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Health Technology Assessment and Decision-Making Processes: The Purchase of Magnetic Resonance Imaging Technology

Dissertação para obtenção do Grau de Doutor em Avaliação de Tecnologia

Orientador: Doutor António Paulo Brandão Moniz de Jesus, Professor Associado com Agregação, Faculdade de Ciências e Tecnologia da Universidade NOVA de Lisboa

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ABSTRACT

Medical devices play an essential role in health care. For instance, magnetic resonance imaging (MRI) has revolutionized the way images of the human body are acquired. However, although medical devices improve diagnosis and treatment, they are also one of the causes of increasing health expenditure. Thus, the purchase of new technologies and the determination of how and when they should be used are among the most important decisions made in the health care system in general, and by hospital decision-makers in particular.

Health technology assessment (HTA) studies aim to provide a range of stakeholders with accessible, usable and evidence-based information to guide decisions about the use and diffusion of technology and efficient allocation of resources. For this reason, HTA acts as a bridge between evidence and decision-making by ensuring better synthesis, communication and dissemination of information.

However, empirical research on decision processes in the purchase of medical devices is sparse, and a gap on this topic was found in the literature. The present research focuses on the Portuguese health system and sheds light on the characterization of decision-making processes by those involved in MRI purchases, in order to understand the influences of HTA.

In terms of research design, two strategies were chosen, aiming at different objectives. *To characterize the decision-making process* a mixed method was chosen. Data was collected using a questionnaire (40 respondents), and parallel semi-structured interviews (27 participants). Both data sets were analysed and merged. Descriptive statistics were chosen as a data analysis strategy, as well as content analysis (categorical analysis). *To assess competences for decision-making* a questionnaire retrieving only quantitative data was developed (369 valid respondents), and Exploratory Factorial Analysis was performed, followed by Structural Equation Modelling (Confirmatory Factorial Analysis and Path Analysis).

Results show that steps in the decision process are well-defined. Cost and suppliers' characteristics are seen as the most important indicators to guide decisions. Few studies are performed to support the decision, and these are mostly related to the workload of the Radiology Department. No national or international HTA study was used to support any decisions. The decision process is characterized by a bounded rationality, influenced by intuition and a consultant decision-maker. The decision is a bottom-up process where information gathering and consensus building is undertaken by a committee, although external consultancy is also used. The reasoning and justification for selection of committee members is unclear. The process is considered to be bureaucratic, time-consuming and long. Patients are negatively perceived as stakeholders in the process. Their experiences, needs and expectations are not considered.

Decision-makers in Portugal have limited knowledge and training in areas of decision-making, health informatics, health economics and especially HTA. This may limit their ability to truly understand the future implications of their purchase decisions.

Recommendations are made to: (1) deepen the present research in particular regarding the elements that influence the strategies and tactics adopted in the decision-making process for the acquisition of medical devices (2) foster the uptake of HTA by decision-makers with the establishment of an HTA in-house unit, able to carry out TA studies considering the hospital context and aiming to inform managerial local decisions on the uptake or disinvestment of medical devices (3) promote a team comprise by not only TA multidisciplinary researchers but also by professionals from the health institution able to carry out HTA studies (3) foster common languages and values to increase uptake of HTA studies.

Keywords: Health Technology Assessment, magnetic resonance imaging, evidence, purchase, decision-making, competences

SUMÁRIO

Os dispositivos médicos desempenham um papel essencial nos cuidados de saúde. Por exemplo, a ressonância magnética tem revolucionado a forma como as imagens do corpo humano são adquiridas, tendo como objectivos diagnosticar e tratar várias condições de saúde. No entanto, embora os dispositivos médicos ajudem no diagnóstico e tratamento, são também uma das causas para o aumento dos gastos em saúde. A compra de novas tecnologias e o modo como e quando devem ser utilizadas estão, de um modo geral, entre as decisões mais importantes tomadas no sistema de saúde e pelos decisores em meio hospitalar, em particular.

Os estudos de avaliação de tecnologias em saúde (ATS), visam fornecer a várias partes interessadas informações acessíveis e úteis, baseadas em evidências, para orientar as decisões sobre a utilização e difusão da tecnologia e a distribuição eficiente dos recursos. Por esta razão, a ATS funciona como uma ponte entre a evidência e a tomada de decisão, assegurando uma melhor síntese, comunicação e disseminação da informação.

No entanto, a pesquisa empírica sobre os processos de decisão na compra de dispositivos médicos é escassa, tendo sido encontrada uma lacuna sobre esta temática na literatura. A presente investigação, tendo como foco o sistema de saúde português, procura caracterizar os processos de tomada de decisão, por parte dos envolvidos na compra de ressonância magnética, a fim de compreender as influências da ATS.

Em termos metodológicos, foram escolhidas duas estratégias, visando objectivos diferentes. Para caracterizar o processo de tomada de decisão, foi escolhido um método misto. Os dados foram recolhidos através de um questionário (40 respondentes) e entrevistas semi-estruturadas (27 participantes), realizadas de modo paralelo. Ambos os conjuntos de dados foram analisados e combinados. A estatística descritiva foi escolhida como estratégia de análise de dados, assim como a análise de conteúdo (análise categorial). Para avaliar as competências para a tomada de decisão, foi desenvolvido um questionário que colheu apenas dados quantitativos (369 respondentes válidos) e foi realizada a Análise Factorial Exploratória, seguida pela Modelação de Equações Estruturais (Análise Factorial Confirmatória e Análise de Caminhos).

Os resultados mostram que as etapas do processo de decisão estão bem definidas. O custo e as características dos fornecedores são vistos como os indicadores mais importantes para orientar as decisões. Poucos estudos são realizados para apoiar a decisão, estando estes na sua maioria, relacionados com a carga de trabalho no Departamento de Radiologia. Nenhum estudo de ATS, nacional ou internacional, foi utilizado para apoiar a decisão. O processo de decisão é caracterizado por uma racionalidade limitada, influenciada pela intuição e por um decisor consultor. A decisão é um processo *bottom-up*, sendo a recolha de informações e a reunião de consenso realizada por uma comissão, embora

consultoria externa também seja utilizada. O motivo e a justificação para a seleção dos membros da comissão não é claro. O processo é considerado burocrático, consumidor de tempo e longo. Os pacientes são percepcionados negativamente como partes interessadas no processo. As suas experiências, necessidades e expectativas não são consideradas.

Em Portugal, os decisores têm limitações a nível de conhecimento e formação em áreas de, tomada de decisão, informática na área da saúde, economia da saúde e especialmente ATS. Tal facto pode limitar as suas capacidades em compreender verdadeiramente as implicações das suas decisões de compra.

São feitas recomendações para: (1) aprofundar a presente investigação, em particular no que diz respeito aos elementos que influenciam as estratégias e tácticas adoptadas no processo de tomada de decisão para a aquisição de dispositivos médicos (2) fomentar a utilização de estudos em ATS pelos tomadores de decisão, com a criação de uma unidade interna de ATS, capaz de realizar estudos de avaliação de tecnologia (AT), considerando o contexto hospitalar e com o objetivo de informar as decisões gerenciais locais sobre a adopção ou desinvestimento de dispositivos médicos (3) promover a criação de uma equipa composta não só por investigadores multidisciplinares de AT mas também por profissionais da própria instituição de saúde, capazes de realizar estudos de ATS (3) fomentar linguagens e valores comuns para aumentar a aceitação de estudos de ATS.

Palavras-chave: Avaliação de Tecnologia em Saúde, ressonância magnética, evidência, compra, tomada de decisão, competências

Table of Contents

LIST OF FIGURES

List of Tables

LIST OF APPENDIXES

LIST OF ABBREVIATIONS AND ACRONYMS

CATS	Comissão de Avaliação de Tecnologias de Saúde (Health Technology Assessment Committee)
CFA	Confirmatory Factor Analysis
CICS.NOVA	Centro Interdisciplinar de Ciências Sociais (Interdisciplinary Centre of Social Sciences)
DATS	Direção de Avaliação das Tecnologias de Saúde (Health Technology Assessment Directorate)
CT	Computerized Tomography
DGH	Directorate-General of Health
DL	Deep Learning
DM	Decision-maker
EFA	Exploratory Factorial Analysis
EPTA	European Parliamentary Technology Assessment
FA	Factor Analysis
FCT-UNL	Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (Faculty of Sciences and Technology of Universidade Nova de Lisboa)
fMRI	Functional Magnetic Resonance Imaging
GOF	Goodness of fit
GrEAT	Grupo de Estudos em Avaliação de Tecnologia (Study Group on Technology Assessment)
HRA	Health Regulatory Agency
HTA	Health Technology Assessment
HTAi	Health Technology Assessment International
HTM	Health Technology Management
HTR	Health Technology Regulation
INAHTA	International Network of Agencies for Health Technology Assessment
Infarmed	Autoridade Nacional do Medicamento e Produtos de Saúde (National Agency for Pharmacy and Pharmaceuticals)
KMO	Kaiser-Meyer-Olkin measure
ML	Machine Learning
MoH	Ministry of Health
MR	Magnetic Resonance
MRI	Magnetic Resonance Imaging

NHS	National Health System
OAT	Observatório de Avaliação de Tecnologia
	(Observatory of Technology Assessment)
OTA	Office of Technology Assessment
PCA	Principal Component Analysis
PET	Position Emission Tomography
RHA	Regional Health Authorities
RF	Radio Frequency
SEM	Structural Equation Modelling
SIATS	Sistema de Informação para a Avaliação das Tecnologias de Saúde
	(Information System of Health Technology Assessment)
SiNATS	Sistema Nacional de Avaliação de Tecnologias de Saúde
	(National System for Health Technology Assessment)
SIE	Serviço de Instalações e Equipamentos
	(Installation and Equipment Services)
T	Tesla
TA	Technology Assessment
UNIDO	United Nations Industrial Development Organization
VHI	Voluntary Health Insurance
VIF	Variance Inflation Factor
WHO	World Health Organization

1. INTRODUCTION

"Nothing is more difficult, and therefore more precious, than to be able to decide."
– Napoleon Bonaparte

1.1 Context and justification

Medical devices play an essential role in health care. In particular, Magnetic Resonance Imaging (MRI) has revolutionized the way images of the human body are acquired, in order to diagnose and treat many health conditions. However, although medical devices are improving diagnosis and treatment, they are also increasing health spending (OECD 2017) due to inappropriate investments. The acquisition of new technologies and the determination of how and when they should be used are among the most important decisions made in the health care system in general, and by hospital decision-makers in particular.

The way in which a decision is made is an important factor in generating greater acceptance of that decision by stakeholders. Decision-making processes that are transparent, based on evidence and incorporate a review mechanism can enhance broader stakeholder support for decisions (Paolucci, Donnon, and Poulin 2006 23).

The principal aim of Health Technology Assessment (HTA) is to provide a range of stakeholders with accessible, usable and evidence-based information to guide decisions about the use and diffusion of technology and the efficient allocation of resources. Technology assessment (TA) can help to ensure that health policies include a real health benefit from a technology, which facilitates evidence-based decision-making. This is why TA has been called the bridge between evidence and decision-making, since it provides information for health care decision-makers at the macro, meso and micro levels (Battista and Hodge 1999). However, HTA scientific evidence is still not incorporated routinely into the decision-making process (Merino and Lema 2008).

To generate greater acceptance and appropriate use of HTA, greater efforts are needed in the area of building decision-makers' skills in interpreting and analysing evidence, and establishing an information infrastructure to make evidence more readily available. In order for HTA to support decision-makers, it has to produce the evidence that they require (Coburn 2005).

There is a need for a better understanding of decision-making processes, when it comes to the acquisition of medical devices, however, empirical research on decision processes is sparse and not up to date (Greenberg et al. 2005).

It seems that in Portugal, the justification for most medical practices, including medical devices allocation, rests on the experience and expertise of clinicians, rather than on objective evidence. As the system improves its knowledge on what technology works better and where, decision-makers can use this knowledge to improve health inequalities in an aging population. The efficacy, effectiveness and above all, equity in Portuguese Health Service also improve with this knowledge.

It is therefore important to shed light on the characterization of the decision-making process, with a special focus on the MRI purchase decision process in the Portuguese healthcare system. This information is relevant for TA since a study of the decision-making process can aid professionals developing TA studies to understand how the process is characterized and conducted, mainly by identifying which decision-makers are involved and how they can influence the process. TA relies strongly on evidence such as indicators, and since in general, selection of indicators is not an unbiased task, it is important to identify which indicators were used in order to improve knowledge of the decision-making process.

Decision-making processes can be very complex. Thus, in order to better understand them, the focus of attention should not be only on the final decision. Instead, all phases of the process should be considered.

1.2 Objectives and Research questions

This research has the general objective to provide guidance as well as methodological support for improving decision-making in healthcare. With an innovative and pioneering perspective, this thesis aims to contribute to a deeper understanding of the decision-making process characterization, regarding the acquisition of medical devices, taking the MRI as its object of study.

This overall objective can be separated into a theoretical and a practical objective. The primary theoretical objective is to analyse existing theories and research approaches with regards to their contributions to decision-making, and to identify and synthesize findings of suitable theories into a general framework. The practical goal of this research is to provide empirical evidence that can shed light on how the decision process is characterized, and by doing so, to understand how decision-makers legitimize their decisions regarding the purchase of MRI equipment. The present research tries to explore the role of HTA in decision-making processes for the acquisition of MRI equipment in Portugal, by examining sources of information and other relevant considerations used by decision-makers.

The research question addressed is: *What is the influence of HTA in the decision-making process for MRI purchase?*

In order to maintain the focus of the research, three specific aims emerged following the literature review:

- To identify the decision-makers actively involved in the technology purchase decision process
- To characterize the decision-making process by identifying the use of evidence, steps, goals and competences perceived by the decision-makers
- To understand the role of Health Technology Assessment studies in the decision-making process.

In order to pursue these aims, the following research questions (RQ) were addressed in the research:

RQ 1: Who are the decision-makers involved?
RQ 2: What competences are involved in the decision process?
RQ 3: How is the decision-making process characterized?
RQ 4: Which are the main drivers for the technology purchase?
RQ 5: Which factors influence the decision (e.g. relationships, other stakeholders, personal characteristics, etc.)?
RQ 6: What kind of evidence was used?

Considering that in order to decide, a set of knowledges needs to be mobilized by the decision-maker (DM), it is important to understand how these knowledges can influence the decision. It is assumed that they will play a similar role in the process. In addition, the following hypothesis will be tested: *In the decision-making process, the different knowledges have an equal influence on the decision-maker competences.*

It is intended that the results of this study will help to shed light on the decision-making process for medical devices purchase. A sound strategic purchase is important, in both public and private sectors, if the health system performance is to be improved and optimized. Thus, a clear and unbiased assessment of the technology impacts in different fields, such as the social, ethical, economical and medical, for instance, is extremely important and useful to guide purchase decisions.

In order for HTA recommendations to be taken into consideration in the decision process by the decision-maker (DM), the process itself needs to be deconstructed. To understand how decisions take place, meaning what motivates them, who is involved, what abilities, knowledge and thus competences that the decision-makers are in possession of, what tools are used and how they are used, is therefore important in order to better frame the result of HTA, assuring that it will be used and integrated in the decision-process, promoting transparency and accountability in the process.

On a more practical level, it is hoped that this study can contribute as a basis for work on the further development of HTA in Portugal.

1.3 Research development phases

The present research was structured in two main phases: a literature review and collection and analysis of the data. A literature review was performed in order to collect information about recent developments on the topics under discussion in the research, mainly on decision-making, competences, TA and HTA, MRI and medical devices purchase. The aim was also to identify the gap that eventually led to the research questions and hypothesis.

