of healthcare namely patients' satisfaction (Haas et al., 2000; Linn et al., 1985), patients' medication adherence (DiMatteo et al., 1993) and physicians' Burnout (Spickard et al., 2002). In matter of fact, additional studies, like

the one of Sinsky et al., show that physicians' dissatisfaction with EHRs is an independent risk factor for physicians' turnover and will to reduce clinical hours (Sinsky et al., 2017). Besides, Robertson et al demonstrated that EHRs are a factor contributing to poor work-life balance among physicians (Robertson et al., 2017).

Thus, in short, the burden of EHRs use is associated with increased burnout which, once more, negatively impacts on physicians' well-being (Gardner et al., 2018; Robertson et al., 2017; Gregory et al., 2017) since, as seen before, EHRs are responsible for increasing physicians' time spent after-hours in documentation tasks, increasing overall documentation time and decreasing the time spent in direct interaction with patients (Arndt et al., 2017; Victores et al., 2015; Wormer et al., 2015). However, it is important to highlight that possible differences in physicians' satisfaction in the available literature can be explained by differences in EHR design, regulations and documentation requirements between different countries (Downing et al., 2018).

The evidence goes even further about EHRs' risks. The negative impact of EHRs can be even wider and more detrimental because there is an increased risk of harming the patients associated with the incorrect processing, entering or retrieving of the patients' information (e-iatrogenesis) (Weiner et al., 2007). In matter of fact, Howe et al, documented 2000 medical errors directly associated with the use of EHRs over a period of 3 years, and it is believed that this number could be underestimated because of the underreporting of events (Howe et al., 2018).

Summarily, with the introduction of EHRs, it was believed that this technology would be capable of relieving the burden of administrative and clerical tasks and of improving physicians' workflow. However, studies have been showing exactly the opposite, with EHRs bringing more work and burden for physicians (Reith, 2018). So, even though documentation of clinical data is essential to care delivery and it is intrinsic to medical practice (Poissant et al., 2005), decreasing documenting time is crucial for physicians (Allan & Englebright, 2000).

1.1.3. Impact on Efficiency, Productivity and Communication

As showed earlier, the evidence supports the idea that EHRs can negatively impact on time-efficiency (Black et al., 2011; Poissant et al., 2005). Efficiency influences productivity and studies have shown that physicians' productivity is crucial since it impacts in different Healthcare aspects namely quality of care delivery (Hill et al., 2013), Healthcare's costs, physicians' (Dewa et al., 2014) and patients' (Wood et al., 2009) satisfaction and accessibility to healthcare services (Bank et al., 2013). In turn, physician's productivity is negatively influenced by many factors including increased paperwork (Gilchrist et al., 2005; Ritchie, 2014), higher EHR usage (Bhargava & Mishra, 2014; Verdon, 2014), tremendous amount

of available patient's clinical data (Bank & Gage, 2015), medical regulations and bureaucracies (Cocco, 2012) and physician's burnout (Dewa et al., 2014; Shanafelt et al., 2003; Shanafelt et al., 2012).

In short, EHRs constitute a technology with many advantages that can potentially improve the overall Health outcomes with the right use but if not correctly developed, it can adversely affect physicians' well-being, patient safety and Healthcare outcomes (West, 2016).

Another relevant aspect to mention is communication. Physicians' communication is pointed out as one of the most important dimensions of healthcare that impacts on patients' perception of care's quality (Al-Amin & Makarem, 2016). Physician-patient communication influences their relationship, retrieve of information, therapeutic adherence, patient satisfaction and Health outcomes (organizational, medical and patient outcomes) (Bank et al., 2013; Chang et al., 2006; Stewart & Roter, 1989; Schneider et al., 2004; Zachariae et al., 2003; Trummer et al., 2006; Clever et al., 2008; Hammerly et al., 2014).

EHRs impact on communication since it creates what is called a blocked style of communication instead of a psychosocial conversation and it conflicts with the patient's agenda (Makoul et al., 2001; Margalit et al., 2006; Warshawsky et al., 1994). Besides, increased physicians' workload leads to less time spent with patients which can impact on physician-patient communication. In turn, this can negatively influence patient satisfaction and care experience (Al-Amin & Makarem, 2016).

The truth is that EHRs and the digitalization of health implies the need for a computerization of consultations, leading physicians to deal more with their computers and less direct contact with their patients, which in turn, creates communication barriers and impacts on patients' satisfaction (Linder et al., 2006; Powsner et al., 1998; Schaeffbauer & Siek, 2012). So, EHRs are responsible for interruptions, distractions and clerical and cognitive burden that outbalances EHR' benefits (Shanafelt et al., 2016a).

A recent study (Tsai et al., 2020), reviewed 141 studies in order to determine the effects and barriers of EHRs use. The authors demonstrated mixed findings and results regarding some positive and negative effects of EHRs namely efficiency and communication (Tsai et al., 2020). Yet, a closer look to their study results shows some data conflicts and heterogeneity. For instance, they included studies from different countries and study timeframes, which means different Healthcare realities, different EHR designs and programs and different providers' needs and perspectives which, in turn, can explain this data heterogeneity. Besides, some of the effects were studied with a different propose. For example, communication was studied in the perspective of communication among healthcare providers and teams. Another example is that the improvement in physician-patient communication reported in the study is associated with the sharing of information and messaging between provider and patient. When the focus is on patient-physician relationship and direct interaction, the reviewed studies highlight the negative impact of EHRs. So, the evidence suggests that EHRs disrupt patient-physician communication and negatively impact in their interaction and relationship. About efficiency,

the differences in the Healthcare realities and EHR programs can justify the mixed results (there are studies suggesting that EHRs improve efficiency and other studies demonstrating impaired efficiency with EHRs). However, there are much more studies demonstrating decreased efficiency with EHRs use because of the increased time spent in data documentation than otherwise. The same with workload. The evidence is much wealthier suggesting increased workload with EHRs than workload improvements. Besides, the study didn't perform a quality assessment of the included studies, meaning that the results should be interpreted with caution. So, after analysing the literature and the previous data, the evidence is wealthy regarding the negative effects of EHRs.

1.1.4. Information Exchange and Interoperability

There is still one main concern about EHRs that is very important to discuss which is the lack of interoperability and standards (National Institute of Standards and Technology, n.d.). That fact is that, many times, patient's data is digitally available in different, not integrated health information systems (National Institute of Standards and Technology, n.d.). To take the most advantages of EHRs, systems should be interoperable, integrated and secure, patient's information must be sharable and accurate and it is essential not to create barriers to EHR's implementation (National Institute of Standards and Technology, n.d.).

According to Ehrenfeld and Wanderer, some of the factors related to EHRs that contribute to physicians' lack of satisfaction with this technology include lack of interoperability and poor usability, being the others, the ones already mentioned before (impaired efficiency, degradation of direct physician-patient interaction, decreased documentation quality and excessive time spent in data entry) (Ehrenfeld & Wanderer, 2018). In their review study, Tsai and colleagues gathered information about barriers to EHR use (Tsai et al., 2020). One consistent barrier identified by many of the reviewed studies is precisely the poor systems' integration and interoperability (Howard et al., 2013; Laitinen et al., 2014; Nguyen et al., 2014; Wells et al., 2014; O'Malley et al., 2015; Topaz et al., 2017; Al-Rawajfah & Tubaishat, 2019; Priestman et al., 2018; Liew & Harjadinata, 2017; King et al., 2017; Hamamura et al., 2017; Gesulga et al., 2017). Another mentioned aspect was the disruption of workflow associated with weak EHR' connectivity among organizations (Howard et al., 2013; Laitinen et al., 2014; McAlearney et al., 2010). Alromaihi et al. also reported troublesome of EHRs regarding exchange of health information between systems (Alromaihi et al., 2011).

The capacity of exchanging and sharing information and interoperability between systems is important and has differences among countries. In the USA, only around 50% of the hospital physicians

has access to the necessary patient's data from other institutions from their workplace (Health IT Dashboard, n.d.) which is in accordance with the evidence that shows that information is still not shared properly in the USA (Adler-Milstein & Pfeifer, 2017; Department of Health and Human Services, 2018) despite the 21st Century Cures Act had prohibited the restriction of health information exchange (Black et al., 2018).

In Norway, patient's data from hospitals and outpatient institutions weren't integrated (Norwegian Health Network, 2021) which motivated the launch and implementation of a national platform for health information exchange to meet the interoperability needs (Arnesen, 2017). This gave Norwegian physicians access to all the information they need regardless of the institution that the patient has previously been (Norwegian Health Network, 2021; Arnesen, 2017).

In a recent study from 2022, Garcia and Crenner showed that frustrations with EHRs and heavier workload extends to other countries beyond USA (Garcia & Crenner, 2022). One aspect to highlight is related to interoperability where the participants describe the negative consequences of the lack of interoperability, namely the increased patients' risk and higher care expenses that result from the redundant and repetition of diagnostic tests (imaging and laboratory) since physicians can't electronically access them (Garcia & Crenner, 2022).

In another interesting and recent systematic review from 2022 (Kruse et al., 2022), the authors analysed the available literature from the last 5 years. They included 25 studies in their systematic review (Kruse et al., 2022). It makes even clearer the pressure, stress and burden that physicians are submitted to due to EHRs (Kruse et al., 2022). Many of the EHRs downsides and barriers previously mentioned are repeatedly described in many of the included studies namely excessive hour spent with EHR, long hours, workload, EHR design issues, poor work-life balance, EHR-related stress, administrative burden of EHRs and its impact on workflow, impairment in physician-patient relationship and less time spent in direct contact with patients (Kruse et al., 2022). Furthermore, one EHR-related issue described in 4 of the included studies that is worth mention is precisely the lack of interoperability (Kroth et al., 2019; Quinn et al., 2019; Kroth et al., 2018; Shahmoradi et al., 2017), which generates barriers to the integration of information and data sharing between organizations (Kruse et al., 2022).

Thus, the evidence shows EHRs issues regarding its design, interoperability and usability that hamper EHR's acceptance and implementation and also shows that the increase in documentation tasks is associated with work dissatisfaction, physicians' burnout, longer hospitalizations and augmented rates of errors (Gardner et al., 2018; Robertson et al., 2017; Westbrook et al., 2018; Elliott et al., 2014).

So, there is a link between EHRs and Burnout that justifies more information on the subject, which will be discussed on the next chapters.

1.1.5. Burden and Lack of Interoperability

As debated before, there are important aspects regarding EHR interface design that impairs physicians' experience with EHRs which, in turn, contributes to physicians' exhaustion (Ratwani et al., 2017).

Besides, the evidence suggests that poorly functioning and scarcely user-friendly EHRs that presents with technical problems that do not correspond to physicians' needs increase physicians' stress, pressure (Vainiomäki et al., 2020), negatively influences physicians' workflow and decreases physicians efficiency and satisfaction (Khairat et al., 2018; Khairat et al., 2019) which means that physicians' well-being is influenced by various and important EHR factors (Vainiomäki et al., 2017; Heponiemi et al., 2018).

Many other authors also demonstrated that issues associated with EHR that contributes to physicians' burnout include usability, documentation time and repercussions on workflow (Tajirian et al., 2020; Thomas Craig et al., 2021; DeChant et al., 2019; Khairat et al., 2020a; Melnick et al., 2020a; Melnick et al., 2020b). This means that the burden associated with documentation is exacerbated by EHR lack of user-friendliness and usability which is responsible for decreased physicians' satisfaction (DiSanto & Prasad, 2017; Lowry et al., 2017).

Interestingly, a recent study (Khairat et al., 2022), showed similar physician fatigue levels independently of the physicians' EHR expertise, which is in accordance with previously mentioned studies that physicians' burnout and stress could be more related with particularities of EHR design rather than with EHR user.

Thus, unfortunately, there is still many challenges regarding EHRs functioning and design that negatively influence physicians' work and quality of care (Rathert et al., 2019) and the evidence seems consistent regarding the disadvantages associated with poor EHR interoperability (Tsai et al., 2020).

More detailed information specifically about interoperability will be discussed later on this literature review.

1.2. Burnout

Since Burnout has already been mentioned, it seems important to go deeper into the knowledge and the evidence about Burnout and its impact in the Healthcare system and providers.

Burnout is a syndrome characterized by depersonalization (feeling of cynicism), emotional exhaustion (loss of enthusiasm to work), compassion fatigue, sense of clinical ineffectiveness and feeling of low personal accomplishment, which results from work stress (Reith, 2018; Shanafelt et al., 2012; Willis et al., 2017; Leiter & Maslach, 2016).

It was first described by Herbert Freudenberger in 1974, a clinical psychologist (Freudenberger, 1974). Later, Christina Maslach, a social psychologist, proposed a model of Burnout that included three dimensions that were previously described in its definition – low sense of personal accomplishment, emotional exhaustion and depersonalization (Maslach & Jackson, 1981; Maslach et al., 2001). Then, based on this model, she created the Maslach Burnout Inventory (MBI) (Maslach & Jackson, 1981) which is the most used tool to evaluate Burnout (Rotenstein et al., 2018). This Burnout's assessment tool consists in a spectrum of scores, with higher scores in each dimension reflecting worse outcomes and illness severity (Maslach et al., 1997; Palamara et al., 2018).

Studies and research started to focus their interest on physicians' Burnout in 1981 (Battle, 1981). Since then, physicians' burnout has been widely studied all over the world and studies have been demonstrating alarming rates of physicians' Burnout (Shanafelt et al., 2012; Heponiemi et al., 2018; Shanafelt et al., 2009; Ramirez et al., 1996; Soler et al., 2008; Thommasen et al., 2001; Imo, 2017; Mullola et al., 2019).

About half of the USA physicians reported Burnout symptoms (Shanafelt et al., 2012; Rotenstein et al., 2018; Shanafelt et al., 2015b; Medscape, 2022; Shanafelt et al., 2019; Tawfik et al., 2018; West et al., 2018) and studies have been showing an increasing tendency in physicians' Burnout rates (Shanafelt et al., 2015b; Medscape, 2022). In the other hand, according to a Canadian Medical Association (CMA) survey, Canadian physicians' burnout rates are of 30% (Canadian Medical Association, 2018). In matter of fact, Healthcare providers' Burnout is so important that it has been identified as a public health crisis (Noseworthy et al., 2017). Interestingly, some studies feature GP's as the physicians with the highest burnout rates (Olson et al., 2019; Mishra et al., 2018).

Research has been crucial regard this subject. In fact, the mind set about physicians' burnout has changed from a solely individual-caused related (Shanafelt et al., 2002), associated with personal weakness and not being suited for the job (Suran & Sheridan, 1985) to an organizational/structural-caused view of the problem (Shanafelt et al., 2012). Besides, those preoccupying statistics about physician's burnout also suggests this association, i.e., that Burnout's rates might be more related to Healthcare system's environmental and organizational issues than with individual susceptibility (Shanafelt et al., 2012; Willis et al., 2017; Maslach & Leiter, 1997). However, efforts must be in put to find both individual and organizational interventions to decrease physicians' burnout (West et al., 2016).

Many authors have dedicated their studies to this subject. Shanafelt, in particular, is an author that dedicated many of his studies to physicians' burnout. In 2003, Shanafelt and colleagues identified some factors that contribute to physicians' burnout including excessive administrative tasks (leading to inefficiency), impaired work-life balance and workload (Shanafelt et al., 2003¹). Latter, in 2012, Shanafelt et al specifically suggested that EHRs can contribute as a factor to physicians' Burnout

(Shanafelt et al., 2012). And, in 2016, Shanafelt et al showed that EHR usage is independently associated with higher rates of burnout (Shanafelt et al., 2016a). Maslach and Leiter, listed some organizational and physician-specific causes of burnout. Among them, it is included work overload, bureaucratic tasks and EHR documentation duties (Maslach & Leiter, 1997). The Institute of Medicine listed “too many bureaucratic tasks”, “spending too many hours at work” and “increasing computerization of practice” as causes of physicians’ burnout (Institute of Medicine - Committee on Data Standards for Patient Safety, 2004). Patty M. White, president and CEO of St. Joseph’s Hospital and Medical Center in Phoenix, Arizona, identified two main reasons that decreases physicians’ satisfaction – EHR documentation and bureaucracy (White, 2015). The Agency for Healthcare Research and Quality (AHRQ) identified the use of EHR as one of the five reasons that contributes to healthcare providers’ burnout (Agency for Healthcare Research and Quality, 2017). In Gold and McLaughlin study, the authors found EHR as a contributor that greatly influences physicians’ burnout (Gold & McLaughlin, 2016). In the studies by Dyrbye et al. and Tajirian et al., EHR also has been identified as a factor contributing to physicians’ burnout (Tajirian et al., 2020; Dyrbye et al., 2017). Some authors identified that EHRs use is associated with physicians’ fatigue (Kapoor, 2019; Collier, 2018), while others found that work overload with EHR tasks and the increased time spent dealing with EHRs are associated with emotional exhaustion (Shanafelt et al., 2016a; Babbott et al., 2014; Tawfik et al., 2017; Tai-Seale et al., 2019; Adler-Milstein et al., 2020; Hilliard et al., 2020), which is, as seen before, a dimension of Burnout. In the studies by Gregory et al and Edwards et al, EHR has been proven as factor contributing to Healthcare providers’ burnout, increasing burden and declining job satisfaction (Gregory et al., 2017; Edwards et al., 2018). Gardner et al reported, in their survey, preoccupying rates of physicians’ burnout and roughly 65% of the physicians identified EHR as a stress and frustration factor in their work (Gardner et al., 2018). Harris et al demonstrated that stress caused by EHR use is associated with physicians’ burnout (Harris et al., 2018). According to Gardner et al, EHRs can generate an increase in clerical tasks even during the appointments, leading to an increase in providers’ burden which, in turn, contributes as a factor for burnout (Gardner et al., 2018). On the other hand, Kroth et al. identified EHR as a stress inductor that increases overall physicians’ stress which could increase burnout (Kroth et al., 2019). Moy and colleagues (Moy et al., 2021) also identified that EHR documentation burden is associated with physicians’ burnout. These authors go even further, associating EHR use with decreased patients’ safety, impaired quality of documentation, increased medical errors and increased work burden (Moy et al., 2021). In Linzer et al survey, they documented elevated percentages of physicians reporting burnout symptoms (38%), too much documentation stress and pressure (60%) and excessive time spent dealing with EHR even at home (50%) (Linzer et al., 2016).

More recently, the 2022 Medscape Report reinforces these factors as causes that most contribute to physicians’ Burnout, among other factors (Medscape, 2022). So, according to this last Medscape

Report, which is an early survey, there are many contributors to physicians' burnout. The list includes "too many bureaucratic tasks", "lack of respect from administrators/employers, colleagues or staff", "too many hours at work", "lack of control/autonomy over my life", "insufficient compensation/salary", "increasing computerization of practice (EHR)", "lack of respect from patients", "government regulations", "stress from social distancing/societal issues related to COVID-19", "stress from treating COVID-19 patients" and "other" (Medscape, 2022).

However, care providers' burnout and well-being are not solely a physicians' problem. As Boehm L et al. pointed out in their study (Boehm et al., 2017), nurses also show burnout's symptoms manifested by high turnover, which has a negative financial impact. An important aspect to mention is that one of the top three factors pointed out as a Burnout causer is precisely the administrative tasks and the burden associated with technology (Boehm et al., 2017). Besides Boehm L et al., other authors also reported preoccupying Burnout rates among nurses (Aiken et al., 2001; McHugh et al., 2011). And, similarly to physicians' studies, EHR has also been pointed out as an important factor impacting on nurses' well-being and contributing to nurses' dissatisfaction and burnout (Khairat et al., 2020b).

Furthermore, the literature also shows high Burnout rates among physician residents (Shanafelt et al., 2002; Holmes et al., 2017; Ishak et al., 2009; Dyrbye et al., 2018; Rodrigues et al., 2018; Lin et al., 2019; Dyrbye et al., 2014) and medical students (Dyrbye et al., 2014; Ishak et al., 2013; Frajerman et al., 2019; Dyrbye et al., 2010). Interestingly, like in the physicians' and nurses' case, Domaney and colleagues also found a strong correlation between Burnout and EHR usage among physician residents (Domaney et al., 2018).

These statistics are important because Healthcare providers' well-being is crucial since it influences patients' safety and outcomes (Boehm et al., 2017). In matter of fact, care providers' burnout has been associated with higher risks of surgical errors (Shanafelt et al., 2010) in the case of exhausted physicians; higher turnover (Leiter & Maslach, 2009), patient mortality (Welp et al., 2015) and infections rates (Cimiotti et al., 2012) in the case of exhausted nurses; therapeutic errors in the case of exhausted physician residents (Fahrenkopf et al., 2008) and clinical dishonesty, alcohol abuse and less altruistic attitudes in the case of exhausted medical students (Dyrbye et al., 2010; Jackson et al., 2016).

Besides, studies have identified Burnout as an important factor contributing to providers' withdrawal (Downing et al., 2018), loss of productivity (Dewa et al., 2014) and, in turn, causing loss in healthcare services' quality (Downing et al., 2018). Salyers MP and colleagues have also demonstrated a statistically significant impact of Burnout on Healthcare quality and patients' safety (Salyers et al., 2017).

It is important to mention that, as described earlier, EHRs use and time spent in data documentation duties are associated with inefficiency and loss of productivity but, studies also show

that efficiency (Shanafelt et al., 2016b) and productivity (Shanafelt et al., 2016b; Windover et al., 2018) can be negatively impacted by physicians' burnout.