In terms of research design, two strategies were chosen, aiming at different objectives: To characterize the decision-making process a mixed method was chosen. Data was collected using a questionnaire, and in parallel semi-structured interviews were conducted. Both data sets were analysed and merged for discussion. Sampling issues were considered, namely saturation of information, when participants were selected by convenience in a snowball approach. In terms of data analysis strategy, descriptive statistics were chosen as well as content analysis, namely categorial analysis; To assess competences for decision-making, a quantitative approach was selected. A questionnaire retrieving only quantitative data was developed and Exploratory Factorial Analysis (EFA), was performed in terms of data analysis strategy, followed by Structural Equation Modelling (SEM) (namely Confirmatory Factorial Analysis (CFA) and Path Analysis).

The thesis is structured following the phases of the research study:

Chapter 1: Introduction. A brief contextualization of the topics approached in the research is presented, with reference to the justification for the research and its aims. The research questions and hypothesis are presented as well as the research development phases.

Chapter 2: Conceptual Framework. A literature review is presented to address decision-making processes and associated influences and competences by the decision-maker, role and use of technology assessment studies as a tool for unbiased evidence. An overview of the technology in focus is given with reference to the Portuguese health care system and its regulation on medical devices.

Chapter 3: Methodology Framework. The methodology used to obtain and analyse data so that the research questions could be addressed, and the hypothesis tested, is presented. Thus, a detailed description of the research approach and design is presented.

Chapter 4: Decision-making: Purchase of an MRI Scanner – Results of Survey Analysis. As title suggests, in this chapter results from surveys are presented: one questionnaire as well as semi-structured interviews. The chapter is organized in two parts: in the first part, the characterization of the decision-makers and the characterization of the decision-making process is present; on the second part, in depth analysis of the semi-structured interviews are presented.

Chapter 5: Competences in Decision-making: Model Testing Using SEM. The steps taken in the SEM analysis are described, namely the theory and the model construction, how the instrument was constructed, data collected, and the model tested, evaluated and modified and finally interpreted.

Chapter 6: Discussion of Results. This chapter discusses the results previously presented in Chapters 4 and 5, in the context of the literature review presented in Chapter 2.

Chapter 7: Conclusion. This final chapter presents the main conclusions of the research, with a reflection on its practical recommendations and limitations encountered during the research.

2. CONCEPTUAL FRAMEWORK

“Making good decisions is a crucial skill at every level.”
– Peter F. Drucker

In everyday situations, people make decisions. Some appear to be more rational than others. Some appear to have more importance than others, and some have consequences which can impact other people’s lives. The context where a decision takes place plays a crucial role. When applied in the healthcare field, decisions on the purchase of medical devices may take a particular approach, as their implications can affect the lives of many people. Specificities in the healthcare field play a role in moulding the decision process. It is therefore important to understand, in the broader sense, how decisions are made in general, how the technology purchase is framed in a healthcare system and the contributions one can expect from Technology Assessment (TA). In addition, it is also important to understand the importance of the technology focus in this research study, and in the Portuguese context, where all of these themes are applied.

In the literature, one can find descriptions of different types of decision-making contexts, however, few of them are related to the decision-making process regarding the acquisition of medical devices. This chapter aims to provide a literature review on the above-mentioned topic, and in addition to clarify some definitions and concepts which are considered relevant for the better understanding of the subject under study. To this end, five sub-chapters have been organized, each referring to a specific topic. They represent the theoretical framework (sub-chapters 2.1 to 2.5) used for the development of the conceptual framework (2.6).

In the first sub-chapter (2.1), contributions from TA with a focus on health are presented. The aim is to provide an overview of how TA emerged and how Health Technology Assessment (HTA) gained its position. Similarities and differences between the two disciplines are addressed. In order to shed light on "How do decision-makers make decisions?”, sub-chapter 2.2 provides a literature review of some theoretical models that underline the process and the different types of decisions. Possible steps that characterize the decision-making process are considered, as well as group versus individual decision-making. Influences (internal and external) on the process and common mistakes made by the decision-makers in the process of deciding will also be addressed. Since the present research focuses on the decision to purchase medical devices (such as Magnetic Resonance Imaging (MRI)), sub-chapter 2.3 provides an overview of the procedures related to the acquisition process, and the challenges it creates to the health system.

The technology object, MRI, is addressed in sub-chapter 2.4, which aims to provide an overview of this technology that, since its initial clinical use in the early 1980s, has revolutionized the diagnosis and treatment of a wide variety of medical conditions. A brief overview of MRI is given in terms of its physical characteristics, followed by its clinical applicability. Insights into future developments and trends are also provided.

Sub-chapter 2.5 focuses on the Portuguese case study, regarding HTA and MRI. Here, the National Health System (NHS) is summarised, followed by the characterization of the development of HTA in Portugal and the characterization of MRI scanners in the country. Overall remarks on this chapter are presented in sub-chapter 2.6.

2.1. Contributions from Technology Assessment

In the mid-1960's the term "technology assessment" emerged in the United States, from the need to assess technology's side effects and the consequence of its introduction in different areas such as environment, health, mobility, etc. (Daim, Gerdsri, and Basoglu 2011). It is said that the term was first introduced in 1965, in the US Congress, by the congressman Emilio Daddario, who emphasized its purpose when stating that policymakers needed to have technical information to support their decisions, which was frequently not available (Goodman 2004). Daddario was responsible for many studies that addressed several subjects in science and technology, including the nature, process, and uses of TA.

After hearings and five versions of a bill, the Technology Assessment Act passed in the US Congress in 1972 (Herdman and Jensen 1997), and the US Congressional Office of Technology Assessment (OTA) was established. OTA became operational in 1974, not as a national agency working for the public, but as part of the US Congress, and formally working only for the Congress. At that time, "[n]owhere in the world was there an organization solely dedicated to understanding the scientific and social impacts of technological change" (U.S. Congress 1982). However, after 21 years, in 1995, it was closed for political reasons (Herdman and Jensen 1997). The work developed by OTA was, however, a stimulus for the development of TA activities, not only in the US but also internationally.

In the following decades, parliamentary TA facilities were implemented in several European countries. The "classical" TA approach contributed to the political decision-making processes by providing comprehensive knowledge on the consequences of technology (Decker and Ladikas 2004, 1). Regardless of these differences, TA is in general characterized by a mix of empirical research and prospective thinking. It aims for knowledge production, sometimes under conditions of uncertainty, in order to clarify argumentation in opinion formation and decision-making. It does so by promoting scientific independence in order to give advice to policymakers on science and technology (Grunwald 2006). Thus, TA results are intended to influence not only political practices, but also social ones (Decker and Grunwald 2001). And because societal problems imply that technological, economical, ecological, legal and ethical aspects, among others, need to be taken into consideration, there is a need, in general, for an interdisciplinary TA approach (Decker 2004; Grunwald 2006). In fact, due to the selective scope on ethical, legal and social implications (ELSI) or aspects (ELSA) of new technologies and emerging fields, ELSI studies took on a prominent role, often to inform not only decision-makers, but more broadly the interested public (Grunwald 2009, 1142).

Over the years, European TA institutions developed several methodological concepts that aimed, in general, to enhance the initial approach of "classical TA" (Decker and Ladikas 2004, 2; Butschi et al. 2004). Three classes of methods characterize a TA "methods toolbox". These methods complement one other and are considered as current TA practice (Butschi et al. 2004), namely:

- scientific methods (Delphi, expert interviews, modelling, risk analysis, scenario technique, discourse analysis, value research, ethics, etc.)
- interactive methods (consensus conference, expert hearing, focus group, scenario workshop, etc.)
- communication methods (newsletter, opinion article, video presentation, dialogue conferences, websites, etc.).

The production of knowledge promoted by TA studies on the consequences of technological development and its side effects, as well as its evolution from a societal perspective will promote recommendations that can be shared on a political and societal level (Grunwald 2009). Therefore, its studies should be integrated at an early stage of decision-making processes, in order to support the evolution of the value of technologies and their impact. However, it is TA's responsibility to create optimal conditions for reaching impact on its recommendations (Grunwald 2019, 200).

As mentioned above, OTA developed TA activities in several fields. Although health was not initially thought of as a high priority topic for TA in the US Congress, or as a central task for the Health Program, in 1974–75, some important members of Congress, namely Senator Edward Kennedy (several times chairman of the OTA Board), believed that OTA should engage assessments in the health field. For that purpose, David Banta was hired to begin to work on health topics, namely on issues regarding policies and existing medical and justification practices (Banta and Behney 2009, 28). One of the first assessments requested, in February 1975, by the US Senate Committee on Labour and Public Welfare (on behalf of its Subcommittee on Health) was on this topic: the justifications required before the implementation of costly new medical technologies and procedures (Banken and Juzwishin 2011,11).

From 1975 to 1983, OTA was generally little known to the majority of Congress members, and the Health Program was able to carry out studies, at the time called "medical technology assessment", without much Congressional interest or "interference" (Banta and Behney 2009, 28). The work developed by the OTA Health Program was essential as it defined a new field of TA applied to health. In the 1980s, the term "health technology assessment" became dominant, and widely used in the 1990s (Banta 2009).

The OTA Health Program produced approximately eighty full assessments, plus a large number of shorter technical documents and briefing papers, among others (Banta and Behney 2009, 28). Searching the OTA database, it is possible to find the category "Health and Health Technologies", containing a total of 87 published reports focusing on health and / or related health technologies. Some of these reports can be seen as pioneer studies in the field of HTA, in the sense that they introduced new concepts and approaches or methodologies for health technologies' assessment. For instance, the report on "Development of Medical Technology: Opportunities for Assessment" presented the idea of the diffusion of technology and its diffusion curve. The stages of diffusion became the underlying model for much of the Health Program's later work, especially that formal governmental policies could be related to different phases in the diffusion of health technology (Office of Technology Assessment 1976).

The report on "Assessing the Efficacy and Safety of Medical Technologies" was important due to the introduction of new terminology. Its definitions of medical technology, efficacy and safety, and medical technology assessment, for instance, were widely used as a standard for many years and some are still accepted today (Banta and Behney 2009, 30). The core of the report was a model of the assessment process that was later used in many HTA programs around the world, and for organizing the framework in the EUR- ASSESS report[1], in which HTA in Europe was examined and stimulated. The model suggested the following steps: (i) identification of the technology to be assessed, including setting priorities between candidates for assessment; (ii) testing or carrying out studies, especially concerned with efficacy and safety; (iii) synthesis of available information on efficacy and safety to reach conclusions in the case of a specific technology; and (iv) dissemination of the conclusion to those who needed the information and could act on it (Office of Technology Assessment 1978).

In the report "Implications of Cost-Effectiveness Analysis of Medical Technology", a particular contribution on cost-effectiveness studies was performed, by examining different US Federal government programs to see whether analysis of cost-effectiveness might be of assistance in making decisions in those programs. The issue of basing insurance coverage on such information was publicly discussed, probably for the first time, which later became a key issue and was systemically raised and analysed in the US as well as other countries. Several policy options were presented, suggesting how cost-effectiveness analysis could be used in formal decision-making. The range of authors commissioned to prepare these cases, illustrates another way OTA affected the history of HTA: it involved a large number of people who had played, or who would subsequently play, a major role in

[1] See Banta D et al., eds. (1997). Report from the EUR-ASSESS Project. International Journal of Technology Assessment in Health Care, 13:133–340.

health policy in a common effort to understand these new issues surrounding cost-effectiveness assessment (Office of Technology Assessment 1980).

The report on “Strategies for Medical Technology Assessment”, published in 1982, proposed a method for managing technological changes in health care. Although this report did not develop or present any truly new material, it drew together the material from earlier reports into a comprehensive synthesis of issues related to HTA, especially methods and policies toward health technology (Office of Technology Assessment 1982).

In 1979, the report “A review of selected Federal vaccine and immunization policies” was published, and from the standpoint of HTA history, it was the first report to include a cost-effectiveness analysis (Office of Technology Assessment 1979). Many more would follow. Its consequences were truly important for decision-making in terms of coverage in the Medicare Program[2]. As a result, if a technology was not found to be cost-effective, then it would not be covered by the healthcare system.

HTA began to have an impact in the rest of the world in the late 1980s, with the establishment of the first institutions, initially at regional/local level in France and Spain, followed by the first national Swedish Council on Technology Assessment in Health Care (SBU) in 1987 (Velasco-Garrido and Busse 2005), making these countries leaders in HTA (Banta and Oortwijn 2000a). During the following two decades, HTA spread to nearly all European countries, and later to some of the wealthier countries in Latin America and Asia, where national HTA programs were established. The spread of HTA has been facilitated due to contributions from membership associations in HTA, notably the International Society of Technology Assessment in Health Care and its successor organization, Health Technology Assessment International (HTAi), and the International Network of Agencies for Health Technology Assessment (INAHTA) (Banta and Jonsson 2009, 2).

HTA is organized and implemented differently depending on the nature of the health system of each country, this being one of the main determinants of such differences (ibid.). In 2000, a series of paper were published in the International Journal of Technology Assessment in Health Care, covering the situation of HTA in several European Union (EU) countries. From this study several conclusions were drawn, mainly that, although European healthcare systems are sometimes described as if they are quite similar in their organization and financing, in reality they are not. In fact, they are complex and diverse. They evolved over time and share similar trends such as population aging and increases in healthcare

[2] Medicare is the federal health insurance program for: people who are 65 or older; certain younger people with disabilities and for people with end-stage renal disease (https://www.medicare.gov/glossary/m, accessed June 2020).

expenditures, but decisions are based on social and cultural preferences. Thus, mechanisms for dealing with health issues are approached differently, leading several countries to experience HTA in different ways. This learning process and experience can be used for mutual learning, in terms of the development and use of HTA (Banta and Oortwijn 2000a, 626).

HTA is currently defined by INAHTA and HTAi (2020) as “the systematic evaluation of the properties and effects of a health technology, addressing the direct and intended effects of this technology, as well as its indirect and unintended consequences and aimed mainly at informing decision making regarding health technologies”. It focuses on the medical, economic, social, and ethical implications of the development, diffusion, and use of health technologies, such as drugs, medical devices, screening tests and medical procedures (WHO 2011a). Ethical issues in healthcare belong to one of the most challenging areas, and despite ethics being one of the recognized dimensions of HTA, it is seen as methodologically less well-developed than the other HTA areas, such as clinical or economic effectiveness (Scott et al. 2017).

The main purpose of HTA is thus to inform technology-related policy-making in health care, where policy-making is used in the broad sense to include decisions made at, for instance, the individual or patient level, the level of the health care provider or institution, or at regional, national and international levels (Goodman 2004). It is a dynamic, rapidly evolving process, embracing different types of assessments that inform real-world decisions about the value (i.e., benefits, risks, and costs) of new technologies, interventions, and practices (Drummond et al. 2008, 247) in healthcare.

HTA is conducted by interdisciplinary groups that use explicit analytical frameworks drawing on a variety of methods. It is a tool to review technologies and provide evidence on the value that these technologies can deliver to patients and their families, health system stakeholders, and to society in general (INAHTA, HTAi *et al*. n.d.).

Considering the technology diffusion depicted in Figure 2-1, HTA studies play a role along its different phases. Prior to the incorporation of technology in the health system, an initial assessment process can be made, for instance from an economic point of view (production costs). Other types of studies can also evaluate the advantages and disadvantages, benefits and risks as well as impacts of the use of technologies, since these impacts are observed after the initial diffusion of the new technology. The retrieved information and evidence are very important to assist the decision-maker (DM) to decide, for instance, on the incorporation of certain technologies on the market. Several problems can emerge through the introduction of new medical technologies and usually, when this happens, hospitals or health institutions are not prepared to handle them.

In Switzerland, in order to handle these problems, two non- governmental institutions were created: The Swiss Hospital and Public Health Institute and the Association of Swiss Hospitals. These new institutions were invited to study emerging problems in health associated with the introduction of new medical technology, for instance the introduction of MRI into clinical practice. In this case, a panel of experts (including representatives of diagnostic radiology, biochemistry, medical physics, social medicine and epidemiology, universities, insurance companies, etc.) prepared a report on MRI, establishing the need for this kind of technology in the country and suggesting the number of sites of MRI systems and the estimated unitary costs of this diagnostic procedure (Chrzanowski and Gutzwiller 1986). The assessment helped plan investments and to deal with reimbursements and other issues on health care policy, and promoted new recommendations related to the introduction of MRI in the health system.

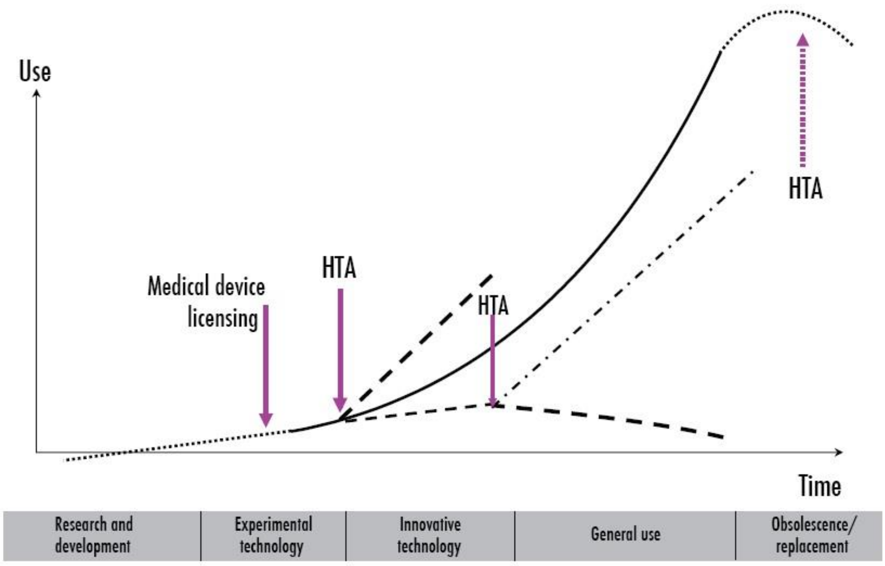

Figure 2-1 Health technology assessment and diffusion of health technologies
(Source: Banken and Juzwishin 2011, 19)

In the final phase of a technology life cycle, decision-makers need to choose whether to abandon or replace a certain technology. In this regard, HTA can be helpful by providing information/evidence on the alternatives and possible consequences of different paths.

HTA can therefore be used to guide decisions about use and diffusion of technology and resource allocation, promoting optimum levels of health outcomes (Paolucci, Donnon, and Poulin 2006, 4). Possible input into the decision-making processes include: evidence on the impact of new technologies, and appraisal of evidence and other factors such as economic conditions, organizational features, and national and international regulations (ibid., 8). HTA is therefore a useful tool to inform decision-makers on technology-related topics. Since there are several groups of potential decision-makers (from government agencies or parliaments, to hospitals or health care managers, to manufacturing industry and patients, their representatives or citizens) with different backgrounds and therefore different knowledge, it is crucial that the results from an HTA study are well-structured and the outcome is suitable to be understood by the decision-makers who will read the report. Thus, the success of such decisions depends critically on the skills of the TA researcher to convey wisdom and confidence in applying rules of argumentation (Grunwald 2007a), and it is of utmost importance to identify all potential decision-makers involved in the technology assessment process.

Therefore, the identification of decision-makers, activities and priority setting for HTA, is needed at a national level. Following the example of countries who have already undertaken this data collection, for example, the Netherlands (Oortwijn et al. 1999), the US (Perry and Thamer 1997) and France (Stephan 1988), lessons can be learned and experiences studied. In fact, decision-makers can work as a team and share experiences. This data gathering is very important for a balanced TA process.

There are several reasons to include the DM in an early stage of the assessment process: a) to have a more clear definition of the question(s) that the TA should address, b) to understand how TA will be used by the DM and which types of decision it is likely to influence, c) to understand what should be the scope of the assessment, that is, which aspects need to be included or excluded and in what detail, and d) what should be the time frame for the assessment (Hailey, Babidge, and Cameron 2010). In order to have an impact, the TA study should consider the needs and competencies of those who are asking the question(s) (ibid.).

Aiming to identify the needs and demands of health decision-makers regarding evidence in general (and HTA in particular), Merino and Lema (2008) carried out a systematic review on the use of research in decision-making, identifying as main barriers the following aspects:

- Lack of personal contact between researchers and decision-makers.
- Mutual distrust between researchers and decision-makers.
- Negative attitudes towards scientific evidence among decision-makers.
- Decision-makers who lack the tools and skills to interpret scientific evidence.
- Lack of time and human, material and financial resources.

In 2020, some of the above-mentioned barriers continue to be identified as challenges for HTA (O’Rourke et al. 2019), namely: Scarcity of human resources to conduct HTA; the need to design better approaches to involve stakeholders in HTA; pressure to evolve existing HTA methods and processes; inadequate data management and the declining quality and validity of evidence; increasing the impact and influence of HTA, and translating HTA into policy and practice.

One way to measure the success of a TA report (in health as in other fields) is to understand the degree of its acceptance among decision-makers, and to understand to what extent it was considered, or the role it played in the decision process – that is, its influence (Hailey, Babidge, and Cameron 2010). For this reason, it is extremely important that both decision-makers and (H)TA researchers make the effort to understand each other and the way each works. In this way, decision-makers should have some understanding of the methodology and other aspects of the assessment process, just as HTA agencies should obtain some understanding of the policy-making process (ibid., 4). This includes understanding how decisions take place, by having awareness of the machinery for decision-making on the technology topic in question (ibid., 12), and the role of the persons who will use the results of the assessment. Thus, the most desirable aim concerning the results of an HTA study is that they are used by decision-makers to assist and empower the decision-making process, by providing evidence to the process, since most of the decision will shape health care outcomes and improve its quality. In the end, the impact of a TA study can, for instance, affect the final decision taken, by affecting the decision on the acquisition or adoption of a new technology.

HTA is described as “the bridge between evidence and policy making” (Battista & Hodge, 1999). It provides information for health care decision-makers who are involved in funding, planning, purchasing and investment decisions. Thus, there is an identified need to look at decision-making in the health care system, to gain a better understanding of its processes and the use of evidence. Better knowledge of decision-making processes will contribute to a better understanding of the widespread variation in technology diffusion and utilisation (Lehoux et al. 2003, 21). The lack of a clear decision-making process, or lack of knowledge about the process, can lead to the absence of transparency and make it more difficult to disseminate the findings of HTA effectively (ibid., 92). A major challenge for HTA in the future concerns impact - to bridge the gap between evidence and health policy and practice - which may require some type of mechanism to hold decision-makers accountable for making use of evidence (Banta and Jonsson 2009, 5).

When a decision-making process is not fully understood by TA researchers or agencies responsible for the assessment, the probability of the study being used as evidence is diminished. The use of high-quality and trusted evidence is an important factor in the successful implementation of decisions. Thus, an increasing number of organizations are undertaking or commissioning HTAs to inform a particular resource allocation decision (Drummond et al. 2008, 246).

HTA has become increasingly important in the European Union as an aid to decision-making (Banta and Oortwijn 2000, 299), and for this reason, it has been institutionalized by a number of members of the European Union (Banta and Oortwijn 2000, 626).

A recent report that mapped HTA national organizations, programmes and processes in EU and Norway, listed: twenty-five EU countries and Norway having an HTA system informing decision-making on a national level; fifty-six organisations (all public bodies) were identified as HTA bodies having a clearly defined role in the HTA production process to inform decision-making on the national level; fifteen EU countries have a single national body whose main role includes the development of HTA recommendations, and twelve EU countries have a model that includes two or more national HTA bodies whose main role includes development of HTA recommendations (Chamova 2017, 8). In terms of scope, twenty-three EU countries have an HTA system that includes assessment of pharmaceuticals, twenty EU countries an HTA system that includes assessment of medical devices, and seventeen EU countries a system that includes assessment of other technologies. Norway has an HTA system that includes assessment of all three types of technologies (ibid.). HTA is used primarily to inform pricing and reimbursement decisions, with a majority of the EU countries (24) and Norway using HTA to inform reimbursement decisions on pharmaceuticals. With regards to decision-making on medical devices, fewer EU countries (19) apply HTA to inform reimbursement decisions and a clear minority (9 EU countries) apply HTA to inform pricing decisions (ibid.).

Looking at the history and evolution of TA it is debatable if the broad field of TA shares linkages with HTA. Looking at how the research questions are addressed, HTA tends to go in the direction of safety, efficacy, clinical and cost effectiveness, and economic aspects of heath technologies (Banta 2009; Grunwald 2019), while TA tends to relate more to the societal context (meaning the social, ethical, legal and organizational aspects) of the technology, and therefore the implications and interactions between technology and society.

The way such questions are formulated will determine how the rest of the assessment will be addressed and conducted. Methodology of HTA usually includes quantitative cost/benefits and benefits/harm evaluations (Grunwald 2019, 86), and one reason for this has to do with the necessity for HTA to responded to fast technological developments, increasing costs, and growing demands that characterise the health care sector (Reuzel et al. 2004, 248). Thus, over the years, HTA has developed a specific approach and methods to be applicable mostly to health technologies. And although it is concerned with the implications of health technologies for policy-making, the majority of its studies aim at decisions outside this level, unlike TA, which focuses specifically on the political level (Perleth and Wild 2001).

Although both HTA and TA are problem-oriented and both must provide evidence-based solutions to the problems addressed, they differ in terms of approach and methodology. Therefore it can be considered that they are independent fields (Grunwald 2019). However, this does not rule out cooperation between them. In fact, in some areas this cooperation could be beneficial for both TA and HTA communities (M. Maia 2016) as well as for the decision-making process in health care as a whole (Perleth, Gibis, and Göhlen 2009).

The contexts in which TA and HTA research are carried out are different, and for this reason, so are the methods used, as well as the comprehensiveness of the assessment that each conduct. Depending on the research questions (e.g. purchase of a medical device) some aspects will be evaluated and others minimized or not assessed (e.g. organizational and economic aspects) (Velasco-Garrido and Busse 2005). This leads to a specific selection of some tools at the expense of others.

2.2. Decision-making process

One aspect transversal to all organizations' daily work, is the fact that they all need to constantly make decisions. Every day, different types of decisions, some more important and complex than others, occur in an organization.

Decision can be understood as the analysis and choice process between several available alternatives, from the course of action that one should take (Chiavenato 2004). *Decision-making* is understood as "choosing one alternative from among several options" (Ebert and Griffin 2013, 176).
Given a determined situation, the DM follows a strategy to get results, in order to fulfil certain aims. According to Tersine (1973, 139) there are six elements to take into consideration in a *decision*:

1. The decision-maker: person who makes a choice or option among several possible alternatives.
2. The aim: aim(s) that the *decision-maker* intends to achieve with their actions.
3. Preferences or value system: the criteria that the *decision-maker* uses to make a choice.
4. The strategy: the course of action that the *decision-make*r chooses to better achieve the *aims*, in close connection to the resources available.
5. The situation: concerns environmental aspects that involve the *decision-maker*, many of which out of their control, knowledge or comprehension e that affect the choice.
6. The result: refers to the consequence of a given strategy.

Understanding of the decision processes can provide a meaningful framework to understand how people and organizations perform, and how to facilitate decision-making in practice. It is therefore important to understand how decision-makers make decisions, in order to find a common ground in this sense, to better understand and modify suboptimal decision practices.

2.2.1. Approaches to making decisions

The primary aim of this research is descriptive research, meaning it is concerned with how individuals make decisions in different organizational contexts, by focusing on behaviours and cognitions of the decision-makers (Simões 2001), rather than being prescriptive research designed to inform decision practices by focusing on the methods that aid an optimal decision possess and therefore give a higher emphasis to the result of the decision process (ibid.).

Aiming to improve decision-makers' capabilities to deal with non-programmed decisions, some theoretical models have been developed, some of which are supported by extensive empirical research (José M. C. Ferreira and et al. 1996).

The stereotype version of a health care DM suggests a manager who systematically considers all well-defined options by carefully weighting evidence, and who is fully objective and logical. This perception is in line with the rational perspective of decision-making. As the name states, the rational model assumes a rationality during the process of decision, and therefore it assumes that the DM is in possession of total knowledge and therefore is completely informed on the topic over which a decision has to be made. This approach is accepted in traditional economic theories of behaviour, where it is assumed that decision-makers are able to integrate all available information to rationally determine the utility of decision outcomes (Carnevale, Inbar, and Lerner 2011, 274).

The rational process can be described as having four steps (Simon 1977; Turpin and Marais 2004, 144):

- Intelligence: finding occasions for deciding
- Design: inventing, developing and analysing possible courses of action
- Choice: selecting a course of action from those available
- Review: assessing past choices.

This would require that all alternatives are identified and listed, that all consequences resulting from each of the alternatives is determined, and that the accuracy and efficiency of each of these sets of consequences are compared (H. Simon 1976). The main rationale for using information in rational decision-making is its role in reducing uncertainty in making a choice among a set of policy alternatives. In this concern, the lack of information is often perceived as a determinant of "irrational actions".

According to Grünig and Kühn (2013, 29), rationality does not refer to the success of the chosen and realized option; rather it refers to how thoroughly and systematically the decision-making process is carried out. This model meets the vision of neo-classic economists and statisticians who saw human beings as totally rational decision-makers. It is generally assumed that a decision can be qualified as "rational" if the decision-making process has the following characteristics: (1) The decision-making process is continuously goal-oriented; it consistently focuses on overriding goals. (2) The considerations in the decision-making process are based on information which is as objective and complete as possible. (3) The decision-making process follows a systematic procedure of action and uses clear methodical rules.

This model has received a lot of criticism, since research showed that decision-makers often deviate from normative standards of rational decision-making (Carnevale, Inbar, and Lerner 2011) and in addition the process of deciding was not as orderly as the model assumes (Giesecke 1993). One critical voice of this model was Herbert Simon, who studies human behaviour in an organization, and was acknowledged for his work with the Nobel Memorial Prize in Economic Sciences in 1978. Simon proposed that decision-makers were limited in their ability to decide. Decision-makers are rational within their own limits (bounds) to process information. Therefore, they are subject to a bounded rationality. Thus, it is difficult for them to achieve the best possible decision (Robbins, DeCenzo, and Coulter 2013).

The model, "Bounded Rationality" tends to have a more realistic approach to reality then the rational model. Bounded rationality has to do with maximizing utility, meaning that bounded rationality "looks for satisfactory choices instead of optimal ones" (Simon 1978, 353). In this model, two concepts are central: search and satisfaction, meaning that if the alternatives for choice are not given initially to the DM, then he/she will search for them. For this reason, according to Simon (1978, 356) "a theory of bounded rationality must incorporate a theory of search" .

Information is gathered for making rational decisions within the limits of resources and cognitive abilities, which is the structure of the process that makes the decision-making process rational. This means that a rational decision-making process is evidence-based (H. Simon 1976). Those who do not seek and use information do not act on a rational basis (Rich and Oh 2000, 174). However, in bounded rationality, it is assumed that the search for information is constrained due to limits related to cognitive capacities of the DM, as well as other factors such as time. In addition, decision-makers tend to be selective in terms of the sources, meaning that there is a tendency to acquire information from preferred sources (ibid.). Therefore the search for information is limited and will stop as soon as the DM is satisfied with the amount of information collected (ibid., 174).

There are several decisions support techniques widely developed that can aid the DM. Some of the main decision support techniques are (Zhang, Lu, and Gao 2015, 7):

- Mathematical programming, "also called optimization seeks to minimize or maximize a function by systematically choosing the values of variables from an allowed set." It is possible to modulate by mathematical programming's models, several problem decisions.
- Multi-criteria Decision-Making refers to "the choice of the best option from a list of alternatives based on multiple criteria for a decision problem, that is, making preferred decisions in the presence of multiple and conflicting criteria over the alternatives available".
- Case-Based Reasoning concerns a solution for a given problem based on the decision-making previous experience and knowledge, since sometimes problems cannot be mathematically modulated. Problems are usually solved based on solutions of similar past problems.
- Data Warehouse and Data Mining. Data warehouse is an electronic repository of stored data concerning a specific organization. Data can be stored, retrieved, analysed, extracted,

transformed, etc. Data mining is “the process of extracting hidden data and undiscovered patterns from data”.