In matter of fact, the literature is vast concerning the negative impact of burnout in healthcare. Summarily, after gathering several studies (beyond the ones previously mentioned), the evidence shows that Burnout negatively impacts Healthcare delivery and quality, since it is suggested that Burnout can lead to higher risk of medical errors, poorer patient outcomes, malpractice suits, early retirement, professionals' turnover, professionalism's degradation, decreased productivity, patients' dissatisfaction and worsen quality of care (Shanafelt et al., 2012; Willis et al., 2017; Tawfik et al., 2018; West et al., 2018; Dyrbye et al., 2010; Shanafelt et al., 2010; Windover et al., 2018; Wallace et al., 2009; Shanafelt et al., 2011b; Balch et al., 2011a; Drummond, 2014; Balch et al., 2011b; Halbesleben & Rathert, 2008; Landon et al., 2006; Jha et al., 2019; Bodenheimer & Sinsky, 2014; Ariely & Lanier, 2015; Del Carmen et al., 2019; Patel et al., 2019; Shanafelt & Noseworthy, 2017; Lambden et al., 2019; Papathanasiou, 2015). Besides, studies also suggest that Burnout negatively influences Physicians' health, since it can contribute to work disengagement, fatigue, stress, higher risk of cardiovascular diseases, depression, sleep disorders, suicidal ideations, reduction in life expectancy, drug and alcohol abuse and marital problems (Shanafelt et al., 2003; Shanafelt et al., 2012; Willis et al., 2017; Salyers et al., 2017; Drummond, 2014; Ariely & Lanier, 2015; Del Carmen et al., 2019; Oreskovich et al., 2012; Shanafelt et al., 2011a; Shanafelt et al., 2017; Center et al., 2003).

Alongside with these problems, Healthcare providers' burnout also has a financial and economic negative impact (Han et al., 2019). For instance, and besides the previously mentioned financial impact of nurses' Burnout, there is more evidence suggesting that Healthcare professionals' Burnout is expensive since it is associated with higher turnover rates or early retirement/quitting (Sinsky et al., 2017; Windover et al., 2018).

Another important aspect to bear in mind is that burnout negatively impacts work's environment and detracts physicians' interaction, which, in turn, puts non-burden-out physicians' colleagues and co-workers at risk for burnout (Smith & Christakis, 2008; Christakis & Fowler, 2013).

Thus, Burnout is a complicated syndrome that comprises a complex net of interactions between causes and consequences (Stehman et al., 2019). The truth is that EHRs are supposed to help and ease physicians' work (Vainiomäki et al., 2020) but it still doesn't meet the physicians' and Healthcare needs (Evans, 2016). And it is important to be aware that Burnout has detrimental consequences in the whole Healthcare system, including staff's well-being, Healthcare outcomes and patients' satisfaction (Reith, 2018). The excessive time spent dealing with EHR is an important factor impacting physicians' well-being and burnout rates and, in turn, this negatively influences the quality and the efficiency of care delivery (Farber et al., 2015; Ouyang et al., 2016; Hingle, 2016; Hessels et al., 2015). Besides, excessive

administrative tasks and clerical duties are also responsible for causing burden among physicians which, in turn, decreases quality of care delivery (Olson et al., 2019; Rao et al., 2017).

So, it is fundamental to focus on organizational interventions capable of influencing Healthcare system's factors that impact on physicians' burnout rates (Shanafelt et al., 2012; Boehm et al., 2017), since it is crucial to invest in care providers' well-being and experience to improve and maintain a sustainable Healthcare system (Boehm et al., 2017; Drummond, 2014; Bodenheimer & Sinsky, 2014). Satisfied care staff positively influences patients' experience (Willis et al., 2017; Spiegelman & Berrett, 2013).

1.3. Solutions

As mentioned before, Burnout has a multiplicity of causes that need to be addressed. An extensive comprehension of those causes is crucial to understand the potential interventions to reduce healthcare professionals' burnout (Lown et al., 2019). So, considering all of the information that has been mentioned above, this epidemic healthcare crisis should be addressed at two levels – individual-focused and organizational/structural-focused interventions (West et al., 2016; Lown et al., 2019).

Individual-focused interventions like positive psychology tactics, mindfulness training and communication skills training are meant to improve physicians' well-being and positive emotions (Krasner et al., 2009; Rippstein-Leuenberger et al., 2017; Seligman et al., 2005). Studies have been showing that these individual-focused interventions are effective (West et al., 2016; Panagioti et al., 2017).

On the other hand, organizational-focused initiatives from healthcare leaders and managers are also effective in reducing burnout, improving workers engagement and increasing a culture of safety (Kaiser Permanente Southern California Nursing Research, 2010; Sexton et al., 2018). This is related with their ability to influence work environment (Lown et al., 2019) and includes, among others, giving feedback, encouragement, respectful treatment to their employees, coaching and considering workers' opinions (Kaiser Permanente Southern California Nursing Research, 2010; Sexton et al., 2018; Shanafelt et al., 2015a).

Despite the importance of both individual-focused and organizational-focused potential initiatives and interventions to improve physicians' burnout, studies suggest that organizational/structural-focused interventions appear to be more beneficial (West et al., 2016; Panagioti et al., 2017).

In that previously mentioned study from Boehm L et al., more focused on nurses' burnout, technology optimization is mentioned as one measure to increase resilience (Boehm et al., 2017).

Interestingly, leaders from Healthcare organizations have proposed three approaches to address this issue, one of which is precisely making EHR' improvements to reach a more user-friendly platform, interoperable and able to decrease time-consumption (Jha et al., 2019). The other two interventions include providing mental health aid and support for those in distress and the nomination of a chief wellness officer for each Healthcare organization (Jha et al., 2019).

It has been postulated that more than a specific EHR, it is crucial to put efforts in creating solutions to enhance and improve EHR's functionalities and time-efficiency on documentation processes (Makam et al., 2013; Poissant et al., 2005), since it is considered crucial to achieve a harmony between this technology and clinical practice (Bates et al., 2003; Kuhn & Giuse, 2001; LaDuke, 2001; Ammenwerth et al., 2003; Beuscart-Zéphir et al., 2001; Staccini et al., 2001). This can add value to EHRs. Some suggested solutions include making the EHR platform more user-friendly in carrying-out medical tasks and more capable of improving work efficiency (Makam et al., 2013).

In Thomas Craig et al systematic review, the authors named, among others, the importance of reducing documentation and task time as an intervention to reduce physicians' burden with technology (Thomas Craig et al., 2021). Also, in a recent study from 2022, the results obtained by the authors follow similar principles referred by other studies, namely system' changes that result in efficiency enhancements and design and functionality improvements that reduce documentation time and burden are of most importance (Mishra et al., 2022).

EHR technical problems affecting physicians' workflow and causing delays and work overload are responsible for physicians' stress and pressure meaning that it is crucial to put efforts in improving and developing EHR systems that are more user-friendly and that fulfil providers' needs which in turn contributes to physicians' well-being and satisfaction (Vainiomäki et al., 2020; Kuo et al., 2018; Lintern & Motavalli, 2018).

In one study, the authors implemented a physicians' well-being and burnout rates research in their institution in a 3 years period and created a set of strategies to improve providers experience based on the WellMD Professional Fulfilment model from Stanford Medicine WellMD Center (Shields et al., 2020). Similarly to Stanford's model, they implemented a 4 strategies program that encompassed "provider engagement & growth", "workflow/office efficiencies", "relationship building" and "communication" (Shields et al., 2020). In this study, they found physicians' burnout rates like those from other studies that were previously mentioned (Shields et al., 2020). Focusing on EHR usage, their evaluation indicated that physicians were frustrated and overwhelmed with the excessive time-consuming of EHR, especially after-hours (Shields et al., 2020). Physicians also find their work to be less efficient because of it (Shields et al., 2020). To address this issue, the authors implemented an optimization of EHR design and usage to improve physicians' workflow and efficiency (Shields et al., 2020). After implementation, physicians could spend more time in direct contact and care with their

patients and they were less burden with administrative, clerical and EHR tasks (Shields et al., 2020). Physicians were less frustrated, less burned-out, more committed, more fulfilled and better at building physician-patient relationships (Shields et al., 2020). This is in line with Tawfik et al. study, who also claim the importance of fulfil physicians' needs by decreasing documentation burden and improving physicians' workflow and efficiency (Tawfik et al., 2019). In matter of fact, it is expected that any modification in the Healthcare system that increases physicians' efficiency and productivity (without, obviously, decreasing physicians' and patient's satisfaction or healthcare quality) will financially and positively benefit both physicians and the Healthcare system (Bank et al., 2013).

So, among the possible individual-focused and organizational-focused interventions to improve physicians' well-being and decrease physicians' burnout, EHR's optimization is considered an important workflow intervention (organizational level) (Parsons et al., 2020).

Besides improving physicians' well-being and decreasing physicians' burnout, the evidence also supports that it is crucial to put efforts in redesigning and improving EHR to increase physicians' efficiency (Kruse et al., 2022) and that physicians' job satisfaction is higher when they have the opportunity to participate in EHR's development (Vainiomäki et al., 2017).

Shortly, Healthcare technologies should be able to harmonize physicians' workflow, to put patients at the center of healthcare and to allow physicians to manage their job with ease (Wang et al., 2022).

1.4. Interoperability

As early as 1920', the importance of standardization was discussed by Herbert Hoover. It was identified as a tool to prevent waste, to decrease costs and to improve productivity in an industrial era and the relevance of standards' implementation across different industries was also identified (Peristeras, 2013). In parallel, stablishing information standards plays a crucial rule in an information society (Peristeras, 2013). Information technology's (IT) standardization is seen as an extension of industrial standardization and it its progress first began at a technical level (Peristeras, 2013). Increasing and improving hardware's and software's interoperability constitute the principal objective of establishing standards in IT (Peristeras, 2013).

However, barriers to interoperability can arise from other levels beyond the technical one namely semantic and/or organizational levels (Peristeras, 2013). So, as technical standards have substantially contributed to systems' interoperability, semantic standardization emerges as an important barrier to

the ability of smoothly exchanging information and interoperability (Peristeras, 2013), which is the aim of this dissertation.

But, before getting into the knowledge of semantic interoperability, what is interoperability exactly? According to the Regulation of the European Parliament and of the Council on the European Health Data Space (European Commission, 2022), which creates and regulates the European Health Data Space, interoperability is “the ability of organizations, as well as computer applications or devices from the same or different manufacturers, to interact in order to achieve mutually beneficial objectives, involving the exchange of information and knowledge, without changing the content of data, between those organizations, computer applications or devices, through the processes they support”. On the other hand, according to the European Interoperability Framework (EIF), interoperability is “the ability of organisations to interact towards mutually beneficial goals, involving the sharing of information and knowledge between these organisations, through the business processes they support, by means of the exchange of data between their ICT systems” (European Commission, 2017).

1.4.1. The European Interoperability Framework

The EIF is an important document from the European Commission (EC) that proposes a “commonly agreed approach to the delivery of European public services in an interoperable manner” (European Commission, 2017). In this EC’s document, basic interoperability guidelines are defined “in the form of common principles, models and recommendations” (European Commission, 2017). The EIF is promoted and maintained by the Interoperability Solutions for European Public Administration (ISA) program (European Commission, 2017), which will be discussed later in more detail. More specifically, the EIF constitutes an important guide with 47 recommendations on how to “improve governance of their interoperability activities, establish cross-organisational relationships, streamline processes supporting end-to-end digital services and ensure that existing and new legislation do not compromise interoperability efforts” (European Commission, 2017). Besides, the EIF also features 12 interoperability principles which are important behavioural elements to drive interoperability actions. These principles are included into 4 categories (“Principle setting the context for EU actions on interoperability”, “Core interoperability principles”, “Principles related to generic user needs and expectations” and “Foundation principles for cooperation among public administrations”). The principles include Subsidiarity and proportionality; Openness; Transparency; Reusability; Technological neutrality and data portability; User-centricity; Inclusion and accessibility; Security and privacy;

Multilingualism; Administrative simplification; Preservation of information; and Assessment of Effectiveness and Efficiency. For each principle, there are some of the previously mentioned recommendations (European Commission, 2017).

The EIF's objectives include: 1. Inspiring European public administrations in designing and delivering public services which should be digital-by-default (data and services through digital channels), cross-border-by-default (accessibility for all EU citizens) and open-by-default (reuse, access and transparency); 2. Providing public administrations the necessary guidance about the design and update of National Interoperability Frameworks (NIFs) and, also, the national strategies, guidelines and policies in order to promote interoperability; 3. Promoting the establishment of a digital single market through cross-sectorial and cross-border interoperability (European Commission, 2017).

Generically, to achieve its interoperability goal, the EIF proposes what is called European Interoperability Frameworks (EIFs) which give a common core of elements regarding interoperability, NIFs which add new or fine-tune existing elements and Domain-specific Interoperability Frameworks (DIFs) which capture specific interoperability requirements to keep up with national, local or regional policies and needs (European Commission, 2017).

More can be added about the EIF. Previously, interoperability was mentioned as having levels/layers. Consequently, the EIF features an interoperability model. This model has 4 layers of interoperability (legal, organisational, semantic and technical), a component that crosscuts the four previous layers (integrated public service governance) and a background layer (interoperability governance) (European Commission, 2017).

Summarily, interoperability governance includes "decisions on interoperability frameworks, institutional arrangements, organisational structures, roles and responsibilities, policies, agreements and other aspects of ensuring and monitoring interoperability at national and EU levels". This is crucial since it is important to align stakeholders' policies and objectives to achieve interoperability between systems. Besides, it is fundamental to coordinate and monitor this process. So, interoperability governance is the key to this holistic approach on interoperability and to guarantee it in a sustainable way. At the EU level, the EIF, the Interoperability Action Plan and the European interoperability architecture (EIRA) constitute important elements of interoperability governance. On the other hand, integrated public service governance arises from the fact that "public service provision often requires different public administrations to work together to meet end users' needs and provide public services in an integrated way". This means that "services should be governed to ensure integration, seamless execution, reuse of services and data and development of new services". So, integrated public service governance emerges as a key to integrate public services and to "ensure interoperability and coordination over time". Legal interoperability is about "ensuring that organisations operating under different legal frameworks, policies and strategies are able to work together". Organisational

interoperability is referred as “the way in which public administrations align their business processes, responsibilities and expectations to achieve commonly agreed and mutually beneficial goals”. In other words, organisational interoperability is associated with the process of “documenting and integrating or aligning business processes and relevant information exchanged” and “aims to meet the requirements of the user community by making services available, easily identifiable, accessible and user focused.” Technical interoperability includes “the applications and infrastructures linking systems and services. This layer also includes “interface specifications, interconnection services, data integration services, data presentation and exchange, and secure communication protocols”. Finally, semantic interoperability “ensures that the precise format and meaning of exchanged data and information is preserved and understood throughout exchanges between parties”. This means that this layer is responsible for preserving that “what is sent is what is understood”. In other words, Peristeras described, in his article, that semantic standards represent “a way of looking at the world” (Peristeras, 2013). According to the EIF, semantic interoperability includes not only semantic but also syntactic aspects. Semantic is about “the meaning of data elements and the relationship between them” and includes “developing vocabularies and schemata to describe data exchanges and ensures that data elements are understood in the same way by all communicating parties” while syntactic is associated with “describing the exact format of the information to be exchanged in terms of grammar and format” (European Commission, 2017). There are important differences between environments including at a linguistic level which impairs information exchange and data portability meaning that it is crucial to focus on semantic standardization to improve interoperability. So, to improve semantic interoperability, information and data must be seen as a valuable asset.

Thus, it seems clear that it is fundamental to put efforts in semantic standardisation to prevent information technologies investments’ waste (Peristeras, 2013) and this is important for IT investors like the Government (Peristeras, 2013), where the health sector is included. More detailed information about semantic interoperability and standardization will be discussed in the last session.

1.4.2. Interoperability, Regulations and the Single Digital Market in Europe

In May of 2022, the European Commission (EC) launched a document – the Regulation of the European Parliament and of the Council on the European Health Data Space (European Commission, 2022) – where it is mentioned the importance of accessing health information between member states and the barrier caused by lack of interoperability. In matter of fact, the COVID-19 pandemic exposed the importance of improving interoperability. In this paper, the EC also reminds the benefits of assuring

interoperability in its layers (namely legal, semantic and technical). However, it is described that there is still a great barrier for the free and smooth exchange of health data and lack of interoperability which negatively impact in care provision and follow-up (European Commission, 2022). So, it is important to improve interoperability while complying with data protection requirements and with national specifications to provide better healthcare (European Commission, 2022). One important aspect described in this regulation, is precisely the needed work to achieve systems' interoperability with RSE while keeping patients' data secure (European Commission, 2022). This regulation also mentions the EIF as a reference for systems' interoperability and for the secure health information portability and exchange (European Commission, 2022). This constitutes the path to achieve a single digital market.

In short, this EC's document regulates the European Health Data Space whose objectives include giving people their right to control their health data in their country or among EU member states, increasing the smooth and free health information portability and exchange between systems, including RSE, to improve healthcare delivery, quality and patients' management, treatment and follow-up. To achieve those objectives, it is imperative to make efforts in improving interoperability and data safety, for which the EIF gives a common guidance. The 2018 Report to Congress also mention the importance of improving interoperability, of giving patients the capacity to control of their data and of assuring secure and transparent health data exchange and share to improve Healthcare quality and outcomes (The Office of the National Coordinator for Health Information Technology, 2018).

Health data exchange and interoperability is also discussed in the Cross-Border Healthcare Directive. In this directive, it is mentioned the importance of Information Communication Technologies (ICT) and systems' interoperability to provide better health care whilst respecting regulations. In its 14th article, the directive describes one the objectives of the eHealth network as a "work towards delivering sustainable economic and social benefits of European eHealth systems and services and interoperable applications, with a view to achieving a high level of trust and security, enhancing continuity of care and ensuring access to safe and high-quality healthcare" (The European Parliament and the Council of the European Union, 2011). This network is constituted by a group of experts that are working on improving interoperability and on creating guidelines namely semantic and technical standards (European Commission, 2022).

There are some good examples of efforts made to achieve a better and greater Health digitalization and systems' interoperability. For example, Denmark is one of the most highly ranked in e-health implementation (The Ministry of Health, 2017). Their Healthcare system is characterized by extensive digitalization and electronic communication between providers (The Ministry of Health, 2017). In Denmark, all laboratory test results are electronically available (The Ministry of Health, 2017). In matter of fact, Denmark is a world leader in linking data across databases (The Ministry of Health, 2017). This can be used for research, improvement of healthcare outcomes and services, prevention,

monitoring treatments, among other benefits (The Ministry of Health, 2017). In Finland, there is also been made a great work to achieve e-health including efforts in improving interoperability in order to make data electronically available across systems (Hämäläinen et al., 2013).

So, the lack of interoperability constitutes a major barrier to the main goal of a single digital market capable of preservation, reuse and share of data. In Europe, the EIF is a crucial tool to promote an interoperable environment and the delivery of services capable of working together (European Commission, 2017). A crucial aspect to bear in mind to improve interoperability is to consider data and information as a valuable asset (European Commission, 2017).

EU's Member States Public are trying to modernize their public administrations through the introduction of digital public services. However, it is crucial to ensure interoperable systems and avoid isolated digital environments and electronic barriers (European Commission, 2017). That is why, solid coordination at European and National levels is crucial to not only ensure a smooth and single digital market but also to avoid digital fragmentation of both data and services (European Commission, 2017). Besides, it is also fundamental to keep up with European Union's (EU) legislation and meet all the necessary policies to achieve interoperable systems, i.e., capable of ensuring effective communication between digital components (European Commission, 2017).

At this point, an important initiative that worths mentioning is HL7 organization. HL7 is accredited by the American National Standards Institute, and it was founded in 1987 with the aim of creating standards for exchanging, integrating, and sharing of electronic health data (High Level Seven International, n.d.). HL7 produces a worldwide accepted framework with more than 1600 members from more than 50 countries. It is also supported by more that 500 corporate members namely healthcare providers, government stakeholders and pharmaceutical companies. According to HL7, their vision includes "a world in which everyone can securely access and use the right health data when and where they need it" (High Level Seven International, n.d.). Their standards are the most commonly used worldwide and they define "how information is packaged and communicated from one party to another, setting the language, structure and data types required for seamless integration between systems" (High Level Seven International, n.d.). HL7 includes several groups of categories including, among others, Electronic Health Records and FHIR standards. Electronic Health Records standards are intended to build structures for EHR management while HL7-FHIR is an interoperability standard that is meant to ease the exchange of health data between organizations. Thus, HL7 aim is to provide standards to "empower global health data interoperability" (High Level Seven International, n.d.).

1.4.3. Semantic Interoperability

Semantic standards are relevant for the development of open data, Web services platforms, closed and enterprise systems (Peristeras, 2013) and linked open government data (Ding et al., 2012).

All over the world, several initiatives from many different countries have been initiated to establish semantic standardization. This includes not only efforts to create semantic standards but also to create semantic catalogues, libraries or repositories of what already exists. The US and Europe governments are promoting projects that include this process of cataloguing existing semantic standards which contributes to the reuse, prevention of waste and better time and resources management/allocation (Peristeras, 2013).

In the US, the National Information Exchange Model (NIEM) set the goal of developing and deploying a national model that includes information sharing and an organizational structure capable of governing it. The Information Exchange Package (IEP) is the basic element of the NIEM architecture. This element is meant to be exchanged between systems (i.e., public agencies) and includes a description of specific information. Other countries also have been putting efforts in developing and creating repositories or libraries of semantic standards to promote interoperability.