- Decision Tree is a graphic description of a set of decision rules and their possible consequences. They are usually used to help to identify the strategy which is most likely to reach a goal.

In order to develop most of these techniques, there is a necessity also to have access to computerized information systems that can support these decision activities. Therefore, to have knowledge on informatics and related systems is important.

Research has also showed that decisions are often made with little consideration for logic and rationality (Ebert and Griffin 2013, 256) but rather are based on personal experiences, intuition, feelings and judgements. The intuitive decision-making model considers that intuition can help the decision process since it allows a more creative and innovative decision, sometimes needed in risk and uncertain environments (French et al. 2005). Some types of intuitive decisions are depicted in Figure 2-2.

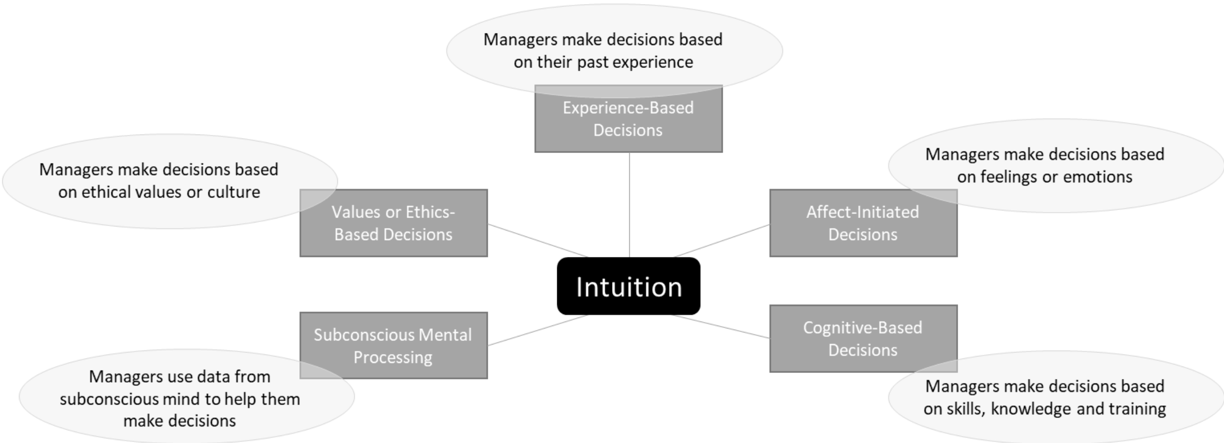

Figure 2-2 Different types of intuition decision-making
(Source: Robbins, DeCenzo, and Coulter 2013, 102)

Intuition is not rational. But it does not operate necessarily in opposition to rational analysis (Robbins, Judge, and Campbell 2010). In fact, intuitive decisions can complement both rational and bonded rationality approaches (Robbins, DeCenzo, and Coulter 2013).

According to Mintzberg and Westley (2000), decision-makers tend to use their intuitive skills rather than to rationalize a decision. In fact, they prefer to collect impressions and opinions from others instead of facts. They prefer to synthesise rather than analyse. Due to the constraint of daily work, decision-makers are more likely not to plan or make decisions systematically.

In fact, while traditional decision models presuppose an autocratic vision, in which the DM chooses the most rational alternative without constraints, based on objective criteria, i.e., measurable and subject to empirical validation, recent contributions from the application of psychosociology to the study of organisations have alerted us to the need to abandon this autocratic vision and to adapt more participatory forms of decision-making. First proposed by Victor Vroom and Philip Yetton in 1973, the Vroom–Yetton contingency model is a normative model that focuses more on the way participatory aspects of the decision-making are connected to the type of leadership behaviour (Vroom and Yetton 1973), having in mind that it is as important to understand the *way* decision-makers decide as it is on *what* she or he decides (Robbins, Judge, and Campbell 2010). In this model the group decision in the organisation is directly related to the participation of the subordinates in the decision-making (Vroom and Jago 1988). This model identifies five different styles (ranging from autocratic to consultative to group-based decisions) on the situation and level of involvement. The proposed alternatives are (Table 2-1):

Table 2-1 Vroom–Yetton normative model

Autocratic	Style AI	The leader makes their own decision using information that is readily available to them at the time.
	Style AII	The leader collects required information from subordinates and then decides on their own. Problems or decisions may or may not be communicated to subordinators who are involved only to provide information.
Consultative	Style CI	The leader shares problems with relevant subordinates, individually. After gathering all ideas and comments, the leader decides alone. The decision may or not may reflect a subordinate's influence.
	Style CII	The leader gathers a relevant group of subordinates and shares the problem with the group. After collecting their ideas and comments, the leader decides alone. The decision may or not may reflect the subordinates' influence.
Consensual	Style GII	The leader gathers a relevant group of subordinates, shares the problem and discusses it with the group. Together alternatives are suggested, and the solution is reached by agreement (consensus) of all members.

The importance of this model resides in the fact that human decision-making is based on hedonic motives rather than on rational motives (Cabanac 1992 cited in Franken and Muris 2005), in contrast to earlier theories that viewed decision-making as a rational choice. This model has also received some criticism, namely when it comes to deciding in groups, which has its advantages but also disadvantages. Managers must have the capabilities to be both participative and autocratic and they need to have the knowledge of when to employ each style (Vroom and Jago 1988).

2.2.2. Types of decision

Not all decisions are the same. Most organizational decisions are a result of a programmed situation, and therefore have a low level of novelty (José M. C. Ferreira and et al. 1996). An organization can also be confronted with unexpected situations which raise complex and difficult problems that need to be solved, leading to non-programmed decisions (ibid.). These decisions are characterized by a low predictability and high importance.

For instance, they can be programmed or routine and non-programmed or non-routine. The difference rests on the approach taken: if the decision is made based on a routine approach (repetitive or regular decision) which means that the problem at stake is already structured, and therefore can be addressed through standard responses, the decision can be categorized as being a programmed one. A non-programmed decision is unique and new, and it includes a nonrecurring matter where past experiences can help but the solution is based on the current situation (Robbins, DeCenzo, and Coulter 2013; French et al. 2005).

The decision can also be part of a strategic plan for the institution or it could only be used for operational control. A strategic decision can be defined as one concerned with deciding the objectives of an organization, the resources used to attain the objectives and policies governing acquisition, use and disposition of those resources. An operational decision is considered to be a decision which ensures that resources are used efficiently in the accomplishment of the organizational objective (WHO 2005a).

The environment where decisions take place also plays an influence on them. And decision-makers can encounter three different conditions when making a decision: certainty, uncertainty and risk (Robbins, DeCenzo, and Coulter 2013; French et al. 2005). We can easily understand that the optimal situation is the certainty condition, since in this situation the DM can make accurate decisions since they know the outcome of every alternative, once they are in possession of all the information. But, as mentioned, this is an optimal situation, rarely experienced by the DM. On the opposite side, decision-makers can decide under uncertainty conditions. This is the less preferential situation since a DM has neither certainty nor reasonable probability estimates available. But this is in fact the most common condition faced by decision-makers, since they only have access to a limited amount of available information and therefore no certainty about the outcome. Under uncertainty conditions, usually decision-makers call on their intuition or hunches. But if, on the other hand, the DM can estimate the likelihood of certain outcomes, then they are facing a condition of risk.

Another factor to consider when characterizing a decision is related to the number of decision-makers. The number of decision-makers that can be involved in the decision process can vary according to the decision topic, difficulty of dealing with the information, time available, type of organization, etc. Strategies for involvement should be present when it is time to decide, and there are at least three possibilities to consider (French et al. 2005, 514): individual decisions, group decisions and consultative decisions. In individual decisions, the DM makes the final decision alone based on the information they possess, and not allowing others to participate. This is an authority decision, since it reflects the decision-maker's formal authority. In a group decision, the decision makers ask others to participate in the discussion choice. The decision is shared (with consensus) and made in a participative environment. The major benefit of having a group decision is related to legitimacy. Group decisions are based in democratic processes which increases the level of legitimacy of the process (Robbins, DeCenzo, and Coulter 2013). Finally, in consultative decisions, the DM solicits inputs from other people and afterwards makes a final choice.

According to Mintzberg (1975) managers spend as much time with peers and other people outside their units as they do with their own subordinates - and, surprisingly, very little time with their own superiors. This way they are able to develop a powerful database of information.

Considering the organization and how it distributes its authority, if most of the decision-making is held by upper-level management, then the organization is described as centralized. Alternatively in a decentralized organization most of the decision-making is delegated to mid-level management (Ebert and Griffin 2013, 169). In summary, a decision can be classified according to different dimensions. Some of these are summarized in the following table:

Table 2-2 Summary of some decisions dimensions

Dimension	Characteristics
Degree of difficulty	Simple *vs* complex
Environment	Certainty *vs* Uncertainty *vs* Risk
Approach	Programmed / routine *vs* non-programmed / non-routine *vs* strategic / operational
Type of actor	Single / Individual *vs* Multi / Group *vs* Consultive
Reasoning process	Rational *vs* Irrational
Background	Evidence-based *vs* Intuitive
Organization	Centralized *vs* decentralized

2.2.3. Characterization of the process

Decisions are usually understood as an answer to a problem that needs to be solved by choosing among alternatives. This is rather a simplistic view, since decision-making is in fact a process composed of several steps in order to identify and choose alternatives, aiming to find the best solution based on different factors and considering the decision-makers' expectations (Robbins, DeCenzo, and Coulter 2013; Mateo 2012). There are many descriptions of the process, some more simple with just 4 steps (French et al. 2005), others with 6 (Ebert and Griffin 2013) or more. For instance, Robbins, Decenzo and Coulter (2013) define a set of eight steps for the decision-making process, following a rational perspective, as shown in Figure 2-3. The steps begin with the identification of the problem, move through the selection of alternatives and conclude with the evaluation of the decision's effectiveness.

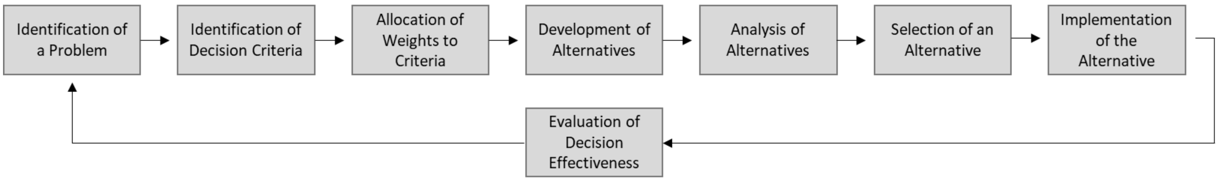

Figure 2-3 Steps in the decision-making process
(Source: Robbins, Decenzo, and Coulter 2013, 94)

In general each step can be briefly described as follows (Robbins, Decenzo, and Coulter 2013; Ebert and Griffin 2013; Bazerman and Moore 2006). The i*dentification of a problem* is the first step to initiate a decision process. Often, decision-makers act without a thorough understanding of the problem to be solved, which leads to solving the wrong problem. Thus, this is a crucial step that demands accurate judgment to identify and define the problem. However, one can argue that this identification can be subjective, since the discrepancy between reality and the desired situation can be a matter of personal interpretation. In the next step, the DM should identify the relevant *decision criteria* that can frame the problem. These criteria, or factors that are relevant in a decision, can include: price of a given technology, model, manufacturer, extra equipment, connections to IT, etc. Once again, these criteria can also be labelled as subjective, since they are identified by the relevancy perceived by the DM. These criteria will guide the decision-making process; therefore, it is crucial that all relevant criteria are identified, since if they are not acknowledged at this stage of the process, they will not be considered in the following steps. Because not all the criteria have the same importance to the DM, who can weigh them according to its importance, *allocation of weights* should be given to criteria. In this phase, the DM will prioritize criteria, by indicating the degree of importance to be assigned to each criterion. The value of each criterion should be quantifiable. In the next step, all the viable *alternatives* for problem solving should be listed by the DM, and afterwards critically and carefully *analysed*, appraising them against the criteria. Often decision-makers spend an inappropriate amount of time seeking alternatives. An optimal search should continue only until the costs of the search outweigh the value of the added information. Strengths and weaknesses for each alternative will emerge when compared to the previously established criteria and weights. This will aid the DM to *select the best alternative*. According to Brunelli and Fedrizzi (2014, 765), to select the best alternative is trivial when the number of considered alternatives is very small, but if the number of alternatives rises, so does the complexity of judging the alternatives.

During this process one should keep in mind that most decisions contain personal judgments and these judgments are reflected throughout all the steps. The *decision implementation* of the chosen alternative refers to putting the decision into action. And finally, the *evaluation of decision effectiveness*. Here, decision-makers will see if the problem was or was not resolved. From this description, it is easy to realize that in the process of deciding, the DM is able to attribute a coefficient to each criterion, and is able to foresee the consequences of their decisions as they are able to attribute weights to the different criteria. These decisions should be based in evidence.

Influence and common errors in decision-making

It is common to say that a good manager is the one that makes good decisions. Some decisions are easy to make, since they are routine decisions, but others can be more complex. Simple or not, they are affected by the decision-maker's expectations of the result. On the one hand, a DM can be very demanding and can therefore expect to pursue an optimal decision where the best possible strategy to address the process and decide is created. On the other hand, they can be less demanding and only take into consideration a satisfying result, since no high expectations are involved and the solution is accepted as "good enough" (Pitt and Koufopoulos 2012).

Although decision-makers try to do their best and commit during the decision-making process, sometimes they cannot escape making common errors or being under the influence of constraints which can affect their objectivity. According to Pitt and Koufopoulos (2012, 117) these constraints can take two main forms:

- Administrative and social processes that must accommodate disparate and partial stakeholder interests, compromise consequent acceptance of sometimes unwise choices.
- Individual shortcomings of intelligence (or cognition) and knowledge (such as analogies drawn from personal experiences; naïve or subjective interpretation of evidence (statistical data for instance); biases created by expectations).

Every decision is influenced by different factors, namely the way information is gathered, and the preferences or values of the DM. Some of these factors are therefore not under the control of the DM. Decisions are therefore made within an environment set that moulds them. For this reason, it is important to understand not only the content of the decision-making choice but also the context in which the decision is being made.

At the individual level, some errors are commonly committed by decision-makers. The most common errors are: overconfidence bias, anchoring effect (tendency to fixate on initial information, failing to adjust to subsequent information), confirmation bias, availability bias, escalation of commitment (maintain a decision in the course of the process due to a commitment of action even though it appears not to be the suitable one), randomness bias, immediate gratification bias, hindsight bias, inertia bias, selective perception bias, framing bias, representation bias, sunk costs, limited self-error and emotional involvement error (Robinson 2004; Robbins, Judge, and Campbell 2010; Ebert and Griffin 2013).

Influence can present itself in an external or internal way. As an example, in terms of external influence, political forces can contribute to a change in the behavioural nature of decision-making, for instance in the form of coalitions, when an informal alliance of individuals or groups forms to achieve a common goal. When these coalitions enter the political arena and attempt to persuade decision-makers to make decisions favourable to their interests, they are designated as *lobbyists* (Ebert and Griffin 2013, 256). In terms of internal influence, the personality of the individual will play a role. In fact, personality (Dewberry, Juanchich, and Narendran 2013) and motivation (Strough, de Bruin, and Peters 2015) are important factors to consider in order to understand decision-making competence and real-life decision-making outcomes. The result of the decision will always have an impact on the DM, since the quality of the decisions will have a repercussion on their professional success and individual satisfaction (Mitchell and Larson, 1987 in José M. C. Ferreira and et al. 1996). In addition, day-to-day decision-making sometimes entails a conflict between reason and emotion (Strough, de Bruin, and Peters 2015; Strough, de Bruin, and Peters 2015), since many decisions require self-control and emotion regulation in order to be successful (Frith and Singer 2008). Given this, certain social skills can be assumed to be fundamental in order to make competent decisions (Geisler and Allwood 2015).

Another internal influence is intuition. According to Ebert and Griffin (2013, 257) intuition is an innate belief about something, often without conscious consideration. It can be expressed as deciding because it “feels right” or due to a “hunch”. However, this feeling does not appear out of the blue. It is in fact the result of years of experience and practice in decision-making. According to Trevis Certo, Connelly, and Tihanyi (2008, 115), skilled decision-makers may actually make higher-quality decisions when they rely on their intuition rather than relying on purely economic utility functions.

Decision-makers and Competences

The ability to make decisions is intertwined with the decision-maker’s competences and its limits. Thus, decision-makers must be able to associate and mobilize their competences in order to play a role in the decision process. For example, to provide for a decision based only on financial resources (a necessary condition, of course) will not per se guarantee the pertinence or the efficiency of the decision. The DM must be able to have and use their competences in order to choose among different choices. This is the result of the sum of their knowledges. In a sense, knowledge is not just something to be studied with the aid of the tools for decision-making, since knowledge itself is at the centre of these tools. The sum of these different knowledges will allow the DM to possess a set of competences that will allow them to perform a task.

Competences can be defined as the combination of a set of skills, abilities, attributes and related knowledge needed to perform a specific task on an activity within a specific function of a job (NPEC 2002) (UNIDO 2002). They refer to the "ability to articulate and mobilize the intellectual and emotional conditions in terms of knowledge, skills, attitudes and practices necessary to perform a particular function or activity, in an efficient, effective and creative way, according to the nature of work" (Organização Internacional do Trabalho 2002, 22). Therefore they are "the ability to mobilize acquired knowledge and emotions to make decisions, to solve new problems and building work in a creative way" (Organização Internacional do Trabalho 1999, 98). The World Health Organization defines competence as "capabilities, skills, knowledge, behaviours and attitudes that are fundamental to the achievement of desired results and therefore performance at work" (WHO 2005b).

To some extent, these definitions have in common the terms "capabilities", "skills", "abilities" and "knowledge". It is important to distinguish these since they do not represent the same thing, but they are intimately related to one another: skills and knowledge are acquired through learning experiences; the different combinations of skills and knowledge that one has acquired define the competencies that an individual possesses, and finally, different combinations of competencies can be combined in order to carry out different demonstrations or tasks or for instance, decision-making. The representation of this hierarchy is illustrated in Figure 2-4:

Figure 2-4 Competences hierarchy
(Source: based on NPEC, 2002)

According to Abreu (2001), training is a complex process of learning, which is reflected in the development of the subject's structure, namely at the cognitive, affective, motor, relational and transformative levels. The mobilisation of all this knowledge by the individual, necessary for thinking, deciding and acting, suggests to us the notion of competence. Competencies are therefore operationalized at the "knowledge" levels.

When a professional performs with competence, three dimensions of competencies are activated: the dimension of the available resources (knowledge, know-how-to-do, cognitive capacities, behavioural competencies…); the dimension of action and the results produced (professional practices and performance), and the dimension of reflexivity (disengagement from the previous two dimensions) (Le Boterf 2006). In more detail, Le Boterf argues that the professional should be able to mobilize two sets of resources: a personal set such as knowledges, cognitive capacities, knowledge on how-to-do, behavioural competences and emotional resources, as well as a set of resources that are not intrinsic to the professional (and therefore are considered to be external) such as data bases, expert network, colleagues or other professional competences, scientific cooperation networks, etc. In order to perform with competence, a professional should mobilize and combine the two sets of resources: the personal and the surrounding environment. When confronted with a problem, the professional will also mobilize their professional experience in order to handle the problem in a particular way. This implies that professional practice, understood as the set of acts that the professional executes in order to do an activity or to handle a situation or resolve a problem, is a consequence of a learning process influenced by past experiences. The last dimension concerns detachment or reflexivity, in the sense that a competent professional is the one with the capacity not only to act with pertinence in a given situation, but also to understand how to act. In order to do so, the professional needs to create a certain detachment in order to have a better consciousness of their own practices. Only in this way can the professional reconstruct reality.

Decision-making competences can be divided into three distinct rubrics. The first is cognitive competence, meaning the "rational capacity of the individual" and therefore designated as "How to learn" knowledge (Kluge 2005, 297). In a general sense this is seen as the mental process involved in knowing, learning and understanding things by the DM. The second is the emotional competence that acknowledges the fact that "human beings are not automata but living beings who are embedded in psychosocial contexts and interact with other persons on more than merely cognitive terms" (ibid., 297). The third is the valuational competence that considers the DM ethically competent to decide, and therefore decisions also must be based on competent values. For Kluge, these values are intrinsic to the DM, but one can also consider that the way people behave in the workplace is a reflection not only of their personal values but also a reflection of the organizational values. Therefore, the alignment of personal values is key to the organization's success. "Value" is understood by The United Nations Industrial Development Organization (UNIDO) as enduring convictions that influence our actions and the choices we tend to make. They also represent our collective sense of what is good for the organization (UNIDO 2002). UNIDO defines three "core values": integrity, professionalism, and cultural sensitivity, which are characterized in the next table:

Table 2-3 Core Value characterization according to UNIDO
(Source: UNIDO 2002)

	Integrity	Professionalism	Cultural Sensitivity
Characteristics	• Places the good of the *Organization above personal, nation*al or other interests. • Resists undue political pressure in decision-making. • Stands by decisions that are in the Organization's interest, even if they could be perceived as unpopular. • Does not abuse power or authority. • Shows consistency between expressed principles and behaviour. • Takes prompt action in cases of unethical behaviour.	• Is at the forefront of best practice in his/her functional area. • Maintains high standards of competence through continuous learning. • Uses appropriate research, techniques and technical resources for which he/she is qualified by education, training or work experience. • Is conscientious and efficient in meeting commitments and achieving results. • Shows persistence in finding lasting solutions.	• Works effectively with people from all backgrounds. • Avoids stereotypical responses by examining own behaviour. • Does not discriminate against any individual or group. • Demonstrates respect for and understanding of diverse points of view in daily work and decision-making. • Knows how and when to adapt personal behaviour to manage or prevent conflict.

Competencies can be grouped into three main categories: managerial, generic and technical/functional, characterized as follows:

- Managerial - Competencies which are considered essential for professionals with managerial or supervisory responsibility. Some managerial competencies could be more relevant for specific occupations, however they are applied horizontally across the Organization, i.e. analysis and decision-making, team leadership, change management, etc. (UNIDO 2002). They include the ability to evaluate a situation, identify alternatives, select a reasonable alternative, and make a decision to implement a solution to a problem. They include in-depth knowledge of how the business works and its budgeting and strategic planning processes, that are necessary for a manager to understand and contribute to the profitability of their organization (Lussier and Hendon 2013).
- Generic - These are the competencies which are considered essential for all professionals, regardless of their function or level, i.e. communication, programme execution, processing tools, linguistic, etc. (UNIDO 2002) as they are related to the ability to understand, communicate, and work well with individuals and groups through developing effective relationships (Lussier and Hendon 2013).
- Technical / Functional - These are the specific competencies which are considered essential to perform any job in an Organization within a defined technical or functional area of work (UNIDO 2002). In general, they are the ability to use methods and technique to perform a task (Lussier and Hendon 2013).

This means that the DM who has to make decisions at the managerial level must have a set of competences related to that category, and so on. It is the gathering of these competences that will make the DM an expert in the field in which the decision must take place. Therefore, to be an expert is considered to be someone who can carry out a specific set of tasks expertly (Weiss and Shanteau 2003).

Many approaches have been developed to identify experts, and therefore to identify the suitable decision-makers for a specific topic. These approaches have one or more flaws, but they can be used in order to identify experts in the absence of external criteria (Shanteau et al. 2002; Weiss and Shanteau 2003):

- Experience – the number of years of job-relevant experience is used as a surrogate for expertise, for this reason it is common to see that a professional with several years of experience is classified as "expert", while professionals who are new to the job are designated "novices". However, experience is an uncertain predictor of degree of expertise, since it only stands for seniority in the job, and little more.
- Certification – As a reflection of their skills, it is common for professionals to receive a form of accreditation or a title. In general terms, one can say that a certified individual is more likely to be an expert that someone who does not have any kind of certification. In some cases, this accreditation is for a limited period of time, but in other cases, the certification provides the professional with an accreditation for life, and even if the skill level of the individual suffers a serious decline, the title or rank remains.
- Social acclamation – Professionals are asked whom they consider to be an expert among peers. The general agreement on the person's identifications labels that person as an expert through means of "social acclamation". In this approach the problem is related to the "popularity" effect, which is in turn related to the fact that a person better known by their peers is more likely to be identified as an expert.
- Discrimination ability – An expert must be able to perceive and act on subtle differences that a non-expert may often overlook, meaning that knowing *how* to combine information is of no value without knowing *what* information to combine. The ability to discriminate is a necessary, but not sufficient condition to identify experts.
- Behavioural characteristics – Behavioural characteristics might be used to develop a "trait profile" of experts. Although this approach holds promise, more work is needed in its development.
- Knowledge tests – Concerns tests of factual knowledge since knowledge of relevant facts is clearly a pre-requisite for expertise. Knowledge alone is not sufficient to establish that someone is an expert, on the other hand, someone who knows nothing about a certain domain will be unable to make competent decisions.

- Creation of experts – experts can be “created” through intensive training programs. By this means, experts can be created for certain narrow tasks. However, it is only with years of training and expertise, and a broad range of skills that a full expert can emerge (for example, radiographers or radiologists in a hospital).

The external criteria against which experts can be evaluated should be an universally accepted outcome measure that directly reflects the behaviour under scrutiny, or a *gold standard* (Weiss and Shanteau 2003).

Ross (1981) stated that wise and compassionate decision-making involves three distinct components: knowledge of the decision context, affective dispositions such as personal control and responsibility, and skill. The skill component consists of identifying a set of alternative courses of action, identifying appropriate criteria, assessing alternatives by criteria, summarizing information about alternatives, and self-evaluation. Mann, Harmoni, and Power (1989), delineated nine components of maturity of decision-making competence: readiness to choose and take responsibility, understanding that a decision is a cognitive process, creativity in problem-solving, readiness to compromise, the ability to think of diverse potential consequences of different choices, ‘correctness’ of choice according to rational criteria, ability to evaluate the reliability of information, consistency of choice, and commitment to a decision. These authors suggested that ‘correctness of choice’ is the most important element in mastery of decision-making competence (Shiloh and Rotem 1994, 478).

In order to be effective and provide for a good result or resolution, decisions should be based on the best available evidence. But for this to happen it is necessary, above all, that the decision-makers know how to mobilize their knowledges in order to identify and comprehend correctly the problem that needs to be solved, to gather the necessary information and to use it in a argumentative and tenable way. It is therefore necessary that the decision-makers possess the necessary competences to achieve such a goal: to make the best evidenced-based decision.

Mintzberg describes the role of a manager in three different categories: interpersonal, informational and decisional (Mintzberg 1989). Decisional roles are primarily related to making decisions. Some skills need to be present in order to perform a good decision-making process. These skills can be described as (Ebert and Griffin 2013; Griffin 2010) :

- Technical skills - necessary to accomplish or understand the specific kind of work being done in an organization. These skills are developed through a combination of education and experience.
- Interpersonal skills – the ability to communicate with, understand, and motivate both individuals and groups.

- Conceptual skills – the ability to think in the abstract, which allows for strategic thinking and to be able to see the “big picture”, making broad-based decisions that serve the overall organization. These skills help managers to recognize new market opportunities and threats.
- Diagnostic skills – enable a manager to visualize the most appropriate response to a situation.
- Communication skills – the abilities both to effectively convey ideas and information to others and to effectively receive ideas and information from others. These skills can also help the manager to listen to what others have to say and to understand the meaning of the communication. They also enable the manager to understand and get along with other people.
- Decision-making skills – the ability to correctly recognize and define problems and opportunities and to then select an appropriate course of action to solve problems and capitalize opportunities.
- Technology skills – ability to deal with technology, especially related to communication and information. New forms of technology have added to managers’ ability to process information while simultaneously making it even more important to organize and interpret an ever-increasing wealth of input.
- Time management skills – the ability to prioritize work, to work efficiently and to delegate appropriately.

<u>Competences for decision-making in a Radiology Department</u>

In a Radiology Department, as in any other in the health system, before committing to a decision, for instance the acquisition of medical devices, the DM needs to evaluate the effectiveness and efficiency of the possible options available on the market. In addition, the DM should also reflect on the following questions (Maia 2011, 83):

- From the technologies available on the market, which ones can meet the needs of the population (in general)?
- Will the technologies - identified as necessary for the general population - generate the expected benefits?
- What are the health gains for the population, with the implementation of the technology?
- Are there enough resources (financial, economic, human...) available, and will they be sufficient to provide and maintain the technology (equipment, software, protocols, etc.) to all who eventually need it?
- Have social and ethical issues been considered, when technological resources are being allocated (e.g. population needs, geographical localization for the new equipment, existing equipment nearby)?

In order to support their decisions, decision-makers should consider evidence and base their choices and argumentation on that evidence, since the success of these decisions depends critically on the decision-makers' ability to transmit prudence and confidence in the application of argumentation rules (Grunwald 2007b).

As a first step, it is important to identify the (potential) decision-makers in Radiology and how their competences influence their decision process, considering that this identification is subject to change, according to the subject of the decision.

Several factors have, in general, boosted people's access to information and knowledge, but at the same time these have led to changes in the organisation of work and in the skills learned. These factors are, to some extent, related to the global context of technology and above all the emergence of the information society (UNSPECIFIED 1995). In Radiology the work transformation is visible since the 1990s. Information and the use of the internet have promoted a huge work transformation, related mainly to the acquisition, storage and sharing of images. With this transformation, professionals have needed to keep their knowledge up-to-date, so that they are not excluded from dealing with new imaging techniques. But it is not enough to deepen and develop this knowledge. There are other skills that should be developed so that the professional does not run the risk of being alienated in their work tasks. Thus, it is important to understand and identify the competences associated with the professionals working in a Radiology Department, seen as potential decision-makers, for the acquisition of medical devices.

As seen previously, "Competence" can be defined as a set of skills, abilities, related knowledge and attributes, which enable an individual to perform a task or an activity within their work activity (Maia and Moniz 2011, 140). Competences are operationalized at the level of "knowledge", described as: knowledge, How to do, How to be and How to learn, which correspond respectively with the competences acquired in training, the competences acquired in the performance of the profession, the attitudes that the professional assumes in their daily life, and the cognitive skills that allow learning, reasoning and processing information (ibid., 141; Cueto 1999). The relationship between the different "knowledges" is schematized as represented in Figure 2-5:

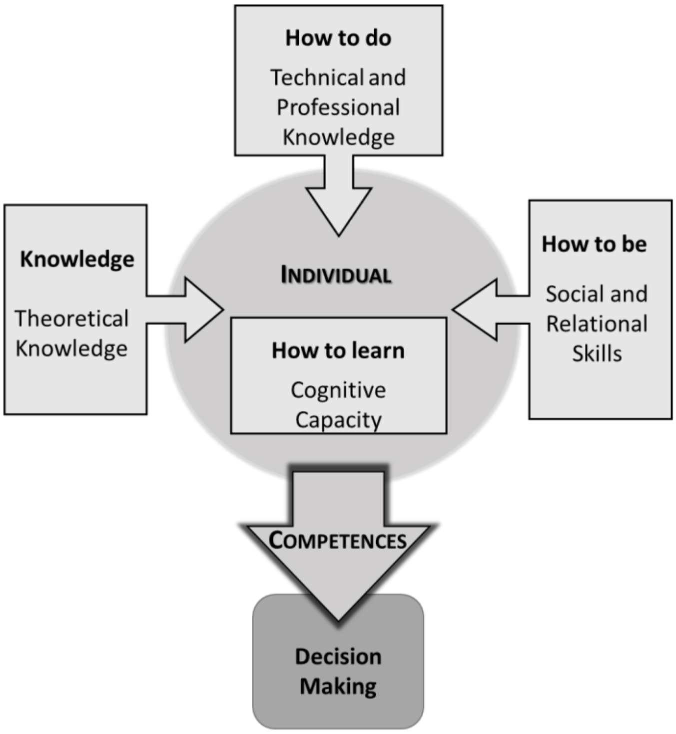

Figure 2-5 Schematization between the different "knowledge" and Skills
(Source: Adapted from Maia 2011, 85)

In Portugal, decisions on whether to adopt new technologies are mainly taken by health professionals themselves, with the greatest contribution from physicians, since the reasons that determine their choices are usually technical and are therefore reserved for this professional group (Silva et al. 2008). However, there is a lack of knowledge of economic assessment techniques among physicians, due to their weak training in health economics (ibid.).