The European Commission (EC) also developed some work on semantic standardization in the context of the ISA program. The ISA program is a project whose objective is to improve interoperability between public services and to increase public sectors' information exchange in the European Union through the increase of awareness about semantic standardization's benefits and through the promotion of semantic standards' management (Peristeras, 2013). This means that, the EC has been promoting the identification, documentation, maintenance and use of common semantic standards through national strategies and national interoperability frameworks (Peristeras, 2013).

In Peristeras study, semantic standards are identified as semantic interoperability assets, which demonstrates the value and importance of semantic standardisation and information exchange. So, to increase semantic interoperability, it is fundamental to reuse and align these specifications. However, there is still lack of common and accepted semantic agreements. That is why the EC identified the lack of a common language to describe standards, the lack of a structure capable of searching existing solutions and, therefore, promoting reuse and the lack of common agreements on semantic models as factors that negatively impact semantic interoperability and data sharing (Peristeras, 2013).

In matter of fact, there are many medical terminologies that are used around the globe. Some examples include ICD-10, ICD-11, CPT, SNOMED-CT, LOINC, RadLex, DSM-5, MedDRA, RxNorm and ICPC-2. ICD is a World Health Organization (WHO) coding system of diseases, and it is the main basis for health records and statistics (World Health Organization, n.d.). It gives knowledge about causes and consequences about diseases and death. Its latest versions include ICD-10 and ICD-11. CPT is a

code created by the American Medical Association (AMA), used to bill for medical procedures, services and administrative management (American Medical Association, n.d.). SNOMED-CT is a comprehensive standard for clinical terminology developed by SNOMED International focused on safe and efficient health data exchange (SNOMED International, n.d.). LOINC is an international terminology maintained by the Regenstrief Institute and it used for laboratory and clinical observations (Logical Observation Identifiers Names and Codes, n.d.). RadLex (Radiological Society of North America, n.d.) is a comprehensive terminology used for radiology reporting and registries created by the Radiological Society of North America (RSNA). DSM-5 (American Psychiatric Association, 2013) is a clinical terminology standard for the diagnosis of mental disorders developed by the American Psychiatric Association (APA). MedDRA (Medical Dictionary for Regulatory Activities, n.d.) is an international terminology used for registration, monitoring, and documentation of medicinal products for human use developed by the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use. RXNorm was developed by the National Library of Medicine (NLM), and it is a standardized terminology for clinical drugs (National Library of Medicine, 2023). ICD-10 is the most recent version of the terminology created by the International Classification Committee of World Organization of Family Doctors (WONCA) and it's an international classification used for capturing and ordering clinical information in primary care (World Organization of Family Doctors, n.d.).

Summarily, information is a valuable asset which should be preserved and used. Standardization is crucial to prevent waste and problems regarding interoperability impairs the full data potential in a modern and information society. All layers can face potential problems and threats that should be addressed. In the specific case of the semantic layer, the lack of common agreements and language impairs interoperability, reason why several entities have been putting efforts in improving semantic interoperability. The disclosure of semantic interoperability's benefits, awareness of the importance of reusing the already existing models and solutions (and, consequently, achieving savings) and agreements in common specifications are crucial to improve and increase interoperability.

Chapter 2: Research Methods

2.1. Research Strategy

For this work, it was used a qualitative research methodology. It includes mixed research methods including both exploratory (identify possible patterns and test some ideas) and analytical research (try to explain some issues and identify different variables involved related to the subject).

Qualitative research methods constitute an important research tool, in both health and management fields, that contributes for the exploration of patients' and healthcare providers' experience (Lewin & Glenton, 2018; Sale & Thielke, 2018; Salmon & Young, 2018; Tugwell et al., 2018; Sibeoni et al., 2020). This means that qualitative research methodology gathers non-numerical data by exploring different experiences, behaviours and perspectives from the involved individuals (Ullrich et al., 2020), resulting in detailed and descriptive results.

2.2. Data Collection Strategies

2.2.1. Literature Review

A review of the literature was also performed to clarify and test some aspects related to the subject in study. For the literature review, ProQuest was used to search for relevant content about the subject in study. ProQuest is the biggest available multidisciplinary database which gives access to full-text content. It gives access to 47 databases including ABI/INFORM Global, ABI/INFORM Trade and Industry and ABI/INFORM Dateline – especially relevant for management and enterprise – and ProQuest Health and Medical Collection, Consumer Health Database, Healthcare Administration Database and Public Health Database – especially for Health and Medicine data (Proquest LibGuides). Different searches using the terms “interoperability”, semantic interoperability”, “systems’ interoperability”, “burden”, “burnout”, “administrative tasks”, “administrative burden”, “health”, “work-life balance”, “satisfaction”, “EHR” and “factors” was performed. Only peer-reviewed systematic reviews were screened. All abstracts were fully read. All the included studies were fully accessed and read. Inclusion criteria were abstract data with heavily evidence of information and consistent data about electronic health records, interoperability and associated physicians’ workload. All studies with non-direct and related information about those included terms were excluded.

References and text citations are according to the American Psychological Association (APA) style (<https://apastyle.apa.org/>).

2.2.2. Data Collection

In respect to data collection and analysis in qualitative research, it can comprise a vast variety of methods namely individual interviews which explores individual perceptions (Dicicco-Bloom & Crabtree, 2006), group interviews which gives an understanding about shared experiences or opinions (Wilkinson, 1998) and direct observations which can give some insights about specific behaviours (Vindrola-Padros & Vindrola-Padros, 2018; Catchpole, 2017). For this work, data collection was obtained through focus groups' interview. Individuals were personally interviewed or through an online meeting. A non-random sampling was obtained, more specifically a convenience sample. Two different groups of interest were interviewed according to their position in the supply chain. One group was constituted by 10 GP's to gather information about their perception and experience on the field about interoperability and its impact on their daily routine. The other group was constituted by 2 healthcare information systems specialists to gather information about interoperability and solutions to improve health data sharing. 8 healthcare information systems specialists were contacted for interview but only 2 responded. For each group, some open-ended questions were used. The interviews' guide used for the first group can be seen in appendix B, while the one used to interview healthcare information systems experts is included in appendix C. This guide, used to collect the data, was carefully prepared to include the relevant subjects needed to analyse the issue in review.

All interviews were audio recorded with interviewees' verbal consent. These audio-records were kept for consultation if needed. The table in appendix D contains the transcription of all GP's answers about each question while the table in appendix F includes healthcare information systems experts' answers.

2.3. Interviews' guide

The guide created for GPs' interviews is constituted by 17 questions and 6 dimensions. These questions are grouped in accordance with those dimensions (see appendix B). Each dimension is related with the main topics that were addressed in the literature review as they were considered as essential foundations about the whole subject. Thus, the questions were chosen to obtain, in the best way as possible, the personal perception and experience of each GP about the subject regarding each dimension. Questions 1 to 3 explore dimension 1, questions 4 and 5 explore dimension 2, questions 6 to 7 explore dimension 3, questions 9 to 11 explore dimension 4, questions 12 to 15 explore dimension 5 and questions 16 and 17 explore dimension 6. Generally, dimension 1 is about Electronic Health Records – all aspects regarding this topic namely EHR characteristics, utility, advantages,

disadvantages, drawbacks and flaws –, dimension 2 is about test results transcription and time consumption – this dimension includes not only the transcription work burden but also all aspects regarding EHR and bureaucratic work time consumption –, dimension 3 is related to burnout – every aspect about physicians' overload, distress, frustrations and burden related with bureaucratic and EHR work and possible consequences –, dimension 4 is associated with clinical data value – includes the perception of physicians about clinical data value and also about other aspects of its importance namely economic value, data privacy and confidentiality and data accessibility –, dimension 5 is related to interoperability – associated with the knowledge about interoperability concept, specificities, importance and its current state in the Portuguese health systems – and dimension 6 explores solutions – physicians ideas and perceptions about actual or possible solutions to improve healthcare services regarding this subject.

The interviews' guide made for healthcare information systems experts (see appendix C) follows the same structure and logic as the previous guide with only a change in the number of questions and their sentence construction. Thus, this guide has 12 questions with the following grouping: questions 1 to 3 explore dimension 1, question 4 explore dimension 2, questions 5 and 6 explore dimension 3, questions 7 to 9 explore dimension 4, questions 10 and 11 explore dimension 5 and question 12 explore dimension 6.

2.4. Sampling Techniques

Gioia methodology (Gioia et al., 2012) was used for this research so, each answer was analysed, evaluated and classified according to sub-dimensions. These sub-dimensions are an objective appreciation and interpretation of each given answer. This provides an easier and more objective evaluation of interviewees' answers, giving a better summarized understanding of the answer's meaning. By other words, sub-dimensions can be seen as a translation of interviewees' answer. With these sub-dimensions, the classification into dimensions become clearer. The dimensions are the 6 dimensions mentioned earlier and are explicitly written in each interviews' guide (see appendix B and C): Electronic Health Records (dimension 1), test results transcription and time consumption (dimension 2), burnout (dimension 3), clinical data value (dimension 4), interoperability (dimension 5) and solutions (dimension 6). With this segmentation and step-up process, it is expected to match the answers of each interviewee with those dimensions, which constitute the main topics addressed and explored in this work.

2.5. Framework for Data Analysis

In respect to data analysis, inductive and deductive research methods are important for exploratory research questions (Emerson et al., 2011), to test or create a new concept or theory, respectively. In this work, data analysis was done using the Gioia methodology (Gioia et al., 2012), which sees people in organizations as “knowledgeable agents” and it takes advantage of their experience and perspective. This translates into a data structure composed by first order concepts (informant-centered terms), second order themes (researcher concepts and themes) and aggregate dimensions, allowing a structured and analysis of qualitative research. The framework and results obtained in this work are detailed in the tables included in appendix D and F. These tables include the answer to each question by all interviewees (first order concepts), its sub-dimensions (second order themes) and dimensions.

Chapter 3: Results and Discussion

3.1. General Practitioners

10 GPs were selected for interview (2 male and 8 female) with ages ranging from 28 to 66 years old. 60% of the interviewed GPs were attending physicians, being the rest in their residency training. Some other demographic data can be seen in the table in appendix E.

When asked about the first question (“What do you think about Electronic Health Records?”), the answer was generally positive with 8 out of 10 of the physicians immediately describing the utility and value of this technology. It was referred as a “useful” and “good tool” because of its capacity to give access to clinical data from hospitals, primary healthcare services and some other important data namely vaccines, prescriptions and exam results done in the hospital. GP IX even highlighted the fact that “patients cannot explain important information and RSE makes possible to check the information written by other colleagues”. GP II mentioned, by personal experience, the benefit of EHR when compared to paper era. However, all physicians pointed out some flaws and problems associated with EHR. The main problem described include poor connection, data accessibility (access to some hospital programs and to the private sector data) and interoperability between different systems (GP I, GP III, GP IV, GP V, GP VI, GP VII, GP VIII and GP IX). Other mentioned problems include poor user-friendliness, slowness, EHR segmentation and the existence of too many programs. GP VII described that “there's so much non summarized information spread all over so many different programs that turns out to be a disadvantage”. He also highlighted that there is “too much redundant and non-processed data which doesn't bring advantage to physicians and makes us, unnecessarily, waste time”.

The second question made even more clearer some of these personal perceived and experienced advantages and disadvantages of EHR (“How Electronic Health Records influence your daily routine and your appointments' management?”). All physicians pointed out the accessibility to patients' clinical data as an EHR advantage, making it the most mentioned advantage. About this topic, interviewees added specifically the access to vaccines, living will, exam results, other physicians' feedback and evaluation, requests and patients' follow up. 4 physicians highlighted the importance of EHR to access data when patients cannot explain themselves about their clinical data or the last appointment. 2 physicians described the advantage of EHR compared to paper-records. GP II mentioned the fact that “the information recorded on paper was frequently lost and not shared” while GP VIII described that “paper-based records take way more time than electronic records”. GP IX referred the importance of EHR has a “channel of communication between the Primary Healthcare sector and the Hospitals”. GP VIII quoted that “it saves time, helps in clinical reasoning, giving better treatments and verifying the information”. On the other hand, there were different disadvantages that were pointed out. 3 interviewees mentioned, generically, the existence of errors and system failures

leading to loss of data access and time wasting (GP I, GP II and GP X). 7 physicians highlighted, in some way, problems associated with data accessibility, interoperability issues or systems segmentation (GP I, GP III, GP IV, GP V, GP VII, GP VIII and GP IX). 2 GPs described the inability to process data as a disadvantage of EHR (GP VI and GP VII). Furthermore, 4 physicians showed concerns about data protection and privacy (GP III, GP IV, GP VI and GP IX). GP X described the time consumption of EHR – “... so many clicks which is also a waste of time. For example, the prescription program requires a lot of steps and clicks. It steals time” – and the loss in patient-physician contact – “We pay too much attention to the computer and little focus on the patient”.

The third question was “How Electronic Health Records influence your daily routine and your appointments’ management?”. 8 out of 10 physicians mentioned that EHR positively influences their daily routine associated with the clinical data access, appointments’ timely preparation and data checking. GP VI quoted that “... RSE is a huge aid to centralise all the information”. GP I described EHR as a “useful tool that can be used for investigation proposes...”. However, of these physicians, GP III, GP IV, GP V and GP VII also described a negative influence of EHR in their daily routine associated with EHR slowness and time consumption. Besides, 2 physicians referred EHR only as a negative factor impacting their daily routine mainly associated with system slowness, data access issues, time consumption and waste and poor user-friendliness (GP II and GP X). On the other hand, GP VIII and GP IX mentioned that EHR helps them save time.

When asked to “Describe your appointments’ time management and how much time do you spend dealing with tests results transcription?” (question 4), the answer was unanimous. All physicians regret the time consumption of transcription work, describing a significant period dedicated just to transcript test results and other bureaucratic tasks. GP I mentioned “at least one hour per day”, GP II answered “about 3 hours in the transcription process”, GP III said that the transcription work is “about 20-25% of a single appointment” adding that “... maybe one-fourth of a workday is dedicated to transcription of test results”. GP IV pointed out that “about half of the appointment is used to transcribe information into the system”. GP V described “an average of 5 minutes per appointment”. This physician also phrased that “about 1h30m per day is dedicated to transcription work”. GP VI said that wastes “about 10 to 15 minutes per appointment” to complete the transcription work and “an extra hour of work in order to finish everything I need to do” while GP VII mentioned “between 1h30m to 2h per day just for transcription work... even more for all bureaucratic tasks”. GP VIII referred that “about 15 to 25% of an appointment’s time” is dedicated to transcription work and “one extra hour of work” at the end of the day. GP IX pointed out that wastes 20 to 30% of patient’s appointment just to transcribe test and exam results...”. Finally, GP X mentioned that “...about 50% of the appointment’s time” is dedicated to transcription work and that needs “... about an extra 45 minutes to one hour per day...” to finish this work. Some physicians pointed out this task as “a waste of time” (GP II, GP III, GP IV, GP VI, GP VIII, GP IX, GP X), “redundant” (GP VI), waste of “productivity” (GP II), a factor that

“unnecessarily increases bureaucratic work” (GP VI) and that “impairs patient-physician communication and relationship” (GP IX), potentially harmful associated with “transcription errors” (GP IV), costly associated with patients repeating the exams (GP IV). GP IV and VI mentioned the overload associated with this task because of the need for double-checking the information contained in the exam report. GP I positively described the personal experience of working with scribes which would transcribe the exams reports for the physicians. Both GP III and GP X mentioned that “exam results should be automatically registered into RSE”. However, GP III also highlighted the fact that “there are already some blood test results that are directly recorded by the laboratory”. GP VI described her personal experience with other EHR systems. She pointed out the advances in health digitalization in the UK and in Sweden, including the absence of transcription work, the use of dictaphone and the medical prescriptions flow between physicians and pharmacies.

Question 5 was meant to study EHR time consumption in physicians’ workday (“How much time do you think you spend daily dealing with Electronic Health Records?”). GP I mentioned “1/3 to half of my workday” and added that everyday needs “extra hours” to complete everything. GP II said that “about two-thirds” of her time is “... spent dealing with RSE” and that spends “1h30 or even more to see the same number of patients compared to the paper-only era”. GP III answered that “almost the whole day” is dedicated to deal with EHR while GP IV said that it represents “two-thirds of my workday” and that has to “stay at least an extra half an hour per day to finish records”. GP V mentioned that “about 5h30m” of the workday is dedicated to deal with information systems, needing “about 30 to 45 minutes” beyond the schedule. GP VI, VII and VIII said answered “about 1/5 of my workday”, “more than half of my workday” and “five to six hours per day”, respectively. GP IX regretted that spends “more time dealing with the computer than with my patients”, describing “about 70% of the patient’s appointment” or “about 80% of my workday” just for dealing with EHR. She also said that “per week, I need about 2 extra hours to complete all my work even with 30 minutes of my schedule reserved just for bureaucratic tasks”. Finally, GP X also said that about 80% of her workday is dedicated to EHR tasks.

The third dimension started with the following question, “Could you describe what kind of problems and consequences do you face in your daily routine associated with the administrative tasks?” (question 6). Interviewees pointed out a variety of problems and consequences including decreased productivity (GP II), mental health disturbances (GP II, GP VI), physicians’ tiredness (GP III, GP X) and exhaustion (GP III), impaired physicians’ focus on the patient (GP IV, GP V, GP VI), less time with the patients (GP V, GP VII), transcription errors (GP IV) with negative consequences to clinical decisions (GP IV, GP VI, GP VIII), decreased time for clinical reasoning (GP IX), paper waste (GP IV), loss of clinical data (GP IV), psychological distress (GP V), burnout (GP IV, GP X), frustration (GP IV), demotivation (GP IV, GP VIII), feel of possibly harming the patient (GP IV), risk of forgetting important data (GP V) or letting important clinical data passing by (GP IX), impaired appointment’s quality (GP VI, GP VII) and clinical activity (GP VI), worse care delivery (GP V), emotional distress (GP VI, GP VIII),

impaired physician patient relationship (GP VII, GP VIII) and communication (GP VII) and physicians' overload (GP VI, GP VIII, GP X).

The next question continued to explore the personal experience of each physician ("Do you feel stressed/time pressured/burdened/tired?"). All physicians expressed feeling stressed, tired, time pressured or exhausted associated with bureaucratic tasks, transcription work or tasks involving EHR. GP VI, GP VII and GP VIII even expressed burnout as a possible consequence associated with this stress. Other physicians also mentioned demotivation, emotional distress and frustration.

Question 8 was intended to study if any of the physicians who mentioned feeling stressed or tired in the previous question were aware of the possible consequences of that pressure ("If yes, what are the possible consequences?"). As described before, some physicians already mentioned some possible consequences. The possible consequences referred include drop-out, early retirement, will of leaving the job or look for job alternatives, personal life issues, increased risk of clinical, therapeutical and recording errors, impaired clinical management, decreased physicians' focus and patience to patients, impaired physician-patient and colleagues' relationships, decreased physician-patient communication, impaired healthcare outcomes, physical symptoms, increased risk of suicidal ideations and other mental health disturbances.

Question 9, 10 and 11 were intended to study physicians' perception and ideas about clinical data including portability, sharing, accessibility and value. The first question of this group ("What do you think about clinical data portability and sharing?") revealed that all physicians see data portability and sharing as valuable principle for clinical activity and judgment for various reasons – patients can't give reliable information (GP II), better and more appropriate care delivery (GP III, GP IV, GP V, GP VII, GP X), for time management (GP IV), better health outcomes (GP V), patients' safety (GP VIII). GP VII and GP IX added that GPs have a central role as patients' data integrators, becoming data sharing even more important for them. 7 interviewees showed concerns about data privacy and confidentiality (GP I, GP III, GP V, GP VI, GP VII, GP VIII, GP IX). GP VI mentioned its particular concern about patients' illiteracy besides data value – "There's a lot of health and digital illiteracy among people. Patients don't have enough knowledge to understand the responsibility they must have in carrying their personal data".

The next question ("Do you think it brings added value to Healthcare delivery and quality?") also showed that all physicians believe that data sharing positively impact Healthcare outcomes, which agrees with previous question's answers. GP I described the risk of medical errors without data sharing. To highlight data sharing value, GP I, GP V, GP VI and GP VII mentioned the inability of some patients to give reliable information. GP II added the importance of improving information systems and data sharing to reduce physicians' time waste. GP VI pointed out that besides data sharing value, "patients should be more self-accountable and aware about their personal data".

The answers to question 11 (“What do you think about clinical data’s value?”) revealed that, once more, all physicians believe that clinical data is a valuable asset. All interviewees mentioned the value of data for clinical proposes with direct or indirect impact on healthcare outcomes (care delivery, health investigation, safer clinical decisions, etc). However, physicians also mentioned clinical data’s economic and political value and its value for insurance and pharmaceutical companies.

In order to investigate physicians’ knowledge about interoperability, 4 questions were made regarding dimension 5. To the question “What do you think about interoperability?”, 3 interviewees didn’t know nothing about the subject (GP V, GP IX and GP X) and 2 physicians said mentioned that they didn’t know much about the subject (GP IV and GP VIII). GP III, GP IV and GP VIII described interoperability as the ability of different programs connect with each other. GP I, GP II and GP VI expressed the importance of interoperability with the first and last of these interviewees mentioning its value in healthcare improvement. GP I, GP II and GP VII regrated the lack of interoperability between different systems.