Maia and Moniz (2011) studied competences for decision-making in a Radiology Department in different scenarios, arriving at the conclusion that decision-makers change according to the decision to be taken, and the associated necessary competences (M. J. Maia and Moniz 2011a). In their case study, decision-makers need technological expertise if they are involved or are responsible for decisions associated with a certain technology. Therefore, the relation between "competences" and "qualifications" is a valid one, since qualifications provide each DM with the theoretical knowledge they will use, to a greater or lesser extent, depending on the degree of their participation in the process (ibid.). The results were supported by a pre-test focusing on the "Theoretical Knowledge" component of competences (Maia 2011; M. J. Maia and Moniz 2011a).

2.3. Technology Purchase in the Health System

Technologies are constantly being acquired and used in a health care facility. The decision to acquire technologies is part of a health system. According to the World Health Organization (WHO) (2000, 5), a health system encompasses all activities whose primary purpose is to promote, restore or maintain health. Its aim is to consider "health gain, cost containment, solidarity, health outcomes, allocative and technical efficiency, consumer satisfaction, equity, access, choice, quality, transparency, accountability, citizen participation and provider satisfaction" (Figueras, Robinson, and Jakubowski 2005b, 46), but their priority and establishment will depend on the context in which it is applied, namely the country where the system is implemented, and therefore on its political values. Over time, health systems have played an important role by contributing to better health and well–being of millions of people who, as patients, also have expectations towards the system.

Each country's health system experiences different challenges. European health care systems for instance, face cost constraints, especially in the public sector, and the demand for efficiency in terms of resources (Figueras, Robinson, and Jakubowski 2005a). One of these resources is health technologies, defined as the application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of lives (WHO 2007). In this context, medical devices are considered to be any instrument, apparatus, appliance, material or other article, whether used alone or in combination, including the software necessary for its proper application intended by the manufacture to be used for human beings for the purpose of diagnosis, prevention, monitoring, treatment or alleviation of disease (Official Journal of the European Communities 1993). Thus, if a device requires calibration, maintenance, repair, user training, and decommissioning and it is used for the specific purposes of diagnosis and treatment of disease or rehabilitation following disease or injury, it is considered to be a medical device (Banken and Juzwishin 2011).

Having to deal with health technologies is a very complex subject, and the World Health Assembly Resolution WHA 60.29 on health technologies specifies that "understanding that health technologies, in particular medical devices, represent an economic as well as a technical challenge to the health systems of many Member States, and concerned about the waste of resources resulting from inappropriate investments in health technologies, in particular medical devices, that do not meet high-priority needs, are incompatible with existing infrastructures, are irrationally or incorrectly used, or do not function efficiently" (WHO 2007). Health care policies, practice and decisions are therefore needed to maximize the positive impact of health care interventions on population health, while maximizing the value from the cost of providing the interventions (Banken and Juzwishin 2011, 10).

The acquisition of new technologies and the determination of how and when they should be used, are among the most important administrative decisions made in a health care system in general, and by hospital executives in particular (Greenberg et al. 2005). The World Health Report in 2000, mentioned that in order to have a more productive health system, in specific areas such as human and technology resources, it is necessary to invest more knowledge and to widely and better apply the existing one. In terms of human resources, efficient use of available personnel through better geographical distribution and assurance of a closer match between skill and functions should be considered. In terms of technology resources, a special focus on strategic purchasing should be considered in order to improve health systems performance, taking into account both public and private sectors (WHO 2000). In a health system, the existence of a central authority that can have an overview of general decisions is essential, in order to ensure better coordination between public and private sectors. This is applicable, for instance, to investment decisions, since "the worst mistake is to promote or allow investments when their running costs cannot be met" (ibid., 2000, 91). Equipment purchases are an easy way for the health system to waste resources, and for this reason, strategic purchasing of health interventions is desirable (ibid., 2000, 139).

The purchase of any medical device should be strategic and not be undertaken without a clear assessment of the technology's impact on the health system. A coherent set of incentives for providers, whether in the public or private sector, should be considered to encourage them to efficiently offer priority interventions (Musgrove et al. 2000, xix). Thus, identifying the opportunity cost of an additional technology, in terms of other required services, may help to rationalize the technology purchase (ibid.).

Major equipment purchases are an easy way for the health system to waste resources, especially if they are underused after their acquisition, due to, for instance, lack of (specialized) personnel to handle and use the technology, or lack of patients that really need the examination(s). In order not to take such risks, access to information on TA is needed, such as information concerning criteria for technology purchase, especially in the public sector. It is also important that the private sector does not receive incentives or public subsidy for its technology purchases unless these further the aim of national policy (Musgrove et al. 2000).

In most countries, modern health technology continues to contribute to rising costs, due to unnecessary purchase and sub-optimal use of equipment, since some of this demand is not based on true needs. One example is the purchase of medical devices such as CT and MRI, and the associated number of available scanners per capita and the number of exams performed, which to some extent, are believed to be medically unnecessary (Musgrove et al. 2000; WHO 2010). Such indicators can be considered when estimating financial burdens on health systems.

To some extent this misallocation of resources is also connected to corrupt practices. In the World Health Report, WHO states that, in health systems, one of the sources of inefficiency is the supplier-induced demand concerning health care products and services due to overuse, supply of equipment and unclear resource allocation guidance, associated also with lack of transparency. It is suggested that a way to address this inefficiency is through the development and implementation of guidelines, to improve regulation /governance and access transparency/ vulnerability to corruption. Thus, corruption can play a share in wasted resources, related to inefficient resource management (Musgrove et al. 2000).

Strategic purchase is relevant as it aims to increase health systems' performance through effective allocation of financial resources to providers, by involving three sets of explicit decisions: which interventions should be purchased in response to population needs and wishes, taking into account national health priorities and evidence on cost-effectiveness; how they should be purchased, including contractual mechanisms and payment systems; and from whom, in light of relative levels of quality and efficiency of provider (Figueras, Robinson, and Jakubowski 2005b, 45). Since the 1990s, despite the WHO recommendations concerning strategic purchase, little has been done concerning this topic, and WHO continues to emphasize the need to address it.

The misuse of resources is common in several countries when "most, if not all, fail to fully exploit the resources available, whether through poorly executed procurement, irrational medicine use, misallocated and mismanaged human and technical resources or fragmented financing and administration" (Musgrove et al. 2000, 61).

There are many models described in the literature concerning health technology management, as well as procurement workflows models. WHO describes a model with the starting point on the health technology life cycle (Figure 2-6), and divided in three phases: provision, acquisition and utilisation (WHO 2003).

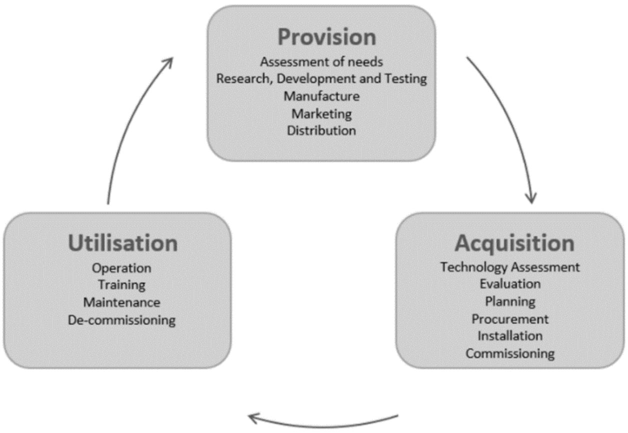

Figure 2-6 Healthcare Technology Life Cycle
(Source: Adapted from WHO 2003)

Focusing on the acquisition phase, several steps can be identified, as represented in Figure 2-7:

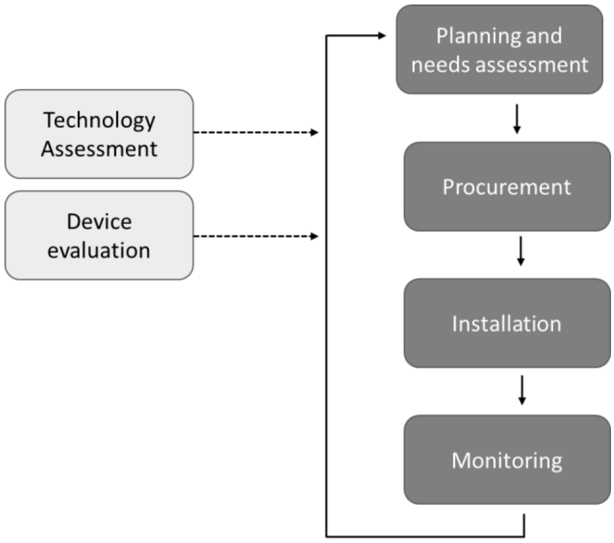

Figure 2-7 Summary flowchart of acquisition procedures
(Source: Adopted from WHO 2011)

Planning and needs assessment is a strategic phase, as it refers to the identification and assessment of gaps between the current situation and the desired one (WHO 2003). If one considers the acquisition and allocation of expensive medical devices such as MRI, needs assessment is a crucial phase if a positive consequence of the decision process is desired. To go through a real need assessment policy can improve the current performance of a healthcare system, since in terms of medical devices, it can improve the offer and amend identified deficiencies (Bauer 2011). WHO defines some steps for the needs assessment process, namely (ibid.):

a) Baseline information on health service requirements – refers to data collection concerning the health situation of the targeted population. Size of the region or area, the number and density of the population, and major disease burdens, are some of the aspects that should be assessed.
b) Baseline information on health service availability – aspects like health service availability and accessibility, facility types, number and conditions, and human resources should be considered in this step.
c) Baseline information on medical devices – information concerning health technology is collected, with a special aim of identifying the availability of medical devices and related infra-structures, and their conditions. This request was made by the WHA resolution 60.29 on health technologies to the Member States, when it stated: “Noting the need to expand expertise in the field of health technologies, in particular medical devices, the WHA urges Member States to collect, verify, update and exchange information on health technologies, in particular medical devices, as an aid to their prioritization of needs and allocation of resources” (WHO 2007). Particularly in cases

of medical devices, gathering the following data should be considered: type and number of equipment; brand name; model; installation date and location.

d) Baseline information on human resources – namely availability, capacity and capability of current human resources. Skills and any training needs for the professionals should also be assessed, keeping in mind that it is the healthcare professional's responsibility to ensure that their own skills and training remain up-dated.

e) Baseline information on finances – capacity to finance overall facility operation, including healthcare technologies should be assessed.

It is expected that the use of the technology will be optimized, however, reality shows that sometimes technology is underused, and thus not profitable. There are many reasons for this; for example, a misallocation of resources, unequal access to technology, and lack of professionals who are able to work with the technology. Over-estimations of market dimensions or social utility can also explain the under usage of such technology. Such reality can be applied to any technology in any region or sector, or even in any kind of organization. The collection of the above-mentioned information is therefore highly relevant. In addition, the assessment of needs from different stakeholders who work and benefit from the use of the technology, such as health professionals and patients, should also be considered.

After all this information is gathered, a meticulous analysis and conclusions should be undertaken, with a special focus on comparing the real needs in terms of medical devices, and the current inventory list of the medical devices available. Only then, after a real characterization of the medical devices is established, can the decision makers make an informed and evidence-based decision on the strategy to take: to buy the technology or not. In some situations, there may not be a reason to buy, but simply to improve or upgrade the existing technology, achieving a more efficient provision of the health system. The results of a needs assessment can be translated into the national health policy, since it provides decision-makers with the necessary information to optimize and select appropriate medical devices at a national, regional or hospital level (Bauer 2011).

"Procurement" is defined as the process of obtaining what is required in the plans (WHO 2011b). During the procurement process, it is expected that public organizations will achieve value for money, ethics, sustainability, efficiency as well as transparency and accountability. These expectations form the basis of public procurement principles (UNOPS 2014, 15; Dimitri, Dini, and Piga 2011, 47). The procurement process includes (WHO 2011b; Fitzgerald, Girón, and Bermudez 2006, 11):

a. Asking for bids and issuing documents (with specifications on technical aspects and also on selection of the most appropriate acquisition method; There are different methods of acquisition, for instance, purchasing or leasing which are the most common used methods, but there are others such as loans (MHRA 2014)).

b. Receiving and evaluating bids and comparing them with specifications (weighting elements for decision-making, financial evaluation, supplier evaluation, …).
c. Awarding the contract.

Purchasing responsibility for the above mentioned factors is a major step to be considered when it comes to improving the performance of health systems (WHO 2000). After the purchase is concluded, installation of the medical device follows preparation of the site (if necessary). Once the technology is in use, monitoring is needed in order to gather data on performance, to control current procurement, and also to inform future ones. The data can be related to (WHO 2011b, 19):

- medical device performance (by checking repairs and maintenance work required, for instance).
- supplier performance (satisfactory history of delivery, proper warranty visits and service calls, occurrence and execution of training, etc.).
- technology suitability (for instance, by checking the actual use of the device, feedback from equipment users for specification development, commitment of professionals to use the equipment, supply of consumables).
- cost-effectiveness (by comparing actual running and life cycle costs with forecast, to check that there are no excessive repairs).
- forecasting accuracy (by comparing number of exams planned with actual orders or requirements).

In addition, and as represented in Figure 2-7, two aspects influence the acquisition procedures described: the device evaluation, and TA. A device evaluation should be conducted mainly via market research, which can include evaluations of the device in the field, concerning for instance its performance, but also the existence of certifications in order to assure good performance and accuracy of data integrity. A good and reliable device evaluation will be useful when making purchasing decisions.

As already developed in sub-chapter 2.1, TA will be important to gather and summarize information on the medical, social, economic and ethical issues related to the use of the technology, in a systematic, transparent and unbiased way. TA studies can be conducted throughout the technology life cycle and in relation to the purchase of devices, several studies can be conducted. For instance, product forecasting is often considered to be the most critical element of the procurement and supply management process for several challenging reasons: available information for product quantification is often inadequate; procurement planners are not aware of the different quantification methods available, and how each method should be applied; a systematic approach to product forecasting is rarely implemented; and the quantification process is often executed by one person without consulting other professionals or persons experienced in the process (Fitzgerald, Girón, and Bermudez 2006, 19). In addition, poor communication and inadequate procedures guiding the product forecasting process will produce incorrect forecast estimates which in turn will result in either product stock-outs or surplus, and the irrational use of limited resources (ibid.).