As earlier, 3 GPs (GP IV, GP IX and GP X) said that didn’t have the knowledge to answer to question 13 (“Could you describe me what do you know about systems’ interoperability?”). The remaining physicians showed poor knowledge about the subject. Some mentioned poor interoperability as a current problem in health systems. GP I described that poor interoperability “hinders data integration”, GP III stated that “... that interoperability is good since it optimizes information systems...”, GP VI pointed out that “interoperability is important not only locally but also worldwide”, referring to patients’ care delivery independently of the country they are at the moment of treatment. GP IV also mentioned the importance of interoperability in preventing data loss and easing physicians’ work. Both GP VII and GP VIII described the redundancy of some physicians’ tasks with the first one referring the importance of improving interoperability to ease physicians’ work.

When asked specifically about semantic interoperability (Question 14 – “What about semantic interoperability? Are you familiar with this term?”) only GP VI had some knowledge about the subject. She stated that she “... heard about Snomed, ICD-10 and ICPC-2”. She also said that “... Snomed is more complete and in a net shape system”. All other 9 physicians never had heard of semantic interoperability.

Regarding question 15 (“What do you think that semantic interoperability is?”), 5 physicians said “don’t know” nothing about the subject (GP III, GP IV, GP V, GP IX and GP X) while GP I, GP II, GP VII and GP VIII said that it should be something related to language between systems. The more complete answer was from GP VI that said “It is associated with the fact that there are many different medical terminology and different medical coding methods. So, there’s been some efforts to standardize medical coding “.

Finally, dimension 6 included 2 questions. The first question was intended to see if physicians were aware of some more technical and technological solutions regarding interoperability while the second

question was about other possible solutions (technological or non-technological). Despite many of the given answers to one question were better placed in the other question, the answers were included with the original question.

To the question 16 (“What kind of solutions do you know/think that could be done to improve data sharing and interoperability?”) physicians mentioned solutions that include multidisciplinary teams that could create more user-friendly systems and in accordance with physicians’ needs (GP I, GP V, GP VI, GP IX), health systems’ maintenance (GP I), increase systems’ interoperability (GP I, GP III, GP IV, GP V, GP VI, GP VII, GP VIII), decrease the variety of health programs (GP IV, GP V, GP VIII, GP IX, GP X), physicians’ training (GP I), notification panels with essential data (GP IV), coding and semantic improvements (GP V).

The last question (“What kind of changes and solutions do you think that could improve clinical management, physicians’ time management, work efficiency and data portability?”) revealed more possible solutions described by interviewees. Physicians mentioned solutions like systems’ improvements – decrease number of clicks (GP I, GP V, GP VI, GP X) and logins (GP VI), increase automatic processes (GP I) like chronic prescriptions renewal (GP VI, GP X), increase systems’ user-friendliness (GP I, GP V, GP VI, GP X), increase interoperability and connection between systems (GP I, GP VI, GP VII, GP X), increase data access and share (GP I, GP III, GP IV, GP VI, GP X), less programs (GP III, GP V, GP VI), notification panel with important patients’ data (GP IV, GP VIII) and data processing supported by artificial intelligence (GP V, GP VI) –, the use of scribes (GP I, GP II, GP VI, GP VII, GP IX), the use of dictaphone (GP VI), give patients a more active role about their own data (GP VII, GP VIII), increase physicians’ communication (GP I), multidisciplinary teams with developers and physicians (GP VII) and physicians’ schedule with period just for administrative and bureaucratic tasks (GP IX). GP IV stated that solutions like this “would give physicians more time to spend with the patient, improve physician-patient communication and give more time to focus on the information that I am reading. I think it would increase productivity and efficiency” while GP VIII believes “that this could reduce costs, decrease physician-patient contacts, reduce the number of times that the patient has to go to the Healthcare Center and improve time and appointment’s management”.

3.2. Healthcare information systems specialists

A similar guide was used to interview 2 healthcare information systems professionals with expertise and developed work in interoperability. Both interviewees were male.

In respect to the first question (“What do you think about Electronic Health Records?”), professional I defined EHR “... as any information system with health data”, including “data that is

crucial for healthcare delivery, test results, clinical observations, discharge notes". The main concern pointed out by professional I was the importance of semantics in data coding to improve data's quality and value ("We do not need any type data. We need useful and quality data. This is related with semantics. Data can't be ambiguous and have different meanings. I have to guarantee that the information kept in one place has exactly the same meaning in another place. This is a crucial issue for healthcare systems."). Both professionals showed concerns about data's property and ownership, which should be with the patients (Professional I – "I believe that, for a better healthcare delivery, information should be with the patient, wherever the patient is."; "We have to ensure that information is close to the patient..." – Professional II – "There is some misunderstanding about data ownership. Who's responsible for them? The patient? The government? This may lead to some technical issues."; "... I find hard to believe that patients are owners of their data. They do not have full access to their data, it is difficult for them to erase or to have a copy of their data"; "Healthcare institutes are data owners when there are legal problems."; "In my opinion, the real owners of health data are software suppliers because they are the only ones who can do anything with that data without anyone notice. For me, that is closer to the definition of data's owner."; "The EHR that makes sense to me is the one that gives patients the real data ownership. In that way, health data belongs to the national sphere, not to the public or private sector"; "It should be easy for the patient to upload his own information"). Professional II mentioned the importance of semantics in healthcare systems and of including more trained professionals to improve EHR ("There're not enough people with strategic data thinking and knowledge about interoperability and healthcare databases"; "Software developers do not have enough training to resolve technological issues regarding healthcare needs. For example, terminology is one of the most critical issues regarding healthcare technology. What we can do is highly influenced by the semantic that it is used. Most of the times, these types of problems are left with developers. This should be addressed by professionals with training in health").

About question 2 ("What do you see as advantages and disadvantages of this technology for the Healthcare system?"), professional I mentioned, as advantages of EHR, the accessibility to health data and the possibility to eventually process it, bringing added value to healthcare delivery. Professional II also referred the accessibility for both healthcare professionals and patients (although only partially for patients) and processes standardization. As disadvantages, professional I pointed out the unauthorized access and abusive use of healthcare data while professional II mentioned the possible dissemination of malpractices, cybersecurity and lack of standards for data's quality. According to this professional, better data's standardization and quality would allow healthcare information systems optimization namely artificial intelligence and automatic alerts.

When asked "How do you think that Electronic Health Records influence General Practitioners (GP's) daily routine and their appointments' management?" (question 3), professional I mentioned the importance of physicians having access to good and trustful data. However, health systems shouldn't

make physicians waste time with administrative tasks (“... it doesn’t make sense to lose physicians time with administrative tasks like transcription work. It is a waste of time”). Professional II also agreed that EHR shouldn’t make physicians lose so much time with administrative tasks and suggested EHR improvements to make EHR a better physicians support to clinical practice (“One thing that I would like to see in EHR is an advanced summarizing tool for health data and then adapt that summarized information for patients’ active problems”; “The system should be capable of give insightful information about patients. This would make EHR a real physicians’ assistant in data reading and also in guidelines support”).

Question 4 was intended to understand healthcare systems professionals’ perception about the time that physicians waste daily in administrative tasks (“How much time do you think that GP’s spend daily with tests results transcription, Electronic Health Records and administrative tasks?”). Professional I mentioned “... at least, one third of physicians’ appointments time” and added that “maybe on many occasions is even more ...”. The second interviewee based his response in international studies and mentioned that “... 25% of physicians’ time and 50% of nurses’ time is spent in processing data”. He estimated that “... in Portugal, a physician spends around 40% of its time in bureaucratic tasks”. Professional II also estimated a 5-10% improvement of physicians’ time spent with bureaucratic tasks with “with positive results for healthcare system”. At this point, he mentioned future possible solutions with EHR with the inclusion of “... reading and processable aids like showing blood analyses with interpretable readings, not just non processed data”.

Regarding question 5 (“Do you think that GP’s feel stressed/pressured because of administrative tasks including transcription of tests results?”), both professionals recognized the burden of physicians’ administrative tasks. Professional I highlighted that “those tasks aren’t intellectually stimulating. There is no pleasure or satisfaction with that kind of work”. Professional II also described administrative tasks as “not stimulating for physicians”. He pointed out the fact that software developers aren’t users, which impact systems user-friendliness and that It would be important to optimize EHR to “...reduce physicians time with it ...”, to “... reduce physicians stress...” and give “... physicians more focus and time to spend with their patients”.

When asked about possible consequences (question 6 – “What are the possible consequences?”), professional I described, as possible consequences, “drop-out”, “dissatisfaction”, “negative consequences on productivity and efficiency” and “higher risk of errors”. Professional II listed, as possible consequences, worse data quality, greater difficulty in following the recommended processes and computer burden.

The following question was the first one regarding dimension 4 (“What do you think about clinical data portability and sharing” – question 7). Professional I highlighted the investments in improving data sharing namely the recent terminology agreements for laboratory test result, allowing the data exchange between laboratory centers and Primary Healthcare centers (“Since the end of 2021 till the

end of 2022, agreements between public and private entities were made to allow the exchange of laboratory tests results between more than 800 laboratory centers and more than 1000 Primary Healthcare centers with a high level of technical and semantic complexity. It is based on CPAL.”). He also pointed out the benefits that occurred with digitalization of medicines’ prescription (“...much simpler for patients, largely decreased fraud cases and enrich health data.”) and possible improving solutions (“...like drug interaction systems, therapeutic reconciliation.”). Overall, the first interviewee mentioned that the efforts are going to “improve data’s quality and confidence a lot in the near future”. Professional II pointed out the importance of defining strategies, terminologies and standards for data quality and data exchange since data sharing is fundamental to improve healthcare (“If properly done, it is, potentially, one of the most important things in healthcare.”)

About the 8th question (“Do you think it brings added value to healthcare delivery and quality?”), both professionals mentioned the importance of data to improve healthcare. Professional I described that “if we have data that we can trust and that has high quality standards, that we can reduce the risk of errors”.

When questioned about data’s value (Question 9 – “What do you think about clinical data’s value?”), professional I pointed out its great value (“Health data has great value. That’s why all Europe is trying to find a strategy to safely keep an economy of data.”) and the importance of its quality (“It is crucial to have confidence in the data. Data’s quality and safety is fundamental.”). Professional II described data’s value by mentioning the costs of not having data (“Based on the last cyber-attacks in Portugal, the costs reached millions of euros.”), its economic value during COVID-19 pandemic (“Health data has such a powerful economic value...”; “Vaccines data was very valuable.”), its value to pharmaceutical companies, ensure companies, SNS and healthcare institutions and its price in USA black market (“...health data was sold in the black market in the United States of America.”).

The first question about interoperability’s dimension was question 10 (“Could you describe me what do you know about systems’ interoperability?”). Professional I defined interoperability (“...data flow and exchange from one place to another, in a safely manner.”) and explained, succinctly, the importance of its 4 layers to improve interoperability. This includes technical interoperability (“...communication channels, accesses, know who’s accessing, I am confident with whom interacts with the network.”), semantic interoperability (“...information that it’s exchanged means exactly the same independently of the place. Information systems must speak the same language.”), organizational interoperability (“...processes, protocols and agreements between entities that allow this data exchange.”) and legal interoperability (“...legal frameworks for this data exchange to occur.”). This professional mentioned PEM and vaccines information as successful examples of interoperability implementation and laboratory test results as a in motion work with great potential for improving not only data sharing but also data quality and health outcomes (“... extraordinary capacity to exchange laboratory test results with potential for data process and exploration. And it’s data with good quality.

This is great for improving healthcare delivery, for academic studies, for population studies, for making policies, for prices adjustments”). Some other projects are in motion (“There are in motion many protocols to integrate health data from private and public sector.”). According to professional II, one of interoperability’s problems lies on the balance between the number of systems created and number of integrations that needs to be done (“Interoperability has been slowly improving but the dimension of the problem has been growing more because the number of information systems and software that we have grow faster than the number of integrations that we built. The distance to the goal of having an ecosystem were everything speaks the same language and fluently exchange data between systems is becoming bigger.”). He also highlighted that interoperability and semantics, in particular, are hard and longstanding problems to be solve.

When asked about semantic interoperability (question 11 – “What about semantic interoperability?”), professional I pointed out the importance of defining good terminologies to improve data’s quality (“It is crucial to have well-structured and quality data...”) and interoperability (“When all entities start using the same structure, codes, standards it will be much easier to exchange data.”) although the difficulty to standardize terminology (“It’s difficult to find agreements in respect to semantic and terminology standards.”). He also described the main differences between ICD-10 and SNOMED terminologies, justifying SNOMED’s quality and use. SNOMED and LOINC were recently implemented for improving laboratory test results exchange. Professional I explained the expected implementation’s expansion of SNOMED in the near future and highlighted the advantages of further expansion (“With SNOMED implementation, we can optimize data searching, navigation and processing, time management and take value from information.”). Professional II also pointed out the importance of semantics, its relation to data’s quality and take advantage it. He also mentioned the importance guarantee data’s trust (“We should have processes and mechanisms of audit to evaluate data’s quality.”) and involve medical entities in this subject (“We should have medical colleges, specialty schools and medical order defining rules”; “Medical entities should get more responsibility about this.”). He highlighted SNOMED’s value as the terminology to use to improve data’s quality (“SNOMED is a powerful tool.”; “It’s the best way to enrich health data.”; “... there is nothing better than SNOMED for clinical terminology.”; “In SNOMED CT, relationships between terms are much richer and complete. That way, we can get much more benefit from health data. This way, processing and take insights about health data is better.”).

The last question was intended to explore solutions regarding interoperability (question 12 – “What kind of solutions/projects do you know that could be done or are in motion to improve data sharing and interoperability?”). Professional I explained that, although the existence of some alternatives, SNOMED is, indeed, the best terminology to use and aggregates other terminologies. Besides, this professional highlighted the rich concepts network of SNOMED, which can be used for

future improvements as artificial intelligence. Professional II described the 4 layers of interoperability structure and gave the solutions for each layer that he finds useful to improve interoperability.

3.3. Analysis

3.3.1. General Practitioners' results

Dimension 1 included a variety of principles and ideas about EHR. The obtained results showed that physicians recognize the benefits of EHR as a tool to record health data and use it as an assistant during clinical activity and decision-making. Health data is an asset that should be preserved and maintained. Results are in line with this principle since physicians highlighted the importance of data access. These results are in accordance with the literature review like the ONC's list of EHR advantages.

However, physicians listed a variety of disadvantages namely poor connectivity and interoperability, data accessibility, poor user friendliness, inability to process data, time wasting, data privacy issues and EHR segmentation which are identified problems internationally as we can see in the literature review (Black et al., 2011; Makam et al., 2013; Bank et al., 2013; Medical Economics EHR Study Update. 2012; Ehrenfeld & Wanderer, 2018; Howard et al., 2013; Laitinen et al., 2014; Nguyen et al., 2014; Wells et al., 2014; O'Malley et al., 2015; Topaz et al., 2017; Al-Rawajfah & Tubaishat, 2019; Priestman et al., 2018; Liew & Harjadinata, 2017; King et al., 2017; Hamamura et al., 2017; Gesulga et al., 2017).

About dimension 2, the results of physicians' time consumption of transcription work, EHR and administrative tasks are in line with the results presented in the literature review. Physicians even point out some problems like time wasting, redundancy, loss of productivity, increased bureaucratic work, jeopardized patient-physician communication and relationship, errors and financial waste which are in accordance with the information gathered in the literature review.

Considering dimension 3, once again, the results obtained with physicians' interviews show many problems that are already documented in a variety of studies that were mentioned in the literature review of this thesis. The interviewed physicians expressed themselves as being stressed, tired, demotivated, distressed, frustrated, time pressured and exhausted associated with bureaucratic tasks, transcription work and tasks involving EHR. All this pressure can have negative consequences that have been reviewed previously. Many were mentioned by interviewees like drop-out, early retirement, will of leaving the job or look for job alternatives, personal life issues, increased risk of clinical, therapeutical and recording errors, impaired clinical management, decreased physicians' focus and patience to patients, impaired physician-patient and colleagues' relationships, decreased physician-

patient communication, impaired healthcare outcomes, physical symptoms, increased risk of suicidal ideations and other mental health disturbances.

Physicians were unanimous about the importance of data exchange and sharing. Besides, health data's value on healthcare outcomes was also unquestionable (dimension 4). This is in accordance with the evidence shown previously in the literature's review. Many physicians showed concerns about data privacy and confidentiality.

Regarding interoperability (dimension 5), results show that physicians are poorly informed about information systems. Some presented a very scarce and unspecific idea about the subject. This shows that, although technology has a big presence in the daily routine of physicians, they are poorly aware of the specificities of it. Only one physician showed a better understanding semantic interoperability.

In respect to possible solutions (dimension 6), the results show that physicians are aware that technology and medicine have a tight connection, which justifies the creation of multidisciplinary teams to build systems that have both physicians and developers' point of view. Other solutions include interoperability and EHR improvements like data processing aids, increased automatic processes and notification panel with important patients' data.

3.3.2. Healthcare information systems specialists' results

Regarding dimension 1, healthcare information systems specialists showed a more robust knowledge about EHR, which was expected. Both experts revealed concerns about data's ownership and the importance of semantics to improve EHR, interoperability and data's quality and value, which was discussed and mentioned in the literature review. The main advantage seen by these experts was healthcare professionals' access to health data and potential for data processing aids with benefits for healthcare. Both mentioned some disadvantages including unauthorized access, abusive use of healthcare data, possible dissemination of malpractices, cybersecurity and lack of standards for data's quality. According to the interviewees, EHR shouldn't make physicians lose time and should be upgraded and improved to become a real physicians' assistant in clinical practice.

Interestingly, both healthcare information systems specialists showed an accurate perception of physicians' time consumption of administrative tasks and were sensitive to the subject (dimension 2), mentioning numbers not far from the ones found on the literature review and from the ones referred by the interviewed GP.

Both experts recognized physicians' burden caused by administrative tasks, which is a problem that should be addressed with EHR and systems' optimization. They pointed out some possible consequences like drop-out, dissatisfaction, impaired productivity and efficiency, higher risk of errors,

worse data quality, greater difficulty in following the recommended processes and computer burden (dimension 3), which are in line with the review of the literature.

Information systems specialists mentioned the unmeasurable value of health data. Data is crucial to improve healthcare outcomes, but data's quality standardization is equally crucial to create trustful and exchangeable data. Semantics and terminology were mentioned by both professionals as a fundamental key to accomplish those goals (dimension 4). The main ideas referred by both professionals include data's value, data's market and the importance of interoperability standards, which are all in accordance with the European entities' view of health data, reviewed in the first chapter of this dissertation.

Once again, the level of knowledge and detail regarding data and interoperability was obvious (dimension 5). Interoperability should be carefully addressed in its 4 layers. Although they are all important, both professionals reinforced the importance and difficulty of establishing agreements for semantic interoperability. Semantics is fundamental to produce quality and trustful data and, in turn, take the most advantage of it. All the information shared by these experts are in accordance with the literature. Both professionals showed the complexity and completeness of SNOMED, a medical terminology with a great network of medical concepts and relationships.

Solutions to improve EHR, healthcare systems and interoperability (dimension 6) included the implementation of SNOMED in Portuguese healthcare and the improvement of all 4 layers of interoperability. The information given by both professionals about interoperability's layers are in line with the literature review, which was detailed previously according to the EIF. Both professionals mentioned extensively SNOMED as core element to improve semantic interoperability.

3.4. Synthesis

EHR is a valuable tool since it is meant to keep record of patients' health data. In turn, health data is an asset with great potential for improving healthcare delivery and quality. To take the most advantage of it, we must guarantee data's quality and trustfulness. To achieve this objective, standardization of terminology and semantics must be a top priority. Semantics is one of interoperability's layer that has been a focus for several entities. Besides, a health data market and ecosystem where data is safely exchanged as been one of Europe's priorities.

Alongside this principle, EHR presents with both advantages and disadvantages that impact several aspects in healthcare. Some of its disadvantages severely impact physicians time, efficiency, productivity, satisfaction and distress. In turn, these consequences can lead to physicians' burnout, drop-out, depression and other personal problems which negatively impact healthcare and patients' outcomes. Some of current EHR characteristics that are pointed out as disadvantages that can lead to

those negative consequences include lack of interoperability and of userfriendliness. This leads to higher loads of administrative tasks and, in turn, physicians' dissatisfaction. So, it becomes clear that this issue is complex net of connections and relations between EHR, causes and consequences.

Putting all this together, interoperability reveals as a crucial subject do solve. Lack of interoperability it's a scourge for portuguese healthcare and standardization of semantics must be addressed. There are several terminologies. However, SNOMED-CT seems to be the most complete medical terminology. SNOMED can be a valuable help to standardize semantics and improve interoperability.

Conclusion

Electronic health records became an important technological innovation with the advent of digital transformation in healthcare. EHR utility and data's value are unquestionable.

Health data is an asset that should be preserved and protected. A recent study (Correia R., 2023) estimated a financial loss between 115.882,96€ and 2.317.659,11€ associated with cyber attacks in SNS from 2017 to 2022. This shows the unquestionable value of health's data, not just restricted to improve healthcare delivery. If health data is so important for clinical decision making and for healthcare delivery improvements, then interoperable information systems should be a priority. In the modern world where everything is becoming more and more digitalized, health sector is no exception. However, we see many conflicts and barriers on technological evolution and innovation in health's public sector. Many software's are created to assist physicians on their clinical practice but they lack on interoperability between them. The obtained results from physicians' interviews share similarities with the ones found in the literature review. Physicians loose too much time dealing with EHR and they are overloaded with bureaucratic tasks, including the transcription work associated with lack of interoperability between health information systems. This leads to loss of productivity, stress and burden. It is in this context that this thesis urges with the objective of enlight about systems interoperability. It is mandatory to give some insight about this matter. Interoperable systems are a main concern that should be addressed promptly.

Improving systems' interoperability will improve health professionals' productivity and satisfaction, alleviate physicians' load, improve data sharing and portability, improve physicians' decision-making process, improve care delivery and decrease the risk of errors and mistakes. The current evidence suggests some benefits of interoperability improvements in healthcare outcomes. Li Y. and colleagues showed a 12% improvement in interhospital transfer time and a 3 percentage points decrease in readmission rates (Li et. al, 2021). Eftekhari's study found a reduction in repetition of therapeutic medical procedures associated with information exchange (Eftekhari et. al, 2017). Another study revealed an improvement in emergency department procedures thanks to better interoperability (Everson et. al, 2017). They showed that a faster information access was associated with a reduction in visit length (52.9 minutes shorter), in imaging probability (2.5, 1.6, and 2.4 percentage points lower for CT, MRI, and radiographs, respectively), in the likelihood of admission (2.4 percentage points lower) and in the average charges (\$1187 lower). Ayabakan and colleagues demonstrated a lower duplication rate, manly in radiology tests, associated with better data exchange (Ayabakan et. al, 2017). Ayer and colleagues found a reduction of 10,2% in the length of stay and a reduction in the time spend in the emergency department by patients with severe or multiple comorbidities in the presence of better interoperability and information exchange policies (Ayer et. al, 2019). In their study, Chen et. al, showed a 20%, 22% and a 24% reduction in the 30, 45 and 60 all-

cause readmission rates of acute myocardial infarction into the group of patients that were being treated in a hospital undergoing an interoperability improvement program (Chen et. al, 2019). Another study (Tzeel et. al, 2012) also showed less inpatient hospital days and shorter length of stay. Vest and colleagues estimated, in their study, a 57% reduction in the likelihood of readmission and annual savings of over \$600000 (Vest et. al, 2015). In another study by Vest and colleagues (Vest et. al, 2014), the authors associated interoperability with a reduction in hospitalizations from the emergency department and with cost savings (30% reduction of admission odds and \$357000 annual savings).

As previously mentioned, semantic interoperability is the capacity to keep and preserve shared information's meaning through different information systems. This is directly associated with clinical terminology. So, it is crucial to define standards and implementations' strategies regarding semantics to improve health systems' interoperability. SNOMED CT (Systemized Nomenclature of Medicine – Clinical Terms) consists in a clinical healthcare and international terminology (SNOMED International, 2021). It is a proven and renowned terminology that enhances semantic interoperability, preserving health data representation. This is especially important in an evolving digital world. In Portugal, ICD-10 (International Classification of Diseases, version 10) and ICPC-2 (International Classification of Primary Care, 2nd edition) are well-known and used clinical terminologies. ICD-10 has a mono-hierarchical structure while SNOMED CT is poly-hierarchical (Vikström A. et al., 2010). In SNOMED CT, terms have certain attributes making it possible to connect concepts and build relationships (Vikström A. et al., 2010). This mapping strategy is advantageous for healthcare data aggregation, description, documentation, representation and preservation of clinical details (Vikström A. et al., 2010). ICD-10, although widely used in Portugal, it has a statistical focus while SNOMED CT is a better terminology tool for capturing health and clinical data details (Fung, K.W., 2012). This means that SNOMED CT gives a better base to produce consistent, comprehensive and reliable clinical data and to process information, making it more suitable for a database structure has EHR (International Health Terminology Standards Development Organisation, n.d.; International Health Terminology Standards Development Organisation, 2014). It is important to adopt a universal language terminology to improve semantic interoperability and, consequently, interoperability as a whole. This will result in improved health and patient outcomes (SNOMED International, 2021).

As we can see in SNOMED International's Executive Summary (SNOMED International, 2021), SNOMED CT "is the most comprehensive, multilingual, clinical healthcare terminology in the world", "... a resource with scientifically validated clinical content that is released globally, twice per year", "enables the consistent representation of clinical content in clinical information systems, health data and analytics platforms, and interoperability solutions", "is mapped to other international standards" and "is adaptable to each country's requirements". This makes SNOMED CT a great clinical terminology language capable of breaking boundaries and limitations in current interoperability issues faced in the Portuguese health information systems. More than just being able to improve interoperability

between two or more software used in Portugal, this has the potential to improve interoperability across borders (health tourism). With this improvement, physicians waste less time in bureaucratic tasks like transcription of test results or duplication of records (if two software are not interoperable, physicians must record the same data twice, increasing time waste) and can spend more time with their patients. This increases physicians and patients' satisfaction, increases physicians' focus on clinical reasoning and decreases the risk of clinical and recording errors.

To further comprehend SNOMED CT dimension, SNOMED CT contains a volume of more than 350.000 terminologies while ICD-10 has around 120.000. This drives from SNOMED CT collaboration with other terminologies like ICPC-2 or ICD-10, making it a core reference for clinical terminology (SNOMED International, 2021).

In matter of fact, in the present year, we assist a new era for SNS with the recent introduction of some blood test results automatically in patients EHR. This interoperability between laboratory centers and primary healthcare was thanks to agreements and protocols for implementation of SNOMED CT terminology. This evolution in semantic interoperability constitutes one of the first steps to a better and stronger health digitalization in SNS.

SNOMED CT represents a semantic standard that allows clinical information sharing, i.e., "electronic exchange of clinical data and documents among Care Providers along the continuum of care, often using interoperability solutions" (SNOMED International, 2021). In other words, SNOMED CT has the potential to improve systems data quality. This thesis showed that systems' interoperability issues constitute a big flaw in healthcare with devastating consequences and costs. The previous mentioned use of SNOMED CT is one of the main reasons to consider it as a valuable solution to implement. However, there are other advantages that worth mentioning. As we can see in its executive summary (SNOMED International, 2021), SNOMED CT can also be used for research ("conducting clinical research, laboratory research and scientific research"), for data entry and integration ("the recording and integration of SNOMED CT in clinical information systems and health data & analytics platforms"), for point-of-care analytics ("creating historical summaries, doing point-of-care reporting and using clinical decision support"), for population analytics ("conducting trend and comparative analysis, pharmacovigilance and clinical audit") and for management analytics ("conducting trend & comparative analysis and health system value analysis"). So, SNOMED CT seems to be a clinical terminology tool that worth our investment.

As mentioned in the literature review, interoperability in general and semantic interoperability in particular, has been a concern for the European Union. Thus, finding a standard for semantics is crucial for improving e-health. What has been shown with this thesis is that SNOMED CT seems a great tool to standardize a language capable of improving systems interoperability, data sharing and exchange.

This thesis presents some strengths and weaknesses that worth mentioning. Regarding its strengths, this dissertation gives insight about the Portuguese healthcare systems reality and impact,

which is poorly explored in the current available literature. Two groups of directly involved professionals were interviewed, giving valuable information about the subject. Besides, an extensive and detailed review of the literature was performed, providing a clear spectrum of interoperability dimension and importance. Finally, a clinical terminology is reviewed, showing great potential to improve healthcare systems semantics and interoperability. On the other hand, the main limitation of this work is the reduced number of interviewed health systems experts, which can be a bias factor and limits statistical significance.

Summarily, in this dissertation's introduction, 1 general objective and 3 specific objectives were established. The developed work gathers coherent and clear evidence, allowing the achievement of each one of the proposed objectives. EHR is a powerful tool with some inconvenients that impact physicians' routine. It carries and stores health data. Good data is crucial for better healthcare. This means that quality data and its exchange are fundamental for healthcare. To accomplish better data and its sharing, agreements on semantic standardization must be a priority. This will improve semantic interoperability, bringing many benefits to healthcare. This is a worldwide concern. Europe and the USA have been working in many strategies to standardize and improve interoperability. EIF is a good example of Europe's efforts to improve interoperability in all its layers. Portuguese physicians' needs and complains are not different from the ones identified in other countries. The evidence suggests that a good terminology is beneficial to improve data's quality, reliability, semantical standards, and interoperability with positive impact on healthcare. SNOMED CT is a complex and robust terminology with great potential to improve semantical interoperability and healthcare systems.

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Appendices

Appendix A: Breakdown of dissertation timescale.

	Aug/22	Sept	Oct	Nov	Dec	Jan/23	Febr	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	
Literature review																
Thesis redaction																
Questionnaire elaboration																
Questionnaire application																
Data analysis																
Thesis presentation																

Appendix B: Interviews' guide to General Practitioners

Interviews' guide – Systems' Interoperability

Interview

Convenience sample – GP's

Dimension 1

1. What do you think about Electronic Health Records?
2. What do you see as advantages and disadvantages of this technology?
3. How Electronic Health Records influence your daily routine and your appointments' management?

Dimension 2

4. Describe your appointments' time management and how much time do you spend dealing with tests results transcription?
5. How much time do you think you spend daily dealing with Electronic Health Records?

Dimension 3

6. Could you describe what kind of problems and consequences do you face in your daily routine associated with the administrative tasks?
7. Do you feel stressed/time pressured/burdened/tired?
8. If yes, what are the possible consequences?

Dimension 4

9. What do you think about clinical data portability and sharing?
10. Do you think it brings added value to Healthcare delivery and quality?
11. What do you think about clinical data's value?

Dimension 5

12. What do you think about interoperability?
13. Could you describe me what do you know about systems' interoperability?
14. What about semantic interoperability? Are you familiar with this term?
15. What do you think that semantic interoperability is?

Dimension 6

16. What kind of solutions do you know/think that could be done to improve data sharing and interoperability?
17. What kind of changes and solutions do you think that could improve clinical management, physicians' time management and work efficiency?

Dimensions	Questions
1. Electronic Health Records	Questions 1 – 3
2. Test results transcription and time consumption	Questions 4, 5
3. Burnout	Questions 6 – 8
4. Clinical data value	Questions 9 – 11
5. Interoperability	Questions 12 – 15
6. Solutions	Questions 16, 17

Appendix C: Interviews' guide to healthcare systems experts

Interviews' guide – Systems' Interoperability

Interview

Convenience sample – Healthcare systems experts

Dimension 1

1. What do you think about Electronic Health Records?
2. What do you see as advantages and disadvantages of this technology for the Healthcare system?
3. How do you think that Electronic Health Records influence General Practitioners (GP's) daily routine and their appointments' management?

Dimension 2

4. How much time do you think that GP's spend daily with tests results transcription, Electronic Health Records and administrative tasks?

Dimension 3

5. Do you think that GP's feel stressed/pressured because of administrative tasks including transcription of tests results?
6. What are the possible consequences?

Dimension 4

7. What do you think about clinical data portability and sharing?
8. Do you think it brings added value to Healthcare delivery and quality?
9. What do you think about clinical data's value?

Dimension 5

10. Could you describe me what do you know about systems' interoperability?
11. What about semantic interoperability?

Dimension 6

12. What kind of solutions/projects do you know that could be done or are in motion to improve data sharing and interoperability?

Dimensions	Questions
1. Electronic Health Records	Questions 1 – 3
2. Test results transcription and time consumption	Question 4
3. Burnout	Questions 5, 6
4. Clinical data value	Questions 7 – 9
5. Interoperability	Questions 10 – 11
6. Solutions	Questions 12

Appendix D: General Practitioners - results

GP	Questions	Answers	Subdimensions	Dimensions	
1	1	"I think it is a useful tool with a lot of clinical and nonclinical data that we can access through Sclinico".	EHR characteristics and utility	1	
		"I find really useful to access clinical data from hospitals".	EHR's data access	1	
		"It also gathers information about vaccines and have a visual patients' chronogram".	EHR's data access	1	
		"However, I think that there is a poor connection and coordination with other systems".	EHR connection issues	5	
		"There's a lot of failures and errors; sometimes, I cannot access hospitals' data".	EHR problems	1	
	2	Advantages			
		"Information integration, many accessible data".	EHR's data access	1	
		"Accessibility to other Healthcare Centers, Hospitals and institutions; access to vaccines and clinical and nonclinical information".	EHR's data access	1	
		Disadvantages			
		"Many system's errors and failures".	EHR issues	1	
	3		"The only way to access RSE is through Sclinico".	EHR issues/drawbacks	1
			"Useful tool that can be used for investigation proposes namely to study clinical data".	EHR advantages and utility	1
			"The possibility to access other colleagues' opinion about a patient, appointment's request, appointment's date, etc."	EHR characteristics and utility	1
			"Often, patients cannot give clinical history and I use RSE to clarify patient's information".	EHR advantages and utility	1
	4		"I think that RSE is a simple and intuitive tool, I can access the information I need with few steps".	EHR's data access and utility	1
			"At least one hour per day".	Time consumption	2
			"I don't like to steal time from patient's appointment so I often save the results and do the transcription at the end of my workday".	Time management and bureaucratic tasks' time consumption	2
			"When the test and exam results are available in RSE and I what to make them available in Sclinico, it is really easy and fast because I just have to copy and paste".	Data accessibility through RSE	1, 2
			"I had the experience of working in a Healthcare Center where there was a medical administrative who transcribed all tests and exams results. So, I find that scribes, someone that could do the transcription work instead of the of physicians, could be something of great value".	Exam results' transcription and use of scribes	2, 5
	5		"It is a shame that not every blood and imaging tests can be accessed".	EHR's clinical data access	1
			"1/3 to half of my workday".	EHR's time consumption	2
	6		"Every day I need extra hours to finish all records and the transcription work".	Time consumption of transcription work and bureaucratic tasks	2
			"We waste too much time dealing with transcription and bureaucratic work. Many times, we need extra hours to finish all of these tasks and it is not medical activity".	Time consumption of transcription work and bureaucratic tasks	2
7		"I think it's a shame that we are so dependents on health information systems but, if they fail, we don't have data backup".	EHR dependency and drawbacks	1	
		"I feel tired; it is exhausting to feel obligated to leave everything recorded".	Physician's overload	3	
		"I think that data entry is redundant. I have to entry the same data over and over again".	EHR drawbacks and physician's overload	1, 2	
		"I feel that health information systems were made from software developers to software developers. It's too segmented, there's too many clicks and steps to do in order to achieve a goal. It makes me lose too much time".	EHR drawbacks and time consumption	1, 2	

GP	Questions	Answers	Subdimensions	Dimensions
I	7	"It impairs clinical flow".	EHR drawbacks	1
		"Systems should be an aid and improve physicians' work but what I feel is almost like they control us. They mostly hamper our work".	EHR drawbacks	1
		"The focus is no longer the patient which is wrong".	EHR drawbacks	1
		"I feel stressed before and after my appointments".	Physician's overload	3
		"Patient's information is spread all over different systems and software's and I have to lose so much time looking for everything I need in order to make a good information's management and centralisation".	EHR drawbacks and time consumption	1, 2
		"Time pressure, stress in order to finish all records".	Physician's overload	3
	8	"It steals personal time".	EHR drawbacks and physician's overload	3
		"Drop-out, look for job alternatives".	Physician's overload	3
		"I feel that I take the stress back home, I am always hurried".	Physician's overload	3
		"I feel I am always racing against time".	Physician's overload	2, 3
		"It affects personal life"	Physician's overload	3
	9	"I believe that possible harms are outweighed by the benefits of data sharing".	Data accessibility	4
		"Patients' data privacy should be preserved".	Data privacy policies	4
		"Data access shouldn't be blocked".	Data accessibility	4
	10	"Yes, it brings added value to healthcare services and improves its quality. I also believe that it is makes healthcare delivery safer. Otherwise, the risk of medical errors increases".	Clinical data benefits	4
		"Often, patients cannot give reliable information. They can make mistakes and give wrong information. So, data accessibility is crucial to deliver better care".	Clinical data access benefits	4
		"I believe that data share have prevented many clinical errors".	Clinical data benefits	4
	11	"Clinical data are very important and bring added value".	Clinical data value	4
		"Half of the physicians' appreciation value is due to clinical data".	Clinical data importance in physicians' activity	4
		"Much of physicians' current activity would be impossible to do without clinical data access or could take way more time to get valuable data".	Clinical data importance in physicians' activity	4
12	"I think that interoperability is crucial. It brings added value to both physicians and patients".	Interoperability importance and value	5	
	"It would save much more time if interoperability was improved".	Interoperability value and time management impact	2, 5	
13	"I believe that there is lack of systems' interoperability which hinders data integration".	Poor interoperability drawbacks	5	
	"Maybe this occurs because of different software developing teams design different softwares".	EHR drawbacks, systems segmentation and possible explanations	1, 5	
14	"I don't know".	-	-	
15	"Same language in order to smoothed data integration".	Semantic interoperability meaning and importance	5	
16	"There should be someone on the field in order to understand which are the physicians' needs. Make systems' improvements in order to become more user-friendly and in accordance with end-users' needs".	Possible solutions to attend phisicians' needs	6	

GP	Questions	Answers	Subdimensions	Dimensions
I	16	"Make health information systems more unified".	Unify healthcare systems	6
		"Gather and diagnose systems' errors and physicians' needs and make the necessary improvements".	Possible solutions to attend physicians' needs	6
		"More systems' maintenance".	Healthcare systems maintenance	6
		"Physicians training and updates about health information systems".	Healthcare professionals training	6
	17	"Fewer clicks, the use of scribes, more automatic processes in order to decrease the time dealing with the computer, more simple and user-friendly systems and less fragmented health information systems".	Possible solutions including system improvements and human resources allocation	6
		"I think that data access should be expanded. I only can access my patients' data on the office. So, if I have to complete some records or clarify some information, have to go back to my office. It should be possible to access data outside of my workplace".	EHR improvements	1, 6
		"Data should be more accessible and shared. For example, if my patient is being seen by other healthcare professionals like a nutritionist, a nurse or a dentist, they don't have access to the information that I registered. Many times, this means an extra appointment with me just to clarify some data for the other colleague".	Solutions that include expanding data accessibility with impact in time consumption and management	1, 2, 4, 6
		"Thus, I believe that data's portability and accessibility is still lacking compared to healthcare professionals' needs".	Poor data accessibility	4
		"Health information systems should allow a better connection and easier communication between physicians".	Interoperability improvement	5, 6

GP	Questions	Answers	Subdimensions	Dimensions	
II	1	"It is a good tool".	EHR utility	1	
		"Back then, there was no digital information and support; So, all information that I obtained was exclusively from the patient. Now, I can confront the information given by the patient with the information from other physicians and healthcare professionals attending the patient".	EHR advantages and utility	1	
	2	Advantages			
		"Get a better and more robust knowledge about patients' clinical information".	EHR advantages and utility	1	
		"Access to clinical information and explain it to the patient when they don't understand the information that other healthcare professional gave them".	EHR advantages and utility	1	
		"I can see if the patient went to the hospital and see the newest data".	EHR advantages and utility	1	
		"In the old days, the information recorded on paper was frequently lost and not shared".	Before EHR existence	1	
		Disadvantages			
	"If there is a system failure, we lose the complete access to clinical information".	EHR disadvantages	1		
	3	"Nowadays, information systems make me spend more time to do my work".	EHR time consumption	2	
		"I spend about 1h to 1h30 more than before".	Time consumption	2	
		"Information systems are not user-friendly".	EHR drawbacks	1	
		"It's stressful and makes me angry because, many times, it disturbs my workflow".	EHR drawbacks and physicians' overload	3	
		"Sometimes, I have to write the information on a paper and later, even after-hours, transcript the information to the system".	Transcription work and time consumption	2	
		"I spend too much time looking at the computer and not paying attention to the patient".	EHR disadvantages and time consumption	1, 2	
	4	"Sometimes, there so much information to introduce in the system about one single patient that it is equivalent to the appointment time (20 minutes)".	Data entry and time consumption	2	
		"I schedule appointments without the patient's presence just to evaluate and transcribe patient's data and, then, I call them to give feedback".	Time consumption	2	
		"About 3 hours in the transcription process. It a waste of time and productivity".	Transcription work, time consumption and impact on productivity	2	
	5	"Nowadays, I spend 1h30 or even more to see the same number of patients compared to the paper-only era".	EHR time consumption and impact on productivity	2	
		"About two-thirds of my time is spent dealing with RSE".	EHR time consumption	2	
		"Again, I feel that productivity would rise substantially without all of this technology disturbance".	EHR disadvantages and time consumption	1, 2	
	6	"It decreases productivity".	Impact on productivity	2	
		"I could see more patients without the interference of information systems".	Impact on productivity	2	
"My mental health and patience could be better" (without the system failures and if it was more user-friendly).		Physicians' overload and distress	3		
7	"I feel stressed".	Physicians' overload and distress	3		