Decision-makers can only improve their decision-making process if they are provided with a better understanding of the future, supported by valid information and evidence. In fact, in Figure 2-7, TA is one source of data that feeds into the acquisition model. If decisions are taken considering foresight studies, then they can improve the decision-making process, through higher ability to understand and shape the future, adding credibility and evidence to their decisions. Foresight improves the impact of decision-making and also its quality, by improving strategic decisions. By providing a variety of outcomes, foresight can improve decision-making implementation and the ability to cope with future challenges in health care (M. J. Maia 2013b). Thus, TA (applied to health) and evaluation of medical devices are two important preparatory steps for the acquisition of medical devices[3]. Technology assessment can play a role beyond the acquisition phase, meaning its studies can also be applied in other phases of the technology life cycle as seen in sub-chapter 2.1 (Figure 2-1). Evaluation is the expert assessment of performance and function of a given device, translated in the form of a certification or standardization. For this reason it is advised to perform market research before evaluating a device (Gammie 2011).

HTA is one of three complementary functions to ensure the appropriate introduction and use of health technology. The other two components are health technology regulation (HTR) and health technology management (HTM). The performance of health systems is strengthened when the linkages and exchange among these elements are clearly differentiated, but mutually supportive (Banken and Juzwishin 2011, 8; Velazquez-Berumen, David, and Rogers 2011), as illustrated in Figure 2-8.

Figure 2-8 Domains of health technology regulation, health technology assessment and health technology management
(Source: Banken and Juzwishin 2011, 14)

HTR focuses on the safety and efficiency of medical devices providing for their certification and accreditation. HTM is concerned with the procurement and maintenance of the technology during its

[3] Two examples related to MRI can be seen in Demaerel et al. (2006) and Kisser, Mayer, and Wild (2014).

life cycle. To fully understand and support synergies between HTA and HTM (and their respective contributions to appropriate diffusion of medical devices decisions) is a step towards understanding the success of a health technology policy (Banken and Juzwishin 2011).

Too often, procurement is distorted by marketing pressure from equipment manufacturers (WHO 2010, 65). In order to overcome this pressure and to ensure that the best device will be chosen, procurement should be a transparent process, and should take into consideration, the end user's needs, previously established in consultation with professionals who will be prescribing, supplying and using the technology (MHRA 2014, 13), and users themselves, in order to ensure that the responsibility for choosing is shared. This way, problems of acceptability can be avoided in the future.

Every decision has a consequence. In health care the decision to buy a medical device can have long-term consequences, since it is expected that the technology will remain in use for many years in order for the health system to obtain health gains. Thus, in terms of competences, the personnel dealing with procurement need to be appropriately qualified, experienced and trained, since supply systems management, and particularly procurement, are complex processes that require a good mix of knowledge, skills, and experience. In addition, the procurement planning team should initiate a systems competency review, to assess the competencies of personnel working within the system against those competencies identified as essential to ensure the efficient operation of the system. The level of motivation of staff should also be considered (Fitzgerald, Girón, and Bermudez 2006, 24).

2.4. Technology Object: Magnetic Resonance Imaging

Medical devices play an essential role in health care systems. One concrete example is the devices available in a Radiology or Imaging Department, which are essentially for diagnostic purposes. Diagnostic imaging has its roots in November 1895, when Wilhelm Konrad Roentgen, a German professor, discovered the X-ray. Since then, many innovations and discoveries have occurred, and many devices that use X-ray radiation have been developed. The use of these images has suffered a decline due to the introduction in clinical practice of new image modalities such as ultrasound and MRI, that do not use X-ray radiation to obtain images.

MRI was initially designated as Nuclear Magnetic Resonance (NMR) due to the proprieties of the nuclei when stimulated (NMR phenomenon was first described in 1938 (Ai et al. 2012)). At the time, in some journal editorials it was suggested that the word "nuclear" should be eliminated and NMR imaging should be denominated "magnetic resonance imaging" (Gerald, Gabriel, and Evanochko 1946, 709), mainly due to potential bad connotations that the term "nuclear" could give to the technology. The suggestion was accepted in the medical community, especially in Radiology, and was followed by manufacturers (ibid.). Presently (2020), the name Magnetic Resonance Imaging – MRI – is fully accepted in both radiology and medical communities in general (Luiten 2003; Eisenberg 1992; Brown et al. 2014; Hashemi, Bradley, and Lisanti 2010), although NMR is still used in applied research fields.

The first Magnetic Resonance (MR) images of humans were produced in 1977 (Ai et al. 2012), and despite being so new, the history of MRI is much honoured; Five Nobel Prizes have been given regarding MRI-related discoveries (Ai et al. 2012; Luiten 2003; Eisenberg 1992; Geva 2006).

MRI technology can be described according to three parameters: its material nature, its purpose, and its stage of diffusion (Goodman 2004). In terms of material nature, MRI belongs to the broad category of "devices, equipment and supplies". Its purpose or application is vast, therefore it fits different groups, such as the those dealing with screening, diagnosis and treatment of diseases (Palesh et al. 2007). Concerning the stage of diffusion, MRI is an established technology, but is still at an investigational stage, considering the intense research that it is being conducted on its potential application.

As mentioned above, MRI does not use radiation to produce images. Although there is plenty of literature that focuses on the consequences of X-ray interaction with human tissue, due to its recent use in the medical field, almost no evidence focuses on the long-term effects of the use of radio frequency (RF), especially research providing scientifically-based evidence regarding the possible harmful effects of RF in pregnancy (Ostensen 2001).

The physics behind MR is complex. It can be summarized as follows (Hashemi, Bradley, and Lisanti 2010):

- Electromagnetic waves have two components: an electric and a magnetic one, which are perpendicular to each other and 90º out of phase. For MRI the magnetic component is important since the electric component merely generates heat.
- Many types of electronagnetic waves exist throughout the electromagnetic spectrum: X-rays, visible light, microwaves, radio-frequencies, and so on. The frequency used in MRI fall in the RF range (3 to 100 MHz). They are called RF pulses.
- Spinning charged particles such as hydrogen protons generates an electromagnetic field. Hydrogen protons are the most prevalent in the human body (particularly in H_20, which comprises 60% of the body). The magnetic components of hydrogen protons behave like bar magnets. This behaviour is referred to as a magnetic dipole moment. In general, all particles with an odd number of electrons in their covalent orbit have this property (meaning they can generate a magnetic field).
- When a patient is placed in a magnetic field, some of the protons are aligned paralell to the magnetic field and some antiparallel to it (with more area parallel than antiparallel) producing a net magnetization (longitudinal magnetization). These protons also oscillate or precess on

the axis of the external magnetic field. The stronger the magnetic field, the faster the protons precess about it.

- Magnetic susceptibility refers to the ability of a substance to become magnetized when placed in a magnetic field. There are three types of magnets, based on design: permanet, resistive and superconducting, and five different types of magnets, which can be categorized in terms of their field strength: Ultrahigh field: 4.0 to 7.0 Tesla (T) (9.4T is the highest field performed on humans in research and 21.1T in animal research); High field: 1.5 to 3.0T; Midfield: 0.5 to 1.4T and Ultralow field: less than 0.2T. Most existing scanners are high-field, super-conducting magnets (which requires liquid cryogens like liquid helium and nitrogen for cooling). An alternative to a close designed bore is the open design. MRI with an open design can significantly reduce the anxiety of patients who suffer from claustrophobia, however due to the low field, special resolution is also low (Ai et al. 2012). Most "open"-type MRI scanners are permanent or resistive magnets; they require no cryogens and thus have low maintenance. However, they usually have lower field strengths and thus generate less signal.
- To create an image, RF pulses are transmited into the patient, who is positioned in the middle of the bore. These pulses flip the longitudinal magnetization and generate a signal from the patient. The received signal has no spatial information. Three types of gradient coils are employed for the purpose of spacial discrimination. Different types of coils are used: body coil, head coil or surface coil.

In terms of equipment, MRI scanners are composed with several basic elements (Nitz 2006):

- A magnet to produce a magnetic field via an electric current and the attached patient table.
- An operating console where the radiographer can select the protocols used to collect the data and produce the images. Another specialized computer can also exist, where the images can be analysed, reconstructed and treated before being sent to archive.
- Inside the magnet bore, there are the gradient coils that provide the magnetic field gradient and the shim coils that improve homogeneity of the main field within the region of interest.
- A refrigerator system to cool down the system.

Installation of the first MRI scanners in hospitals proved to be a challenge, due to environmental radiofrequency interference. To overcome the problem, manufacturers started to develop and implement shielding approaches for hospital facilities. In addition, a large amount of space is required, not only for the scanner unit but also for an attached room needed for the installation of a cooler system using helium, as well as other necessary complementary accessories.

Since its emergence in the 1970s, MRI has become indisputably important and vital in the field of medicine. In terms of clinical applications, due to its unique characteristics, namely excellent soft tissue contrast and the use of non-ionizing radiation, MRI is one of the most adopted and accepted means for image acquisition for diagnosis, therapeutic and interventional purposes. It can therefore be applied for, normal/standard exams; interventional exams (interventional MRI - iMRI) such as MR-guided biopsies; and therapeutic interventions (due to its multiplanar imaging capacity and excellent soft tissue contrast, as well as its temperature); monitoring capabilities (MRI is an important tool e.g. monitoring of minimal invasive ablation thermotherapies (Bremer 2006, 576)). In addition, MRI can also be used in spectroscopy (Magnetic Resonance Spectroscopy - MRS) that researches "image" biochemistry and metabolism in human organs and tissues (Vaughan et al. 2006, 211) and also in functional MRI (fMRI). fMRI represents one of the most advanced and potentially enlightening techniques, with huge potential in a variety of applications in both the cognitive and neural sciences (Faro and Mohamed 2006), since there has never been a non-invasive technique with high spatial and temporal resolution to, for instance, define brain activation. Although still in its infancy, fMRI has already created a tremendous body of knowledge. The number of publications related to the technique is evidence of such importance[4].

MRI is considered to be the best technique for diagnostic imaging and neuroscience research, since it provides morphological images with the highest spatial resolution and unmatched soft tissue contrast, as well as unique functional information of the central nervous system. Exams for diagnosis of brain and spinal cord tumours, infection, and vascular irregularities which may lead to stroke are the most common neurological exams performed. MRI can also detect disorders, along with monitoring degenerative disorders such as multiple sclerosis, and it can even document brain injury from trauma (ibid.). Due to the fact that it does not use X-rays, MRI is used as an alternative technology for screening younger women, and in addition, breast MRI offers better image quality than ultrasound and thus is also recommended for screening younger women (Lerski et al. 2010).

With a large spectrum of diagnosing pathologies and abnormalities, or by providing real-time information, for instance on brain activity, its application field is not yet completely defined. Potentials for its application are still under research.

In terms of MRI trends, they are related to guided images, minimally invasive procedures and therapeutics, since the image provided is getting more high resolution and high-speed imaging acquisition. In the future, MRI images will be used loco to guide minimally invasive procedures, such as biopsies or therapeutics, or even to guide robotics procedures (although the main challenge is to create robots that are MR compatible (Gassert et al. 2006)). Regarding future trends of MRI application, MRI neuro-images are already being used to guide the surgeon during a surgical procedure. The trend will be to use fMRI data superimposed on high-resolution MRI data in order to aid the neurosurgical

[4] A quick search in SCOPUS shows an average of 4000 publications per year (from 2015 to 2019).

treatments of pathological brain lesions. In the future, real time fMRI will probably be possible intraoperatively (Faro and Mohamed 2006).

The tendency for technological advancements is also related to the merging of image modalities, such as the merger between MRI and positron emission tomography (PET) or CT, to provide possibilities with less exposure to harmful radiation. In addition, innovations in the capacity and efficiency of MRI systems driven by software developments are leading to reduced scan times. Higher magnetic fields with 7T systems, now cleared for medical use, will provide even more fine image resolution, for instance of the brain.

Associated with a shortage of radiologists and an increasing demand in diagnostic imaging, new ways of providing MRI are already in place. Following the historical development of other image modalities such as X-rays and ultrasound, portable MRI are a solution for the near future. MR monitoring devices currently exist only in research laboratories and no truly portable commercial MRI scanner has been introduced to date (Wald et al. 2019, 1), but considerable work has been put into the feasibility of such a system, including light-weight, low-field extremity and brain magnets with the required mobility (ibid., 9).

Due to the current difficulties associated with logistics and costs related to the maintenance of MRI scanners, mainly associated with liquid helium, alternatives for cooling superconducting magnets are also in the future scope. Cryogen-free MRI replaces the liquid helium jacket with a revolutionary magnet design incorporating superconducting magnet coils that are cooled by direct conduction from a readily available, off-the-shelf cryocooler refrigerator unit. This results in a much lighter system, with a magnet weight, depending on system size, of approximately 350 kg, compared with two tons previously, which can be wheeled through the door into an ordinary laboratory with no special site alterations. It also allows for a shield coil to be placed optimally within the magnet to reduce the stray magnetic field from meters to centimetres (Taylor, n.d.). The range has grown with models at 3T, 4.7T, 7T, and 9.4T, with a range of bore sizes in each model. All scanners can be combined with either simultaneous or in-series PET and/or SPECT (single-photon emission computerized tomography) capabilities (ibid.). Several applications are already under research, especially in NMR imaging (for instance Rybalko et al. 2019; Kiswandhi et al. 2017). For clinical purposes, a reduction of the helium consumption can already be seen, for instance in General Electric and Philips's new MRI scanners that use a much smaller amount of helium. General Electric's magnet is designed to use just one percent of liquid helium (compared to conventional magnets), meaning that instead of using 2,000 litres of liquid helium, the scanner only uses about 20 litres (GE 2017). Philips scanner, in contrast to classic magnet technology, which requires around 1500 litres of liquid helium for cooling during operation, uses (according to the company), a highly efficient, new micro-cooling technology which requires only a negligible amount (<0.5% of today's volume) of liquid helium (Philips, n.d.).

The need for less helium consumption is not only related to the protection of the environment (helium, is the second most abundant element in the universe, but is relatively rare on Earth), but also promotes changes in the accessibility of MRI scanners, since specific locations of the equipment in a building is no longer required. This is due to no longer needing the vent pipes which are installed in classical magnets to meet safety requirements (for instance to direct helium to an outside vent in case of a magnet quench); this reduces construction costs and allows for a new building design (GE 2017; Philips 2019).

Another trend related to technology development in Radiology in general, but also associated with MRI, is the application of Machine Learning (ML) and Deep Learning (DL). Historically, images could only be analysed through visual interpretation. This is changing with the use of ML, that allows for higher-order statistical analysis of patterns within the image, converting images into data and allowing for subsequent, high-volume analysis of the pooled data, extracted from hundreds of thousands of images (Reig et al. 2019, 1). ML tools then may be used as computer vision to see beyond what is apparent to the radiologist or radiographer, by improving accuracy from interpretation of one or a few MR sequences, such that the number of necessary sequences is reduced, overall improving scan time, and cost (ibid.). The application of ML in Radiology is vast. It provides an effective way to automate the analysis and diagnosis of medical images, thus, it can potentially reduce the burden on radiologists in the practice of radiology. According to Wang and Summers (2012, 934), the applications of ML include medical image segmentation (e.g., brain , spine, lung, liver, kidney, colon); medical image registration (e.g., organ image registration from different modalities or time series); computer-aided detection and diagnosis systems for CT or MRI images (e.g., mammography, CT colonography, and CT lung nodule CAD); brain function or activity analysis and neurological disease diagnosis from fMRI; content based image retrieval systems for CT or MRI images; and text analysis of radiology reports using natural language processing (NLP) and natural language understanding (NLU).

Concerning brain studies, for instance, there has been a significant effort in developing classical ML algorithms for segmentation of normal (e.g., white matter and grey matter) and abnormal brain tissues (e.g., brain tumours) in MRI. However, creation of the imaging features that enable such segmentation requires careful engineering and specific expertise (Akkus et al. 2017, 450). And some challenges still remain, namely to have a generic method that will be robust to all variations in brain MR images acquired in different institutions and MRI scanners. In addition, training datasets are relatively small compared to the large-scale required to achieve generalization across datasets (ibid., 457). In terms of breast studies, the application of ML is rapidly evolving, with advances in lesion detection, lesion classification, radio-genomics, and prediction of response to neoadjuvant chemotherapy (Reig et al. 2019, 18). However, it still has several limitations, for instance both supervised and unsupervised ML techniques require continued study, as they have not yet achieved clinical applicability. According to Reig et al. (2019, 18), a major hurdle is the current lack of standardization, since there is no standard method of segmentation, feature extraction, feature selection, or classification. In addition, the clinical relevance of these techniques has not yet been demonstrated, since ML techniques require large datasets for training, particularly when the image class to be identified (i.e., malignancy) is rare compared with the other classes (i.e., benign lesions).