GP	Questions	Answers	Subdimensions	Dimensions
II	7	"Formerly, I used to see more patients and feel less tired then nowadays".	Physicians' overload, distress and impact on productivity	2, 3
	8	"Increased risk of making clinical mistakes".	Physicians' overload and risks	3
		"Less patience to take care of patients".	Physicians' overload and distress	3
		"Worse clinical management".	Impact on productivity and on outcomes	2, 3
	9	"I think it is a positive thing that adds clinical value".	Clinical data portability and value	4
		"It gives access to data that otherwise would be impossible to have".	Clinical data access	4
		"Many times, patients can't, reliably give their clinical history so, the possibility to share information is very important".	Clinical data portability advantages	4
	10	"Yes, it brings more value to the Healthcare system, but the information systems must be improved in order to make physicians lose less time".	Clinical data portability advantages, time consumption and EHR drawbacks	1, 2, 4
	11	"There are some really important clinical data; So, I believe that I is fundamental to share information and to have access to clinical data".	Clinical data value and importance	4
	12	"It doesn't makes sense that I have to double enter the information, the systems should be interoperable".	Lack of interoperability and impact on time consumption	2, 5
		"It is important to have interoperability".	Interoperability importance	5
	13	"There are already some blood test results that are automatically recorded in the system".	EHR and current interoperability improvements	5
	14	"I don't know, never heard of it".	-	-
15	"Maybe it is related with different words meaning the same?".	Semantic interoperability meaning	5	
16	"Don't know...maybe a program?".	Possible solution	6	
17	"The use of scribes, someone that could do the transcription work instead of the physician".	Human resources solution	6	

GP	Questions	Answers	Subdimensions	Dimensions	
III	1	"It is a good platform; it gives physicians access to patients' clinical data from Primary Healthcare Services and from Hospitals; however, it could be better".	EHR characteristics, advantages and utility	1	
		"Only the information obtained from a Healthcare public service is available. It should also have the data recorded in the private sector".	EHR drawbacks	1	
	2	Advantages			
		"Access to important clinical data that otherwise would be impossible to obtain".	EHR advantages	1	
		"Many times, patients cannot explain correctly the information given by another healthcare professional. So, with the health digitalization, we can confirm the data".	EHR advantages	1	
		Disadvantages			
		"Possible unauthorized access to patients' information".	EHR disadvantages and privacy issues	1	
	3	"Sometimes, there is some information missing, not all data is available in RSE".	EHR disadvantages	1	
		"I believe that positively influences my daily routine because I can access to important clinical data, see the patient follow-up and evolution/progress with other physicians and helps me making better clinical decisions".	EHR benefits and positive impact	1	
	4	"However, many times, the information system is slow or it doesn't work correctly, negatively impacting my daily routine".	EHR drawbacks and negative impact on time management	1, 2	
		"The transcription work is a waste of time. Tests and exams' results should be automatically available".	Time consumption of transcription work	2	
		"Tests done in the Hospital are available in RSE but we have to search for them... many clicks to get them and if we do not copy them to our Sclinico, there are not directly available for us".	EHR drawbacks and systems' disadvantages. Time consumption of EHR tasks	1, 2	
		"Basically, all requested tests that patients bring to us are not directly recorded in the system so we have to transcript all of them".	Time consumption of transcription work	2	
		"It would so much better if laboratories make test results directly available into the system".	Interoperability improvements advantages	5, 6	
		"Although rare, there are already some blood test results that are directly recorded by the laboratory center into RSE".	EHR and current interoperability improvements	1, 5	
		"So much time in the transcription process, about 20-25% of a single appointment...it is variable but maybe one-fourth of a workday is dedicated to transcription of test results".	Time consumption of transcription work	2	
		5	"Almost the whole day... excluding patient's examination".	EHR time consumption	2
		6	"It is a waste of time".	Time consumption	2
			"It is tiring and exhausting".	Physicians' overload and distress	3
	7	"Yes, it is exhausting to realise that I have so many time-demanding tasks to do and see the time passing by...time is limited".	Physicians' overload and distress	3	
	8	"It increases the risk of medical errors, having so many information to register is demotivating, bringing home the work stress and pressure, having to stay working extra-hours... all of it negatively impact the personal life".	Physicians' overload and distress. Time consumption. Risks	2, 3	
9	"It is good and very useful for the clinical decision process".	Clinical data importance	4		
	"It allows us the chance to offer a better and more adequate treatment and follow-up".	Clinical data benefits	4		
	"Health data share is crucial".	Clinical data share value	4		
	"Possible harm of data sharing and portability is the unauthorized access to clinical information, but I believe that this is outweighed by the benefits".	Clinical data sharing and privacy	4		

GP	Questions	Answers	Subdimensions	Dimensions
III	10	"It brings added value since it improves patients caring and Healthcare services".	Clinical data benefits and value	4
		"It allows data checking and confirmation".	Clinical data importance	4
	11	"Clinical data is crucial not only at a medical level (decision making) but also for health ensure companies, which leads me toward the importance of the limits of data access. So, clinical data has great value".	Clinical data value	4
	12	"The possibility to make different systems work together".	Interoperability concept	5
	13	"I think that interoperability is good since it optimizes information systems by taking advantages from different systems".	Interoperability advantages and benefits	5
	14	"I don't know".	-	-
	15	"I don't know".	-	-
	16	"The possibility to make all test results automatically available in RSE and make them easily accessible and organized in Sclinico".	Interoperability and data access improvements	6
	17	"Decrease transcription work by giving physicians a direct access to patients' data".	Data access improvements and decreasing bureaucratic work	2, 6
		"Create a single working software instead of multiple health programs".	Interoperability improvements	6

GP	Questions	Answers	Subdimensions	Dimensions	
IV	1	"It is an excellent and useful tool".	EHR advantages and utility	1	
		"Allows us the access to information from other physicians attending the patient, namely hospital's data".	EHR utility	1	
		"Gives us access to some test and exam results like the ones done in the hospital. It also gives us access to valuable data namely vaccines, prescriptions".	EHR utility	1	
		"Unfortunately, there are Hospitals that work with different systems, impairing systems connection and data accessibility".	EHR drawbacks	1, 5	
	2	Advantages			
		"The access to clinical data and other important information namely, other physicians' evaluation and feedback, test and exam results, appointments' dates and requests state".	EHR advantages	1	
		Disadvantages			
		"Poor connectivity between different information systems. They should be more connected... I have to exit Sclinico to enter RSE".	EHR disadvantages and interoperability issues	1, 5	
		"Not having access to some data like the one from the private sector and even some information from a few public hospitals".	EHR disadvantages and interoperability issues	1, 5	
	3	"Clinical data privacy and confidentiality issues. Healthcare professionals not attending the patient shouldn't have access to patient's data".	Clinical data importance, value and confidentiality issues	1, 4	
		"It is mainly positive because allows me to access important patients' data. I am managing a new group of patients, so it is very important to me to access and gather all the data I need from different information systems in order to make my clinical decisions".	EHR data access and clinical data value	1, 4	
	4	"It negatively impacts my routine when it fails and doesn't work...".	EHR disadvantages and drawbacks	1, 2	
		"It is a tremendous waste of time and can be dangerous because I can unintentionally commit transcription errors".	Time consumption and risks	2	
		"Increased costs because if the information is wrong or the patient forgets to bring the exams results, it can mean that the patient has to repeat them".	Increased costs	2	
		"About half of the appointment is used to transcribe information into the system".	Transcription work and time consumption	2	
	5	"It causes work overload. When I am recording test and exam results into the system, I can't pay attention to what I am reading so, I have to write first and then read the results".	Physicians' overload and time consumption	2, 3	
		"Two-thirds of my workday is to deal with RSE".	EHR time consumption	2	
	6	"I have to stay at least an extra half an hour per day to finish records".	EHR time consumption	2	
		"It steals the focus on the patient".	Transcription work drawbacks	2	
		"Possible transcription errors which, in turn, can badly influence clinical decisions".	Transcription work errors and impact on decision making	2	
		"A lot of paper waste".	Waste and disadvantages	2	
"The test results can be lost which means loss of clinical data".		Risks and harms	2		
7	"Burnout, frustration, demotivation, feel of possibly harming the patient".	Physicians' overload and distress	3		
	"Yes, I feel pressured and stressed".	Physicians' overload and distress	3		

GP	Questions	Answers	Subdimensions	Dimensions
IV	7	"New patients, a lot of exams and information to analyse and register into the system".	Physicians' overload, distress. Time consumption	2, 3
	8	"More tired, less focus and higher risk of committing medical errors".	Physicians' overload and distress. Risks	3
		"Frustration and angry that can be take out on the patients and colleagues, impairing the physician-patient and colleagues' relationships".	Physicians' overload and distress consequences	3
		"That frustration is also affects us at home, harming the family health, relationship and dynamic".	Physicians' distress and personal life consequences	3
	9	"Data portability and share is something that brings added value".	Data portability value	4
		"For example, besides all the work that a physician already has to do, in a single 20 minutes appointment, it is impossible to gather information and write an extra document to a colleague that it is also attending the patient. So, it is crucial to digitally share information among physicians".	Data share value and importance	4
		"Patients are the ones who benefit the most because if there is data sharing among physicians attending the patient, the better the care delivery".	Data share benefits and advantages	4
	10	"Yes, definitely".	Clinical data value	4
	11	"I believe that data's value is associated with the quality of healthcare professionals' capacity to gather information".	Health professionals' role on data value	4
	12	"I am not sure, maybe is related with interconnect more than one system".	Interoperability meaning	5
	13	"I don't know".	-	-
	14	"I don't know".	-	-
	15	"I don't know".	-	-
	16	"I spotted an effort to make some blood test already available through RSE".	EHR and current interoperability improvements	5
		"A notification system that alerts the physician about important things about namely patient's hospital discharge".	Health systems improvements	6
"I think that we have too many different programs that are too much segmented... many programs with different proposes but they are not connected with each other. There should be a unique system for all Healthcare units. I believe that standardizing health information systems would help data sharing".		Health systems improvements regarding interoperability	6	
17	Clinical management			
	"Notification panel about important patient's information namely next appointment, appointment dates, hospital discharge information, etc.". .	Health systems improvements	6	
	Time management			
	"Direct data availability in the information system which would take the transcription work from the physician. This would give physicians more time to spend with the patient, improve physician-patient communication and give more time to focus on the information that I am reading. I think it would increase productivity and efficiency".	Improving heath systems and data share. Impact on time consumption of transcription work, productivity.	2, 6	

GP	Questions	Answers	Subdimensions	Dimensions	
V	1	"It is not practical, too many clicks, a lot of different programs and many times with system errors and failures".	EHR characteristics, drawbacks and disadvantages	1, 2	
		"Is too much segmented and it should be possible to access everything about the patients. For example, I can't access ALERT*".	EHR characteristics and drawbacks. Interoperability and segmentation issues	1, 4	
		*ALERT – software specifically dedicated to patients' data entry in the emergency room in some public Hospitals in Portugal. Also used by Primary Healthcare physicians to make patients' medical referrals to hospital physicians.			
			"Health data should be in a standardized and unique/unified system".	EHR interoperability and segmentation issues. Standardization of health systems	1, 5
	2	Advantages			
			"It allows data integration; I can access different programs from different places to gather information".	EHR advantages	1
		Disadvantages			
			"Everything is too much segmented, there are so many different programs".	EHR disadvantages	1, 5
	3		"When it doesn't work or has some failure, it impairs my workday since it is the only way to access clinical data. However, in general, it positively influences my daily routine because I have access to a lot of information about my patients".	EHR drawbacks. Impact on physicians' daily routine	1
	4		"An average of 5 minutes per appointment".	Time consumption	2
			"About 1h30m per day is dedicated to transcription work".	Transcription work time consumption	2
	5		"About 5h30m of my day is dealing with information systems".	EHR time consumption	2
			"I need about 30 to 45 minutes beyond my schedule".	Bureaucratic time consumption	2
	6		"Less time to be with my patients and less focus on them".	Time consumption and consequences on physicians-patients relationship	2
			"Many times, there are problems with the system and we don't have technical support".	EHR drawbacks and disadvantages	1
			"It takes too much time to do every task".	Bureaucratic tasks time consumption	2
			"It causes psychological distress".	Physicians' overload and distress	3
			"Too much focus on the computer and not on the patient, negatively impacting patients' care delivery".	EHR time consumption and negative consequences for the patients	1, 2
			"To ease the administrative tasks during the appointments, sometimes I leave some things to do later but then there is the risk of forgetting important information".	Bureaucratic tasks time consumption	2
	7		"Yes, it bothers me. Sometimes, I fell angrier and more distressed".	Physicians' overload and distress	3
	8		"Patients are the ones who suffer the most because I have less patience and fell mentally unavailable to hear and help my patients".	Physicians' overload and distress. Negative consequences on patients	3
			"Since I am stressed, sometimes I feel more tired and get headaches".	Physicians' overload and distress	3
			"Increases the risk of medical errors".	Physicians' overload and distress impacting on medical errors and risks	1, 3
		"I can become angry which, in turn, unconsciously affect my colleagues and family".	Physicians' overload and distress	3	

GP	Questions	Answers	Subdimensions	Dimensions
V	8	"I can unintentionally record less information that may be important".	Physicians' overload and distress. Medical errors and risks	3
		"Extra-hours at work which also affect personal life".	Time consumption of bureaucratic tasks. Physicians' overload, distress and negative consequences	2, 3
	9	"It is very beneficial to share data. It allows a more complete and personalized health care delivery. Overall, it allows better health care".	Clinical data share benefits	4
		"It is very important for GPs to have access to data recorded by other colleagues".	Clinical data share benefits for GP's	4
		"However, it is important to consider that the patient have less control of their clinical data, leading to higher risk of confidentiality issues".	Clinical data confidentiality and privacy issues	4
	10	"Yes, it is especially crucial for GPs since they are the patient's manager. Besides, many times, patients can't give reliable information".	Clinical data share benefits	4
	11	"Data has a great added value since data is important to record, to consult, to check patients' evolution and to keep patients' follow-up. This gets even more meaning because, many times, we cannot rely only on the information given by patients".	Clinical data value	4
	12	"I don't know much about the subject".	-	-
	13	"Integrate several information systems?".	Interoperability meaning	5
	14	"I don't know".	-	-
	15	"I don't know".	-	-
	16	"Less, better programs and more user-friendly programs and ready to interconnect with each other".	Increase interoperability, health systems improvements	5, 6
		"Sclinico should have directly available the data from Hospitals".	Increase interoperability, health systems improvements	5, 6
		"Same coding system or language in order to allow better connection between different programs".	Semantic interoperability improvements	5, 6
	17	"Reduce the number of different programs, decrease the number of necessary clicks".	Health systems improvements	6
"Improve programs' user-friendliness and users' interface, make them more intuitive when operating, standardize the operation system for users and improve data integration".		Health systems improvements	6	

GP	Questions	Answers	Subdimensions	Dimensions	
VI	1	"I think it's a good idea to have a platform that allows data centralization as RSE is intended to be. However, as a data integrator from different systems, still has a long way to go".	EHR characteristics, utility and drawbacks	1	
		"There are some good examples of data integration namely information about vaccines and medical prescriptions. It is great to access information from other healthcare centres and hospitals. However, there are some examples where this data integration is lacking. For example, it is impossible to access data from Hospital de Santa Maria".	EHR characteristics, utility and advantages. Data sharing. EHR disadvantages and drawbacks	1, 4	
		"I believe that there are good connections between some systems but there are others which are poorly integrated".	EHR interoperability	1, 5	
	2	Advantages			
		"It provides a lot of information about the patient and a visual perception of his path in the healthcare system (timeline)".	EHR advantages	1	
		"It gives access to many information about patient's appointments and medical records. However, I think that we must be aware of ethical issues namely physicians' generalised access versus restricted access to patients' information".	EHR advantages. Data sharing and privacy issues	1, 4	
	3	Disadvantages			
		"I don't see as disadvantages but as future improvements. I think there's a lot to improve concerning electronic health records and health information systems including clinical coding and data processing in order to improve healthcare services. We have a lot of information, but it's not processed. We should not only see information but also be able to process data in order to draw conclusions and find strategies to improve health indicators and health services".	EHR and data processing improvements. Outcomes' improvements	1, 6	
	4	"It's a powerful tool to collect information that the patient didn't know or wasn't aware of".	EHR advantages	1	
		"However, as I mentioned before, I think there's some important aspects concerning data accessibility; for example, the patient cannot refuse physicians' access to a specific clinical diary".	EHR drawbacks. Data sharing and privacy issues	1, 4	
		"It gives me information that I find useful like which colleagues are attending the patient, which specialties is the patient visiting, vaccines, his timeline of health problems, the last medical prescriptions, hospital's referrals, etc. So, I think RSE is a huge aid to centralise all the information".	EHR utility and advantages	1	
	5	"It's redundant. It consumes a lot of time of my appointments and unnecessarily increases bureaucratic work".	Transcription work time consumption	2	
		"It takes too much time to transcribe and record all exam results in the system".	Transcription work time consumption	2	
		"About 10 to 15 minutes per appointment".	Transcription work time consumption	2	
		"In the UK all tests and exams are digitalised and electronically available. The only thing that the physician do is highlight some important findings. I believe it's way more agile and easier to operate and matches with physicians' needs".	Health systems in the UK. Time savings. Improvements ideas	1, 2, 6	
		"Also in UK, medical prescriptions go directly to the pharmacy".	Health systems in the UK. Improvements ideas	1, 6	
		"In Sweden, there is no test results' transcription. Everything is uploaded directly into the electronic health system and physicians have direct and easy access to them. Physicians record information into voice recorders and there are medical administrative who transcribes that information to RSE for them".	Health systems and bureaucratic work management in Sweden. Time savings. Improvements ideas	1, 2, 6	
		"In Sweden, prescriptions go directly and electronically to the pharmacy and the patient only has to show his ID".	Health systems in Sweden. Improvements ideas	1, 6	

GP	Questions	Answers	Subdimensions	Dimensions
VI	4	"In Portugal, there's so much bureaucratic work. It makes me lose my clinical judgement and thought, leaves me with less time to communicate, to be with my patient and to study my patients".	EHR and bureaucratic tasks time consumption and negatives consequences	1, 2
		"Sometimes, it means an extra hour of work in order to finish everything I need to do".	Transcription work time consumption	2
		"I have to transcribe and then think about what I wrote which means more time than it should be".	Transcription work time consumption	2
	5	"About 1/5 of my workday".	EHR time consumption	2
	6	"It impairs appointment's quality. Information systems should help the physician and not be a disturbing factor".	Time consumption and drawbacks of EHR and bureaucratic tasks	1, 2
		"In Portugal, we have to do a lot of clicks and bureaucratic work which impairs clinical activity and mental health, it harms clinical judgement and adds unnecessary workload and emotional distress. Leave us with fewer time to listen the patient".	Bureaucratic tasks time consumption. Physicians' overload and distress	2, 3
		"Every second we spend transcribing is too much, it's a waste of time".	Transcription work time consumption	2
		"In the UK, physicians don't have to renew chronic prescriptions. It's an automatic process".	Health systems in the UK. Time saving. Health systems improvements	1, 2, 6
	7	"I believe it represents a big flaw because we can type and record so much information but the data is not processed. If we could process the information, we could deliver better care. Besides, healthcare information systems should be more intuitive, easier to use and more user-friendly. Systems should aid clinical activity and not be an obstacle as it is nowadays. In the public sector, we have to type and record too much information. Data should be automatically available as they are in the private sector".	EHR drawbacks. Time consumption of bureaucratic work. Health systems improvements and better outcomes	1, 2, 6
		"This leads to psychological pressure, demotivation, emotional distress and burnout".	Physicians' overload and distress	3
	8	"We have so many redundant tasks".	Time consumption of bureaucratic work	1, 2
		"It decreases physician-patient communication, it negatively impacts healthcare and appointments' quality and it impairs physicians' satisfaction. This can lead to drop-out, early retirement and will of leaving their jobs".	Physicians' overload and distress. Negative consequences	3
		"Medicine is already a stressful and tiring job; we cannot increase emotional distress even more with all of these problems".	Physicians' overload and distress	3
		"I feel like we are fighting everyday against information systems".	Physicians' overload and distress	3
9	"I think it is very useful. However, we must be aware of some potential ethical issues and of patients' consent".	Clinical data share importance. Privacy and confidentiality issues	4	
	"There's a lot of health and digital illiteracy among people. Patients don't have enough knowledge to understand the responsibility they must have in carrying their personal data".	Clinical data value and patients' responsibility	4	
	"I believe that it is very important for physicians to have access to clinical data, but confidentiality must be preserved. If data confidentiality is respected, then data sharing makes perfect sense and it is very positive for patients".	Clinical data value and share importance. Privacy and confidentiality issues	4	
10	"Yes, but I think that patients should be more self-accountable and aware about their personal data".	Clinical data value and patients' responsibility	4	

GP	Questions	Answers	Subdimensions	Dimensions
VI	10	"Patients don't like to be responsible about their own health; many times, they don't know important information about themselves like their health conditions, which medicine are they taking, etc. So, I believe that patients must have a more active role about their own health".	Clinical data value and patients' responsibility	4
	11	"Clinical data is very valuable even for insurance companies so, we must be very careful with health data. We must be careful with sensitive information; that is why it is so important to create data safety policies. I think that patients are not aware of its data value. There are companies that can profit with it".	Clinical data value. Privacy and confidentiality issues. Patients' responsibility	1, 4
		"On the other hand, data has a tremendous value for studying health indicators and improve health outcomes. So, we can study and process data in order to take actions to improve health outcomes".	Clinical data value and its impact on health outcomes	1, 4
		"That is why I believe that data has political and economic value".	Clinical data political and economic value	4
	12	"I think that interoperability is fundamental in healthcare services in order to provide better care. Perfect systems don't exist, but there are efforts to improve them. Obviously, there are issues regarding financial resources and politics that hinders systems' improvements".	Interoperability and positive impact on health outcomes	5
	13	"We should take advantage from different data sources so, efforts to unify and to connect different systems must be done. However, I also believe that integrating and interconnecting different systems is a difficult task specially when new programs are released. Interoperability is important not only locally but also worldwide. Everyone would like to give their clinical data in order to be treated in a different country when needed".	Interoperability value and importance. Improvements on health systems' interoperability. Barriers to improvements	5, 6
		"Interoperability is crucial in order to prevent data loss".	Clinical data and interoperability benefits	5
		"Creating more interoperable systems is important to improve and to ease some of GPs redundant tasks namely exam results transcription".	Interoperability improvements on bureaucratic tasks	2, 5
	14	"I heard about Snomed, ICD-10 and ICPC-2. I heard that Snomed is more complete and in a net shape system".	Interoperability tools and improvements	5
	15	"It is associated with the fact that there are many different medical terminology and different medical coding methods. So, there's been some efforts to standardize medical coding".	Semantic interoperability meaning	5
	16	"Agreement between entities, resources allocation for software development that works more closely with end users (physicians) and intra and interoperability improvements. I know that there are some protocols in course about it, but I don't know specifically their content".	Health systems, interoperability and human resources improvements. Multidisciplinary teams	6
	17	"Better RSE and Sclinico integration, fewer clicks and less mazy programs".	EHR and health systems improvements	6
		"All data and programs should be integrated and unified as it is in the UK".	Health systems improvements	6
		"It shouldn't be necessary to open so many different programs. They should be more connected".	Health systems and interoperability improvements	6
		"Test and exam results should be immediately and directly available for the physician".	Health systems improvements	6
		"More intuitive systems and user-friendly; more adapted to end users".	EHR and health systems improvements	6
		"Less transcription work, fewer clicks and logins, and automatic chronic prescriptions renewal".	Decrease transcription work. Health systems improvements	2, 6
"Data collection, processing and storage supported by artificial intelligence".		Health systems improvements including data processing support	6	
"Physicians could record information via dictaphone that would be subscribed later by a medical administrative assistant".	Health systems and human resources improvements	6		

GP	Questions	Answers	Subdimensions	Dimensions	
VII	1	"Electronic Health Record has a practical goal with the capacity off having all clinical data".	EHR utility	1	
		"There are many failures between primary healthcare sector and hospital systems and, unfortunately, there is no access to private sector data".	EHR drawbacks. Connection between systems	1, 5	
		"I noticed some improvements to make information systems easier to use and more user-friendly; however, it still has a long way to improve".	EHR current improvements. EHR flaws	1, 6	
		"The concept is very good and useful but there's so much non summarized information spread all over so many different programs that turns out to be a disadvantage because there's no time to verify everything, everywhere and still make an organised and clear information summary".	EHR utility and drawbacks. Poor connection between health systems. Non-processed data	1, 4, 5	
		"I believe that it would be more successful if the system was more practical, more unified and more standardised and not so much segmented as it is nowadays. It will be great if systems were integrated".	EHR drawbacks and disadvantages. Interoperability issues	1, 5	
		"We have so many different programs that it hinders data systematization".	EHR and health systems segmentation	1, 5	
		"I also think that we have too much redundant and non-processed data which doesn't bring advantage to physicians and makes us, unnecessarily, waste time. On the other hand, unfortunately, there are important data that we cannot access".	Non-processed data. Time consumption. Privacy and data access issues	1, 2, 4	
	2	Advantages			
		"Having a digital platform that gives physicians access to patients clinical data".	EHR advantages	1	
		"It includes important information like living will and vaccines".	EHR advantages	1	
		"It is very useful for clinical activity since it helps in patient's follow-up".	EHR advantages	1	
		Disadvantages			
		"It doesn't have the ability to systematize or process data".	EHR disadvantages. Non-processed data	1	
		"Electronic health information system should be one single program and not a fragmented system with too many segmented programs. It would be easier to gather and summarize information if there was just one program with all the patient's information".	EHR disadvantages and drawbacks. Connectivity and interoperability issues. Health systems segmentation	1, 5	
		"With such segmented programs, there's the risk of losing some information because it is such a mazy system. If I don't remember to look for specific information, I will never know it. For example, if the patient went to a hospital for an appointment and I don't remember to specifically search for that, I will lose that information".	EHR disadvantages and drawbacks. Interoperability issues. Health systems segmentation. Risks and consequences	1	
	3	"The system in Spain is more unified, easier and simple; here, in Portugal, we waste too much time to access useful information".	Time consumption. Health systems in Spain versus health systems in Portugal	1, 2	
		"It is very important because I use it to prepare myself for the patient I'm seeing before he enters the medical office. However, we are always dependent if the system is working and even when it is, it takes too much time to organise and gather all the needed information".	EHR utility and advantages. EHR and bureaucratic tasks time consumption	1, 2	
		"I think that some information should be in a notification panel namely referrals, appointments dates, etc".	EHR and health systems improvements	1, 6	
	4	"However, the way that the program is built, takes too much time to deal with it. Although useful to keep track of clinical data, it steals too much time and focus from the patient".	EHR time consumption and drawbacks. EHR advantages and utility	1, 2	
		"Between 1h30m to 2h per day just for transcription work. It is even more for all bureaucratic tasks".	Transcription work time consumption	2	
	5	"More than half of my workday".	EHR and health systems time consumption	2	

GP	Questions	Answers	Subdimensions	Dimensions
VII	6	"It negatively impacts the physician patient relationship and communication".	Impact on physician-patient relationship. Distress	3
		"it makes me invest my time in things that it's not necessarily what the patient needs".	Bureacratic work time consumption	2
		"I constantly have to open and close many programs which is time consuming".	EHR and health systems drawbacks and time consumption	1, 2
		"Makes us steal time from the patient and from patient's appointment".	EHR and health systems time consumption	2
		"It is impossible to make a good data summary in just 2-3 minutes, it's something that takes more time".	EHR, health systems and bureacratic work time consumption	1, 2
		"It leads to the need of reschedule another appointment in order to solve every patient's problem".	Bureacratic work time consumption	2
		"There is some information that could be directly recorded by the patient. It doesn't need to be the physician. This would help physicians in their bureacratic work. Things like personal data, blood pressure, etc. could be recorded directly in RSE by the patient".	EHR improvements and impact on time management	1, 6
		"I believe that patients should have a more active role in keeping their own health records".	Patients' active role and responsabilization of their own clinical data	1, 4
		"I think that the electronic health system should be compacted and concentrated in one single platform and programs should be more integrated. For example, we don't have access to URAP* data".	Health systems standardization and improvements. Data access issues	1, 5, 6
		*Unit that includes healthcare professionals as dental hygienist, dentist, nutritionist, psychologist.		
	"As I mentioned before, the system is built in such a mazy platform and with so many separated programs that it makes it difficult to do a good integration of all patient's information and of all patient's needs".	EHR drawbacks and health systems issues. Poor interoperability	1, 5	
	7	"Yes, I feel stressed, time pressured and tired".	Physicians' overload and distress	3
		"It is exhausting having to permanently enter/close so many different programs and do so many clicks. Also, there are some information that you cannot copy and paste to your workspace, so you must transcribe everything which is tiring and time consuming".	EHR flaws and drawbacks. Physicians' overload and distress. Time consumption of bureacratic and transcription work	1, 2, 3
		"System failures are frequent which is frustrating. Besides, we are so dependent on electronic health information systems that if it fails, we don't have alternatives to keep working properly".	EHR flaws and drawbacks. Physicians' overload and distress	1, 3
		"We are always under a lot of time pressure".	Physicians' overload and distress	3
		"Sometimes, there's some changes in the software and we weren't warned".	Health systems non-reported changes	1
		"I think that system improvements should consider physicians' needs".	Health systems improvements	6
		"I believe that, in the worst case scenario, all of this pressure and stress could lead to physicians' burnout".	Physicians' overload and distress	3
		"As I mentioned before, I think that patients should have a more active role concerning their clinical data namely data recording and update".	EHR improvements. Patients role and responsabilization about their own data	1, 6
	8	"Physicians are under higher work pressure, working becomes harder and the risk of affecting physicians' mental health is increased".	Physicians' overload and distress. Risks and consequences	3
"Increased risk of suicidal ideations".		Physicians' overload and distress. Risks and consequences	3	
"I think that medicine is a risky profession".		Physicians' overload and distress	3	

GP	Questions	Answers	Subdimensions	Dimensions
VII	8	"Medicine is a profession where physicians should have a close relationship with their patients and I feel that electronic health system creates distance between them".	EHR disadvantages and drawbacks	1
	9	"Clinical data is very important. We rely a lot on data to keep patient's follow-up and to evaluate patient's evolution. So, data sharing is crucial for clinical decision making".	Clinical data value and share importance	4
		"GPs see the patient as a whole which gives them the responsibility to integrate the patient information. So, we need all the information we can collect in order to deliver better care".	Clinical data value and share importance	4
		"Obviously, data protection is crucial and health data belongs to the patients. Thus, patients have the right to their autonomy regarding their clinical data; however, data sharing is fundamental for physicians".	Clinical data value and share importance. Data privacy and confidentiality	4
		"Unfortunately, many times we don't have access to exam results and clinical reports from the private sector which are also important to share and, consequently, contribute for clinical decision making".	Clinical data access restrictions. Health systems interconnection limitations	4, 5
	10	"Yes, definitely. Many times, patients can't give reliable information, so data sharing, access and portability are crucial for care delivery which directly impact in healthcare services quality".	Clinical data value. Data sharing value and health outcomes	4
	11	"I believe that half of the appointment success comes from clinical data. So, data is very valuable".	Clinical data value	4
	12	"I think that our systems have poor interoperability. There is a lot of redundant data".	Interoperability issues	5
	13	"Systems are not connected with each other which, in turn, leads to the need of repeating data entry; So, I think that there's a lot to improve concerning interoperability. If it is not possible to improve interoperability between systems then, at least, create a unique and single program that fits everything".	Interoperability flaws. Health systems improvements	5, 6
		"We have to open a lot of different programs which causes system overload and physicians' overload. It's a waste of time".	EHR and health systems flaws. Time consumprion. Physicians' overload and distress	1, 2, 3
	14	"I don't know".	-	-
	15	"Maybe it's related to clinical data coding?".	Semantic interoperability meaning	5
	16	"I believe that it is imperative to rethink digital platforms, systems and programs. We need to improve data integration specially when we are talking about information that comes from other sectors like private hospitals, laboratories and imaging clinics".	Health systems and interoperability improvements	5, 6
	17	"We need to improve technical and digital resources and improve interoperability".	Interoperability improvements. Health systems improvements	5, 6
		"Empower patients about their own data namely by giving them the capacity to record some information".	Patients' responsabilization about their own data	6
"Having professionals that could do some work instead of physicians like transcribing data into the system".		Human resources improvements	6	
"I believe that digital transformation in health and technology is fundamental, but physicians and systems' developers work too independently. They should work more together".		Multidisciplinary teams in technology improvements	6	

GP	Questions	Answers	Subdimensions	Dimensions	
VIII	1	"I think it is an awful system. Records and data access is difficult. For example, there are some hospitals that have systems to which we don't have data access like in Hospital de Santa Maria".	EHR drawbacks and flaws. Data access and interoperability issues	1, 4, 5	
		"There are so many different programs and, many times, we can't access them. For example, I cannot access the information in ALERT neither in Cardiobase".	EHR drawbacks and flaws. Data access and interoperability issues	1, 4, 5	
		"One time, I asked an technician why physicians don't have access to some data and he was surprised and said that this was not expected to happen".	EHR drawbacks and flaws	1	
		"I know that nurses also have difficulties with the program. They have a hard time making their records which leads to appointments' delay".	EHR drawbacks and flaws. Time waste and consumption	1, 2	
		The system is frequently slow".	EHR drawbacks and flaws	1	
	2	Advantages			
		"It is a great tool to create a structure of the patient's clinical information and helps to standardise clinical data".	EHR utility and advantages	1	
		"I believe that it is quicker to understand the plan for each patient compared to records in paper and data is more accessible and quicker to get".	EHR utility and advantages	1	
		"It's very common for patients to forget or even leave out some important information. So, it is very useful being able to see what other colleagues wrote about the patient which, in turn, optimises clinical decisions".	EHR utility and advantages	1	
		"I think it saves time, helps in clinical reasoning, giving better treatments and verifying the information".	EHR utility and advantages. Time savings	1, 2	
		"In my personal experience, paper-based records take way more time than electronic records".	EHR utility and advantages	1	
		"The possibility to have remote access to patient's clinical data".	EHR utility and advantages	1	
		Disadvantages			
	"Not having access to data from the private sector. This information also should be in RSE".	EHR drawbacks and disadvantages. Data access and interoperability limitations	1, 4, 5		
	3	"It is an essential tool for my daily practice since I can see the patient's health record and think about my plan for the patient before he enters the offices. I think that helps me save time".	EHR utility and advantages. Time savings	1, 2	
	4	"About 15 to 25% of an appointment's time".	Transcription work time consumption	2	
		"I think it's a waste of time because I end up leaving the transcription work for the end of the workday which often means one extra hour of work".	Transcription work time consumption	2	
	5	"Five to six hours per day".	EHR time consumption	2	
	6	"Emotional distress, demotivation".	Physicians' overload and distress	3	
		"It is a waste of time specially when the system fails. All of this negatively impacts the physician-patient relationship, causes overload, makes me duplicate my work and makes me lose my clinical train of thought".	Physicians' overload and distress. Time consumption of bureaucratic work. Negative consequences	2, 3	
	7	"Yes, I feel very tired".	Physicians' overload and distress	3	
		"I don't believe that medicine without electronic records is better. Actually, it's quite the opposite but the systems should be more user-friendly; otherwise, it's just too exhausting".	EHR importance and value although with flaws. Physicians' overload and distress	1, 3	
		"I believe that burnout is a possible consequence".	Physicians' overload and distress	3	
8	"Medical errors, therapeutical errors and recording errors".	Physicians' overload and distress. Risks and harms	3		

GP	Questions	Answers	Subdimensions	Dimensions
VIII	8	"It has a negative and direct impact on the patient".	Physicians' overload and distress. Risks and harms	3
		"Possible drop out, leaving SNS and early retirement".	Physicians' overload and distress	3
	9	"It's impossible to work without having access to clinical information. It's a matter of patient safety. I need to know what other colleagues wrote about the patient. It's a teamwork".	Clinical data value and sharing importance	4
		"I believe that patients have the right to choose who can have access to their clinical data. Patients are the owners of their information. However, I think that health professionals that are directly helping the patient must have access to the clinical data".	Clinical data access and privacy	4
	10	"Yes, definitely. It is important to know what other colleagues know about the patient".	Clinical data value	4
		"If we have access to patient's clinical data, it's better for him because we can deliver better care".	Clinical data value and health outcomes improvements	4
		"I think that the only risk that we should be careful about is unauthorized access".	Clinical data access and privacy/confidentiality issues	4
	11	"It doesn't have a price. Incalculable value. I believe that safety is the main key subject about this issue. If I have access to clinical data, I can make better, safer and with more confidence decisions. Access to clinical information is also quicker. So, I believe that this shows the importance and value of clinical data".	Clinical data value and health outcomes improvements	4
	12	"I don't know exactly what it is, but I have heard of it".	Interoperability notions	5
		"I suppose that is associated with easier and more efficient connection between different systems".	Interoperability meaning	5
	13	"It makes perfect sense, but I believe that it's poorly done".	Poor interoperability	5
		"Systems' efficiency is poor because there's no interoperability between systems. Many times, I must record the same information in different places which is exhausting and time consuming".	Physicians' overload and distress. Time consumption of bureaucratic work. Poor interoperability and consequences	2, 3, 5
	14	"I don't know".	-	-
	15	"Maybe it's something about having the same language to communicate between systems".	Semantic interoperability meaning	5
	16	"The existence of a single program/system. All patient's data should be in the same place (data from private sector, public sector, blood tests, imaging exams, etc); everything should be integrated in one single place with prompt access".	Health systems improvements	6
		"All the information should be centralised in a one place even if in the dependency of different programs".	Health systems improvements	6
	17	"Notification panel that warns the physician when the patient has his tests ready. I believe that this could reduce costs, decrease physician-patient contacts, reduce the number of times that the patient has to go to the Healthcare Center and improve time and appointment's management".	Health systems improvements and impact on health outcomes	6
"A quiz for the patient to answer when he arrives at the Primary Healthcare Center facility that could automatically introduce important clinical data into the system, making it immediately available for physicians".		Data collection optimization and health systems improvements	6	

GP	Questions	Answers	Subdimensions	Dimensions	
IX	1	"It's a good tool because, many times, patients cannot explain important information and RSE makes possible to check the information written by other colleagues".	EHR utility and benefits	1	
		"It's also important for hospital physicians since it allows them to check the information gathered by GPs".	EHR utility and benefits	1	
		"Unfortunately, there is some data that cannot be access like the one in some programs (ALERT, for example)".	EHR drawbacks. Data accessibility and sharing issues	1, 4	
		"It is crucial to have a data sharing system".	EHR benefits and advantages	1	
		"It would be easier if information systems were unified and standardized into one single program or, at least, if these different systems were more interconnected with each other".	EHR drawbacks and disadvantages. Interoperability issues	1, 5	
	2	Advantages			
		"It's a channel of communication between the Primary Healthcare sector and the Hospitals".	EHR utility and advantages	1	
		"It helps to have a better understanding of the patient. An overview of the patient".	EHR utility and advantages	1	
		"It gives us important data, which is even useful when patients cannot give or explain correctly certain information".	EHR advantages	1	
		Disadvantages			
	3	"It doesn't give access to all the information about the patient".	EHR disadvantages	1	
		"Data protection. Not all data recorded by GPs should be freely accessed by any healthcare professional".	EHR disadvantages and data privacy issues	1	
		"It's useful because I use it to prepare myself before the patient enters the office. I can check the last appointment, what was done in the hospital, evaluate patient's evolution, etc".	EHR utility and advantages	1	
			"It makes me save time because I see everything I need before the patient enters the office".	EHR advantages and time management	1, 2
		4	"It's a waste of time".	Transcription work and time consumption	2
	"It impairs patient-physician communication and relationship".		Transcription work consequences	2	
	"I waste about 20 to 30% of patient's appointment just to transcribe test and exam results that the patient brings to me".		Transcription work and time consumption	2	
	5	"About 70% of the patient's appointment".	EHR time consumption	2	
		"About 80% of my workday".	EHR time consumption	2	
		"There's just too many bureaucratic tasks, too much information to record on Sclinico".	EHR time consumption	2	
		"I spent more time dealing with the computer than with my patients".	EHR time consumption	2	
		"Per week, I need about 2 extra hours to complete all my work even with 30 minutes of my schedule reserved just for bureaucratic tasks".	EHR time consumption	2	
	6	"Leave us with less time for clinical reasoning".	Physicians' overload and distress	3	
		"Increases the risk of letting important clinical signs pass by because you are distracted by bureaucratic tasks".	Physicians' overload and distress. Risks and harms	3	
		"You are lost in a vast work of bureaucratic tasks which are not clinical activity".	EHR time consumption	2	
	7	"Yes, definitely. I feel pressured, tired and distressed with so many bureaucratic tasks".	Physicians' overload and distress	3	

GP	Questions	Answers	Subdimensions	Dimensions
IX	8	"If you are overloaded with so much work, psychological exhaustion and burnout become possible consequences which, in turn, becomes dangerous for the patients because physicians are at a higher risk of committing mistakes and of letting important things escape".	Physicians' overload and distress. Risks and harms	3
		"I believe that it could be an interesting and useful solution to split physicians' workday in 2 halves. The morning period was just for clinical activity and the afternoon period just for bureaucratic tasks which could be done by telecommuting".	Time and schedule management	6
	9	"In medical practice, it's essential to share data".	Data share importance	4
		"It would be important to improve data portability and share. For example, I cannot access the information that healthcare professionals from URAP record in the system".	EHR drawbacks. Data share value	1, 4
		"GPs are patients' managers, which include managing patients' clinical information. I see GPs as the center of patients' clinical data. So, I believe that GPs should have more control of his patients' clinical data. That is also why I think it is important to improve communication between physicians in order to help data sharing".	Data sharing value for medical care, specially for GP's. GP's role and data importance	4
		"There are some sensitive data that should be protected. Not everyone should access them".	Data privacy and confidentiality	4
	10	"Yes, definitely".	Clinical data value	4
	11	"Clinical data have a great value. They are crucial for investigation/study proposes, to compare health data, to understand health standards and realise what can be done to help health indicators and to monitor population's health quality".	Clinical data value in various fields	4
		"Clinical data also have economic value and are valuable for pharmaceutical companies".	Clinical data value	4
	12	"I don't know".	-	-
	13	"I don't know".	-	-
	14	"I don't know".	-	-
	15	"I don't know".	-	-
	16	"A single software for both Primary Healthcare sector and Hospitals. Each one would have his own user interface, i.e., each physician would work independently but with the capability to check the data collected by other colleagues attending the patient".	Heathcare systems improvements and standardization	6
		"A single platform or database where all test and exam results are uploaded to".	Heathcare systems improvements and standardization	6
		"More communication between physicians and software developers in order to improve system's user-friendliness".	Multidisciplinary teams for improving health systems	6
	17	"The use of scribes. Someone that would transcribe all test and exam results instead of physicians".	Human resources improvements	6
"Another solution could be devoting a specific period of physicians' schedule just for administrative tasks. This could alleviate the stress of having to do those tasks during the appointment's time".		Time and schedule management	6	

GP	Questions	Answers	Subdimensions	Dimensions	
X	1	"It's a platform with a huge added value by allowing access to all patient's information".	EHR characteristics and benefits	1	
		"However, sometimes it doesn't work properly and it's slow".	EHR drawbacks	1	
	2	Advantages			
		"It promptly gives all patient's clinical data including vaccines and family history".		EHR advantages	1
		Disadvantages			
		"Sometimes, it has errors and system failures leading to a waste of time".		EHR disadvantages, failures and time consumption	1, 2
		"We need to do so many clicks which is also a waste of time. For example, the prescription program requires a lot of steps and clicks. It steals time".		EHR disadvantages and time consumption	1, 2
	3	"We pay too much attention to the computer and little focus on the patient".		EHR disadvantages and drawbacks	1
		"It negatively impacts my daily routine because, many times, I can't access the information I need. If the system is slow, I end up wasting too much time. Sometimes, I feel like I would prefer going back to the paper era because I could see more patients, could focus more on my patients and do my work quicker".		EHR drawbacks. Time consumption. Productivity issues.	1, 2
	4	"I waste a lot of time transcribing exam results. Maybe about 50% of the appointment's time".		Transcription work time consumption	2
		"Exam results should be automatically registered into RSE".		EHR improvements	6
		"I need about an extra 45 minutes to one hour per day just to complete the transcription work".		Transcription work time consumption	2
	5	"About 80% of my workday".		EHR time consumption	2
	6	"Administrative tasks overload is really tiring and can potentially lead to burnout".		Physicians' overload and distress	3
		"It would be really great if things like chronic prescriptions and physiotherapy could be automatically renewed. It would save time and alleviate physicians' work".		Health systems improvements with impact on time management and physicians' workload	2, 3, 6
	7	"Yes, I specially feel time pressured and tired".		Physicians' overload and distress	3
8	"It can increase the risk of clinical errors, decrease physicians' focus and attention which increase the risk of letting important things pass by".		Physicians' overload, distress and possible consequences and risks	3	
9	"I believe that clinical data portability and share is a good thing specially for healthcare professionals who will be able provide better care and improve their data integration capacity. It really is something with added value".		Clinical data portability value and importance	4	
10	"Yes definitely. Having access to patients' clinical data is essential for healthcare services since it improves healthcare delivery and quality".		Clinical data value and impact on outcomes	4	
11	"Yes, I believe that clinical data has a huge added value".		Clinical data value	4	
12	"I don't know".		-	-	
13	"I don't know".		-	-	
14	"I don't know".		-	-	
15	"I don't know".		-	-	
16	"Maybe the existence of a unique system... less separated systems".		Health systems improvements	6	

GP	Questions	Answers	Subdimensions	Dimensions
X	17	"I believe that we would benefit if we didn't have to transcribe test results at all. All test and exams results should automatically enter in RSE".	Health systems improvements	6
		"Fewer clicks. Systems should be operated with fewer steps and clicks to get the information that we need".	Health systems improvements	6
		"Improve systems' user-friendliness".	Health systems improvements	6
		"More time to communicate, to be and to listen the patient. More time to think and to give the best care possible".	Time management improvements	6
		"Automatic renewal of chronic medication".	Health systems improvements	6

Appendix E: General practitioners' demographic information

Interviewee	Gender	Age	Healthcare service	Years of experience	Training and Certification	Experience outside Portugal
GP I	Female	30	Corroios	5 – 10	Resident	No
GP II	Female	66	Lavradio	30 – 40	Attending physician	Yes
GP III	Male	28	Barreiro	5 – 10	Resident	No
GP IV	Female	31	Sesimba	5 – 10	Attending physician	No
GP V	Female	31	Sesimba	5 – 10	Attending physician	No
GP VI	Female	33	Palmela	5 – 10	Attending physician	Yes
GP VII	Male	33	Lavradio	5 – 10	Resident	Yes
GP VIII	Female	31	Setúbal	5 – 10	Resident	No
GP IX	Female	32	Setúbal	5 – 10	Attending physician	No
GP X	Female	57	Palmela	20 - 30	Attending physician	No

Appendix F: Healthcare systems experts - results

Professional	Questions	Answers	Subdimensions	Dimensions	
I	1	“According to European diplomas, EHR is defined as any information system with health data”.	EHR definition	1	
		“There are well structured projects with stablished norms that include free data exchange between member states. In Portugal, some of these are structures are implemented but not sufficiently disseminated”.	EHR and data portability	1, 4	
		“Data that is crucial for healthcare delivery, test results, clinical observations, discharge notes”.	EHR use and characteristics	1	
		“I believe that, in Portugal, we have good healthcare systems, but it doesn’t mean that they are simple. We have to improve them”.	EHR characteristics	1	
		“EHR is a very wide concept and we should evaluate it in smaller structures”.	EHR characteristics	1	
		“I believe that, for a better healthcare delivery, information should be with the patient, wherever the patient is. It doesn’t make sense to have a lot of data but, when needed, physicians do cannot access to it”.	EHR and data ownership and accessibility	1	
		“We do not need any type data. We need useful and quality data. This is related with semantics. Data can’t be ambiguous and have different meanings. I have to guarantee that the information kept in one place has exactly the same meaning in another place. This is a crucial issue for healthcare systems”.	Semantics	5	
		“We have to ensure that information is close to the patient, when needed, ensure consensus on this information, ensure that data is technologically available, ensure that healthcare professionals make transparent records”.	Data accessibility and specificities. Data standards	1, 4	
	2	Advantages			
		“Data is crucial for better healthcare delivery. It is important to have good and quality data that I can trust. So, clinical records and EHR have a great value”.	EHR and data advantages	1, 4	
		“Healthcare systems are good because they allow us to have health data. However, this is only true if data is accessible and explorable. It doesn’t make sense if data cannot be accessed or processed”.	EHR advantages and conditions	1	
		“Technology, allows us not only get information, but also process it, which is great to optimize processes”.	EHR advantages	1	
		Disadvantages			
		“Not everyone wants to use health data for good reasons”.	Fraudulent use of data	1, 4	
		“There are abusive and malicious uses of health data”.	Fraudulent use of data	1, 4	
	3	“We do not want that some people knowing certain information about us. We do not want that some organizations have access to our data”.	Fraudulent use of data	1, 4	
		“I believe that it is important for healthcare professionals to have data access about test results. I am thinking in patients that are new to the physician. Having access to data and get to know the patient is a positive thing. If patients have all vaccines, any allergies, any disease or a recent event, etc”.	Data value and importance	4	
		“Having all that data, as long as I trust it, is great for physician-patient interaction”.	Data advantages and importance	4	
		“However, it doesn’t make sense to lose physicians time with administrative tasks like transcription work. It is a waste of time”.	Bureaucratic tasks and time waste	2	
		“It is expected that those type of tasks are going to progressively reduced. If healthcare systems are well designed and planned, they enable that scenario. Currently, that is not yet the reality but we have been making progress”.	EHR progress	1, 2, 6	
“Information is power and makes the difference in healthcare delivery”.	Data’s value	4			

Professional	Questions	Answers	Subdimensions	Dimensions
I	4	"I believe that administrative tasks and transcription work represents, at least, one third of physicians' appointments time. Maybe on many occasions is even more but, anyway, the time lost in those tasks is still very significant".	Bureaucratic tasks and time waste	2
	5	"Of course, without any doubts. Those tasks [administrative] aren't intellectually stimulating. There is no pleasure or satisfaction with that kind of work".	Physicians' burden	3
		"Healthcare professionals have a great responsibility and a lot of work. Besides that, still having to do bureaucratic work, is sure exhausting and frustrating".	Bureaucratic work and physicians' burden	3
	6	"Drop-out, dissatisfaction".	Physicians' burden consequences	3
		"One of the transcription work problems is the human factor. Is much more prone to errors".	Transcription work and physicians' burden consequences	3
		"Negative consequences on productivity and efficiency".	Physicians' burden consequences	3
		"Higher risk of errors".	Physicians' burden consequences	3
		"I believe that this is a balance between the work of recording data versus the cost of not having data, because although too much recording is frustrating, zero data is also frustrating".	Recording data balance and time consumption	3, 4
		"In Portugal, things are finally getting solved. Laboratory tests are improving with EHR connection and exams are also going to get there. However, this is something that takes time".	EHR progresses and improvements	1, 5, 6
	7	"There is a lot of work to do although there is also a lot of work that has already been done".	EHR state of the art	1
		"Digitalization of medicines' prescription, made the process much simpler for patients, largely decreased fraud cases and enrich health data. Thanks to this, we can start to think of things like drug interaction systems, therapeutic reconciliation".	Healthcare systems improvements and advantages	1, 4, 6
		"Since the end of 2021 till the end of 2022, agreements between public and private entities were made to allow the exchange of laboratory tests results between more than 800 laboratory centers and more than 1000 Primary Healthcare centers with a high level of technical and semantic complexity. It is based on CPAL".	EHR and interoperability improvements. Semantics	1, 5
		"I believe that we are going to improve data's quality and confidence a lot in the near future".	EHR and data's quality improvements	1, 4
		"Although slowly, I believe that we are taking important steps in improving data sharing and portability".	EHR, interoperability and data exchange improvements	1, 5, 6
		"Portugal is investing in efficient and safe data exchange mechanisms".	EHR, interoperability and data exchange improvements	1, 5, 6
	8	"Yes, definitely. If we have data that we can trust and that has high quality standards, that we can reduce the risk of errors".	Data's value, quality and benefits	4
	9	"Health data has great value. That's why all Europe is trying to find a strategy to safely keep an economy of data".	Data's value	4
		"Data's value is huge, for good but also for bad reasons like fraud. It is crucial to have confidence in the data. Data's quality and safety is fundamental".	Data's value	4

Professional	Questions	Answers	Subdimensions	Dimensions
I	10	“Interoperability means that technically I can make data flow and exchange from one place to another, in a safely manner. I have communication channels, accesses, know who’s accessing, I am confident with whom interacts with the network. After this, I need to ensure that the information that it’s exchanged means exactly the same independently of the place. Information systems must speak the same language. This is harder than the first part [technical interoperability layer]. At the same time, I need to ensure that I have all processes, protocols and agreements between entities that allow this data exchange. Above all this, I need legal frameworks for this data exchange to occur”.	Interoperability meaning, layers and difficulties	5
		“To solve the interoperability issue means to ensure that all 4 layers of interoperability are solved”.	Interoperability layers	5
		“I believe that there are certain contexts where we have successfully interoperated like PEM and vaccines records. About laboratory tests we greatly improved in the last 2 years. At the end of this process, I believe that we are going to have an extraordinary capacity to exchange laboratory test results with potential for data process and exploration. And it’s data with good quality. This is great for improving healthcare delivery, for academic studies, for population studies, for making policies, for prices adjustments”.	Current interoperability state, improvements, advantages and its value	4, 5
		“There are in motion many protocols to integrate health data from private and public sector. The hard part it’s not the technical processes. The problem is to find legal, organizational and processual agreements”.	Interoperability protocols, difficulties and barriers	5, 6
	11	“We are better technically than semantically. It’s difficult to find agreements in respect to semantic and terminology standards”.	Semantic interoperability	5
		“It is crucial to have well-structured and quality data in order to explore and process it”.	Semantics and data’s quality	4, 5
		“ICD-10 is connected to billing processes and it is a tree-like structure. This means that it is much harder to take value from concepts and its relationships then with a terminology like SNOMED”.	Semantic interoperability. SNOMED and ICD-10 terminologies characteristics	5
		“We have many small initiatives all over healthcare system that uses SNOMED but the great implementation of SNOMED and LOINC in Portugal was in the recent advances made with laboratory tests results. A really big network structure of concepts was created with rules for the relationships between them. This is allowing laboratory test results exchange between public and private sectors. Hospitals don’t use this semantics and it is obvious the difference in data’s quality between Primary Healthcare sector and Hospitals. Primary Healthcare centers gave a big jump in data’s quality”.	Semantic interoperability advances. SNOMED implementation	5
		“With the emergence of ULS next year, it will be mandatory to interoperate different levels of healthcare units between themselves. That will be one of the biggest and most successful implementations of SNOMED”.	Interoperability future	5, 6
		“With SNOMED implementation, we can optimize data searching, navigation and processing, time management and take value from information”.	SNOMED and semantics advantages	4, 5, 6
		“When all entities start using the same structure, codes, standards it will be much easier to exchange data”.	Semantics importance and value	5
		“SNOMED is becoming the terminology to use to structure information. In matter of fact, it is being the terminology used across Europe to structure information. WHO terminologies are free. But SNOMED is considered such a relevant terminology that European Commission is co-financing the license for its member states”.	SNOMED value	5
	12	“There are alternative terminologies to SNOMED, there are complements to SNOMED. However, SNOMED is, in fact, the aggregator, because it has a huge network of specialists, organization, dynamic and a very active content production”.	SNOMED advantages and characteristics	5, 6

Professional	Questions	Answers	Subdimensions	Dimensions
I	12	“In SNOMED, since each concept is associated with many other concepts and each relationship makes perfect sense; hereafter, it’s easier to incorporate and create artificial intelligence, process data and produce knowledge”.	SNOMED advantages, characteristics and value	5, 6
		“SNOMED is a network of knowledge and it is a very useful tool. It is recognized at a global level”.	SNOMED value	5

Professional	Questions	Answers	Subdimensions	Dimensions	
II	1	"It is a very interesting idea. It has a great potential for healthcare professionals".	EHR benefits	1	
		"There is some misunderstanding about data ownership. Who's responsible for them? The patient? The government? This may lead to some technical issues. However, globally, electronic health records are very interesting".	EHR importance and data ownership issues	1	
		"Since the beginning, one of the most important problems in Portugal regarding EHR is the difficulty in governance, i.e., define who responsible for what. In my opinion, the existing problems regarding EHR merge from this governance issue".	EHR issues	1	
		"The way EHR is built, I find hard to believe that patients are owners of their data. They do not have full access to their data, it is difficult for them to erase or to have a copy of their data".	EHR characteristics, problems and data's ownership	1	
		"Healthcare institutes are data owners when there are legal problems. They are the ones who end up in court when there is an unauthorized data access. They get the guilt about the unauthorized data access".	EHR and data's ownership	1	
		"In my opinion, the real owners of health data are software suppliers because they are the only ones who can do anything with that data without anyone notice. For me, that is closer to the definition of data's owner".	EHR and data's ownership	1	
		"In Portugal, EHR is implemented in a strange way. The entity that keeps health data is not a healthcare provider facility. The EHR that makes sense to me is the one that gives patients the real data ownership. In that way, health data belongs to the national sphere, not to the public or private sector".	EHR and data's ownership	1, 6	
		"It should be easy for the patient to upload his own information".	EHR characteristics and data's ownership	1	
		"The idea of EHR is very good; however, the way that EHR were implemented doesn't make sense to me. Database shouldn't be centralized; it should be federated. Data should be kept in its origins and, when necessary, collect the data from healthcare institutions using well designed interoperability standards".	EHR characteristics and current state	1, 5, 6	
		"There're not enough people with strategic data thinking and knowledge about interoperability and healthcare databases".	Data and interoperability. Limitations	1, 5	
	"Software developers do not have enough training to resolve technological issues regarding healthcare needs. For example, terminology is one of the most critical issues regarding healthcare technology. What we can do is highly influenced by the semantic that it is used. Most of the times, these types of problems are left with developers. This should be addressed by professionals with training in health".	Semantics importance. Limitations	1, 5, 6		
	2	Advantages			
		"It makes easier for healthcare professionals to access patients' health data".	EHR advantages	1	
		"It gives patients access to part of their own data. Gives them knowledge about what healthcare institutions know about them. It makes them realize that they are part of the healthcare system".	EHR advantages	1	
		"It helps standardize some processes".	EHR advantages	1	
		Disadvantages			
		"It can disseminate some malpractices if some of the standards were badly done".	EHR disadvantages and problems	1	
"Cybersecurity. There are relevant and worrying problems regarding EHR unauthorized access. We are much more vulnerable than we think".	EHR disadvantages and problems	1			

Professional	Questions	Answers	Subdimensions	Dimensions
II	2	"Lack of standards and criteria for data quality. If there were better standards for collecting data with quality, we could get much more benefit from health data like artificial intelligence, automatic alerts, etc".	EHR disadvantages and problems. Data and potential for improvements	1, 4, 6
	3	"One thing that I would like to see in EHR is an advanced summarizing tool for health data and then adapt that summarized information for patients' active problems. That is not science fiction, it is something possible to do".	EHR solutions and possible improvements	1, 6
		"It doesn't make sense to have so much information that makes physicians loose to much time navigating on that information. The system should be capable of give insightful information about patients. This would make EHR a real physicians' assistant in data reading and also in guidelines support".	EHR disadvantages and time consumption. Possible improvements	1, 2, 6
	4	"Internationally, I saw that 25% of physicians' time and 50% of nurses' time is spent in processing data. I believe that, in Portugal, a physician spends around 40% of its time in bureaucratic tasks".	Time consumption and administrative tasks	2
		"I believe that we could improve those numbers by 5-10% with positive results for healthcare system".	Time waste improvements	2, 6
		"Altering EHR should include reading and processable aids like showing blood analyses with interpretable readings, not just non processed data".	EHR improvements	1, 6
	5	"Yes. It is definitely a stress factor".	Physicians' burden	3
		"Most of the bureaucratic work is not stimulating for physicians".	Physicians' burden	3
		"Developers are not users and that is a factor impacting software user-friendliness".	EHR problems	1, 3
		"It would be interesting to optimize physicians' time. EHR optimization would reduce physicians time with it and reduce physicians stress giving physicians more focus and time to spend with their patents".	EHR improvements and time savings	2, 3, 6
	6	"Worse data quality".	Physicians' burden and possible consequences	3
		"Greater difficulty in following the recommended processes".	Physicians' burden and possible consequences	3
		"Computer burden".	Physicians' burden and possible consequences	3
	7	"If properly done, it is, potentially, one of the most important things in healthcare".	Data sharing importance	4
		"If we build strategies, standardize terminologies, define norms of data quality and data exchange, and how they should be kept in health databases, then the potential to expand e-health and improve patients' outcomes and healthcare quality is huge. We have to guarantee that the information's meaning is the same anywhere when it is shared".	Semantics importance, data exchange, data's quality improvements, standardization.	4, 5, 6
	8	"Yes, definitely. Data is fundamental".	Data's value	4
		"I believe that patients should be the owners of their data and give the authorization to access it".	Data ownership	1, 4
	9	"One way to measure data's value is how much does it cost when you do not have access to it. Based on the last cyber attacks in Portugal, the costs reached millions of euros".	Data's economic value	4
		"Health data has such a powerful economic value and that was reflected during the COVID-19 pandemic. Vaccines data was very valuable".	Data's economic value	4
		"Health data has a huge value. Is valuable for pharmaceutical companies, for ensure companies and for SNS and healthcare institutions".	Data's value	4
"The last time I saw, health data was sold in the black market in the United States of America".		Data's economic value	4	

Professional	Questions	Answers	Subdimensions	Dimensions
II	10	“Interoperability has been slowly improving but the dimension of the problem has been growing more because the number of information systems and software that we have grow faster than the number of integrations that we built. The distance to the goal of having an ecosystem were everything speaks the same language and fluently exchange data between systems is becoming bigger”.	Interoperability issues and current state. Semantics. Data sharing	5
		“Every machine and program that arises needs integration and the pace at which new gadgets, devices and programs appear is really fast”.	Interoperability issues	5
		“The distance to the optimal interoperability state is increasing”.	Interoperability issues and current state	5
		“I believe that the problematic about language is going to take a lot of time to get solved”.	Semantic interoperability	5
	11	“Currently, we have a lot of data that it is coded with certain terminologies, and it would be interesting to use it”.	Semantics	5
		“We should have processes and mechanisms of audit to evaluate data’s quality”.	Data’s quality evaluation	4, 6
		“We should have medical colleges, specialty schools and medical order defining rules. Not non-medical entities”.	Semantics	5, 6
		“I fear that semantically, we haven’t yet started to put the necessary efforts to improve it. There are some aligned processes but there are other things missing. Medical entities should get more responsibility about this. Medical terminology is relatively well defined. SNOMED is a powerful tool”.	Semantic interoperability current state. SNOMED advantages	5, 6
		“WHO already established that next versions of ICD are going to be more like SNOMED. It’s the best way to enrich health data”.	SNOMED advantages	4, 5
		“Currently, there is nothing better than SNOMED for clinical terminology. In ICD-10, pneumonia, for example, can be classified as an infectious disease and also as a respiratory disease. In SNOMED CT, relationships between terms are much richer and complete. That way, we can get much more benefit from health data. This way, processing and take insights about health data is better”.	Semantics. Medical terminologies. ICD-10 limitations. SNOMED advantages and characteristics	4, 5
	12	“There is a well defined structure for interoperability. It has 4 layers. Each layer has standards to follow. Technical interoperability is relatively well stablished and is easier to solve. The real problems appear in the next layers. For the next layer, the best thing that we have is FHIR-HL7. Europe is adopting it. In semantic layer, it depends on the areas. We have SNOMED, for laboratories we need LOINC to describe all complementary diagnostic tests. Nurses’ ontology is aligned with SNOMED which is good. In the pharmacology area, INFARMED uses a specific coding system different from the ones used internationally. This makes hard to cross information with big databases, for example, to prevent drug interactions. International coding is ATC and MedRA. Many of these initiatives are already grouped in big organizations working with each other, which belongs to the organizational layer. For this layer, the best initiative is IHE. It defines a lot of process for interoperability. European union already suggests IHE protocols for interoperability implementation”.	Interoperability layers. Technical, semantical, organizational and legal interoperability improvements and solutions. Semantics	5, 6