In addition, the large set of databases needed for ML, as mentioned above, are difficult to gather for several reasons such as data privacy issues, the expense of collecting training data, ambiguities in the ground truth images, and the breadth of associated applications. To overcome this, several methods have been developed to generate synthetic training data from natural images (Kwon et al. 2019, 125). However, since these methods are sensitive and difficult to understand they are labelled as a "black box" (Reig et al. 2019, 18). Thus, there is a need for additional research.

Although in a few Radiology Departments there are MRI units of 7T performing exams, the most widely used fields are 1,5T and 3T. However, in terms of European market trends, due to its potential, industries continue to explore the advantages of medical imaging technologies, and therefore contribute to higher production of the imaging systems (BCC Research 2013a). One indicator for the importance of medical devices is their global[5] market, which reached nearly $521.2 billion in 2017, and should reach $674.5 billion by 2022, at a compound annual growth rate (CAGR) of 5.3% for the period of 2017-2022 (BCC Research 2018a). In terms of tendency, the global[6] MRI scanners market should reach $7.3 billion by 2023 from $5.6 billion in 2018 ($4.9 billion in 2012 (BCC Research 2013b) at a CAGR of 5.7% from 2018 to 2023 (BCC Research 2018b).

2.5. The Portuguese case-study

In the previous sub-chapters, a literature review was conducted on the importance of technology assessment and its role in health care, with a focus on medical devices purchasing. An overview of the decision-making process was also developed.

It is now important to understand how the previous topics are framed in Portugal. Thus, in this chapter an overview of the Portuguese health system will be present, focusing on how technology assessment was introduced and developed in the Portuguese healthcare system, with a specific focus on medical devices. A brief characterization of MRI availability will also be provided.

[5] According to the report, the considered geographic regions were: North America (United States, Mexico and Canada), Europe (France, Germany and Italy) and Asia (China and India).
[6] According to the report, the considered geographic regions were: North America (United States, Mexico, Canada), Europe (United Kingdom, France, Russia, Germany, Italy and Others), Asia-Pacific (China, India, Japan, South Korea, Australia and others), Rest of World (South America and Middle East and Africa).

The Portuguese healthcare system and MRI availability

Portugal is located in south-western Europe, with a population of 10.3 million people. The country has had a democratic regime since 1974, being part of the European Community (1986) and the Euro Zone (1999). The international economic crisis had a major impact in Portugal from 2009, 2011 and 2012, leading the country to sign a Memorandum of Understanding. The Portuguese population is aging rapidly, and this scenario was worsened by the economic crisis and the subsequent migration of fertile and active citizens (J. de A. Simões, Augusto, and Hernández-Quevedo 2017, 1).

In 1976, a new constitution was adopted, and Article 64.º dictates that all citizens have a right to health protection and the duty to defend and to promote it. To ensure this right, the State has a primary duty to ensure access of all citizens, regardless of their economic circumstances, to preventive medicine, curative and rehabilitation, as well as a rational and efficient coverage of hospitals and medical care throughout the country (Diário da Républica 2005).

In 1979, the Portuguese National Health System (NHS) was created with a universal and tax-financed system, covering all residents in the country. The Ministry of Health (MoH) is the government department with the mission to define and lead national health policy, ensuring implementation and sustainable use of resources and assessment of results. The MoH fulfils its responsibilities through integrated services in direct state administration, advisory bodies and other structures and entities incorporated in the state enterprise sector. The Regional Health Authorities (RHA) created in 1993, are an example of the organisation's peripherals, whose mission is to provide the population of its geographical area of intervention with access to health care, adjusting the available resources in order to meet the population's needs and enforce policies and health programs in its area of intervention. There are five health regions that aim to provide access to all effective medical services: The North, The Centre, the Lisbon and Tejo Valley, the Alentejo, and the Algarve RHA (WHO/Europe, República Portuguesa, and European Observatory on Health Systems and Policies 2018). Each RHA has the responsibility (among others) to ensure regional planning of human and material resources, including the implementation of necessary investment projects, institutions and services for health care providers, and overseeing their allocation, as well as licensing private providers' units of health care (Diário da República 2011). The autonomous regions of Madeira and Azores have their own RHAs: SESARAM E.P.E.– Health Service of Madeira Autonomous Region, and SRS - RAM - Health Regional Service of Azores Autonomous Region.

The resident population in Portugal, according to Census 2011, is 10.562.178, representing a 2.6% increase since 2001. However, one can observe wide disparities in terms of territory, which have increased due to the movement of displaced populations from the interior to the coast of the country. The sub-regions of greater Oporto and greater Lisbon are densely populated, with 3.689.682 and 2.821.876 inhabitants, respectively. However, most of the territory presents as sparsely populated, as in the case of sub-regions south of Beira Interior, high Alentejo, litoral Alentejo and down Alentejo (INE 2012).

Despite the existence of the RHA structure, it is still possible to identify some regional health disparities, particularly between urban-coastal and rural-interior regions. Rural regions are the poorest in the country, with the worst health conditions. These health inequalities are associated with economic and social factors, such as income, educational levels, living conditions, unemployment and health care (coverage, utilization rates, among others) (Barros, Machado, and Simões 2011, 12). With a relatively low level of urbanization (just over half of the population lives in urban areas) the Portuguese population enjoys good health and increasing life expectancy, though at lower levels than other western European countries (ibid. 2011).

The Portuguese population is aging. The changes in demographic structure are well-reflected in the composition of the age pyramids in 2010, and projections for 2060. The age structure of the population in 2010 accentuated the imbalances already evidenced in the previous decade: the base of the pyramid (younger population) decreased and the top widened with the growth of the elderly population. Since the 1990s, Portugal lost population in every five-year age group between 0-29 years. From age 30, the situation is reversed, and there is a growth of 9% of the population for the group of 30-69 years, and 26% for ages above 69 years. The age group 30-69 years accounted for 51% of the resident population in 2001, and represented about 50% in 2010. The population aged 70 and over accounted for 11% in 2001, and circa 12% in 2010 (INE 2012).
In projections for 2060, a successive narrowing is expected of all ages inferior to 59 years, and a successive increase is expected above this age range. The phenomena of an aging population is worsening, occurring widely throughout the country, and no longer just located in the interior area.

In 2014 the life expectancy at 65 years was 19.2 years (17, 3 years for men, and 20, 7 years for women), increasing to 19.3 years in 2015 (PORDATA, n.d.). Although life expectancy has increased, healthy life expectancy has performed less well (WHO/Europe, República Portuguesa, and European Observatory on Health Systems and Policies 2018). Circulatory diseases remain the main cause of mortality in most OECD countries, accounting for more than one-third (36%) of all deaths in 2015. Cancer is the second leading cause of mortality in EU member states after diseases of the circulatory system, accounting for 25% of all deaths in 2015 (OECD 2017). In Portugal, the main causes of death in 2014 were malignant neoplasms (152.0 deaths per 100 000 population), and circulatory system diseases (150.8 deaths per 100.000 population). (J. de A. Simões, Augusto, and Hernández-Quevedo 2017).

Regarding health care delivery, the system in Portugal consists of a mixed network of public and private health care providers, specifically three co-existing and overlapping systems: the NHS; special public and private insurance schemes for certain professions or companies (health subsystems); and private voluntary health insurance (VHI) (J. de A. Simões, Augusto, and Hernández-Quevedo 2017).

The 1979 legislation stated that the private sector should complement the public sector by providing health care in areas that could not be served by the public sector. NHS patients referred to private health care providers normally do not pay for the service delivered. Providers are reimbursed directly by the NHS (Pinto, Ramos and Pereira 2000). RHAs play an essential role in contracting health care providers to work with the NHS. They are responsible for setting up (and paying for) conventions[7].

The health care delivery system in Portugal consists of a network of public and private health care providers; each of them is connected to the MoH and to the patients in its own way. The MoH coordinates all health care provision and the financing of public health care delivery. All hospitals belonging to the NHS are under the jurisdiction of the MoH. Private sector hospitals, both not-for-profit and for-profit, have their own management arrangements (J. de A. Simões, Augusto, and Hernández-Quevedo 2017). In Portugal, there are 113 public and 96 private hospitals (WHO/Europe, República Portuguesa, and European Observatory on Health Systems and Policies 2018).

In addition to the health insurance coverage provided by the NHS, approximately 25% of the population is covered by a health subsystem or VHI. Health care is provided either directly or by contract with private or public providers (and in some cases by a combination of both) (J. de A. Simões, Augusto, and Hernández-Quevedo 2017).

Health care expenditure has risen steadily from 7.5% of GDP in 1995 to 10.4% of GDP in 2010, which is above the EU average of 9.8% in 2010 (ibid., 48). In comparison with OECD countries, Portugal's expenditures are below average (Figure 2-9).

Progress in medical technologies continues to transform health care delivery and to improve life expectancy and quality of life, but it is also one of the main drivers of rising health expenditure across OECD countries. For instance, although the availability of MRI units has increased rapidly in most OECD countries over the past two decades (OECD 2012), data concerning their specific number is scarce and incomplete. In Portugal, medical devices are regulated by decree-law nº 145 / 2009 (adopted from the EU Directive nº 2007/47/CE), which determines that the National Agency for Pharmacy and Pharmaceuticals (Infarmed) is the entity responsible for the surveillance of all medical devices (Diário da República 2009). This decree-law establishes rules about research and development, manufacturing, sales, entry, surveillance and advertisement of medical devices.

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7 'Conventions' refers to the contracting of private sector providers to provide NHS patients with specific health care services (Barros, Machado, and Simões 2011, 39).

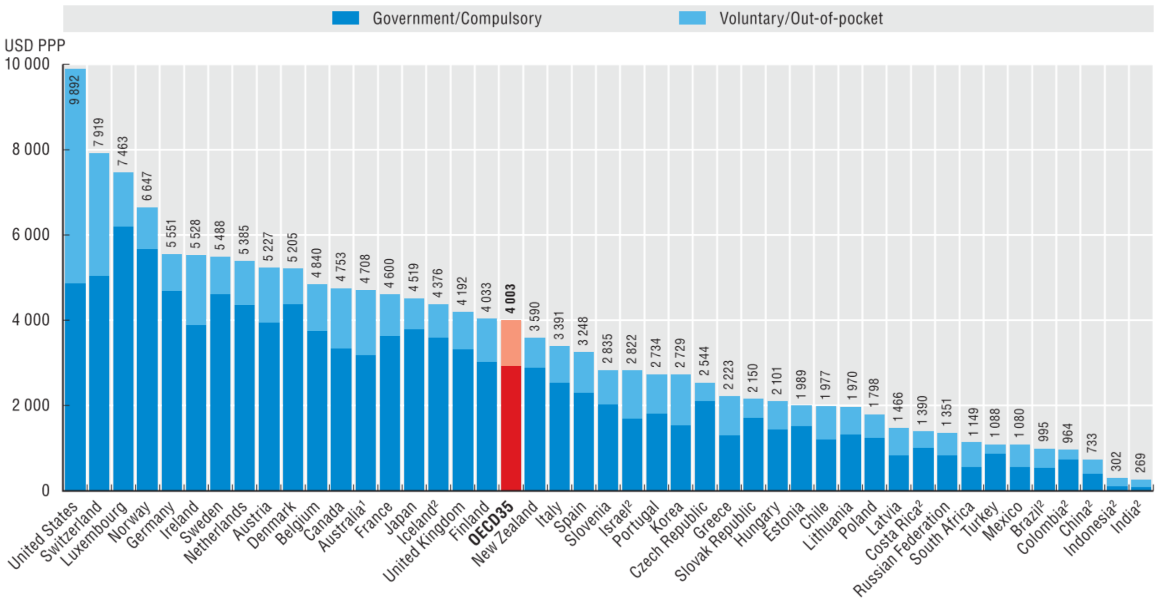

Figure 2-9 Health expenditure per capita, 2016 (or nearest year)
(Source: OECD 2017, 133)

Since 1988 the MoH has authorized the procurement and installation of expensive medical technologies in both public and private sectors. In 1995, new legislation lifted the restrictions on Computerized Tomography (CT) and MRI scanners. Most expensive medical equipment (67%) is located in the private sector, which is more flexible and innovative and therefore outstrips the public sector in the acquisition of high-technology equipment. Hospitals contract with private clinics for the use of equipment, providing a strong incentive for this provision pattern to continue (Barros, Machado, and Simões 2011, 36). There are currently no effective methods for regulating the distribution of health equipment in the private sector.

Progress in medical technologies continues to transform health care delivery and to improve life expectancy and quality of life, but it is also one of the main drivers of rising health expenditure across OECD countries. The availability of MRI units has increased rapidly in most OECD countries since the 1990s (OECD 2017). Recent data show that although Portugal is positioned below OECD countries average, the presented numbers do not include scanners outside hospitals (Figure 2-10). Thus, this average cannot be considered fully representative.

In Portugal, an equipment chart was developed by the MoH in 1998 (referring to the years 1995/1996), establishing national and regional ratios for the major medical technologies for diagnostic imaging in the public sector (Barros, Machado, and Simões 2011).

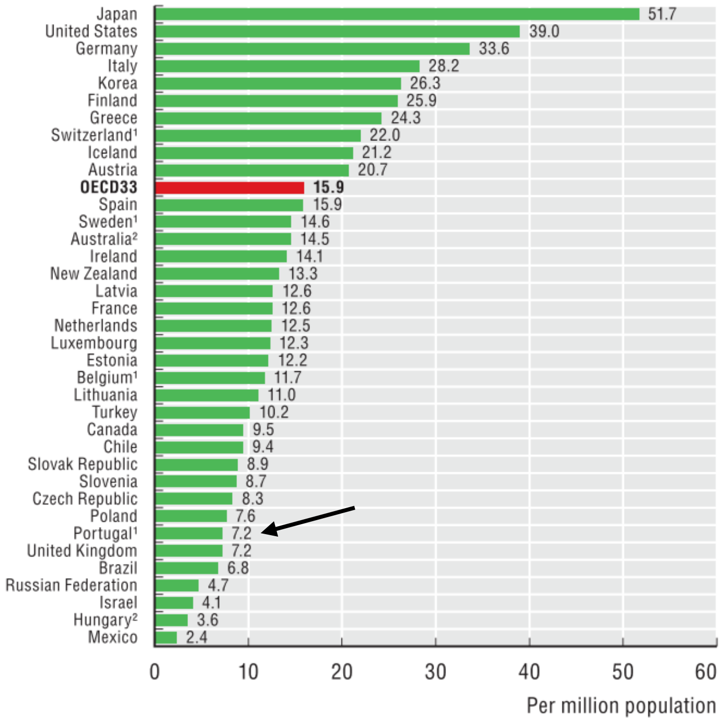

Figure 2-10 MRI units, 2015 (or nearest year)
(Source: OECD 2017, 171)

Since then, new equipment has been introduced and diagnostic imaging examinations have increased. The number of MRI units per million people in Portugal more than doubled between 2003 and 2008: from nearly 4 to almost 9. This was close to the average of the EU 15 countries for which 2008 results were reported. In 2010, Portugal had 9.2 MRI per million people. This was less than the OECD average (12.5 per million people). However, there is no TA study conducted nor any evidence health impacts from these increases (OECD 2012). In 2014, the Heavy Medical Equipment Charter was updated by the Working Group created by Order no. 3484/2013 (26.01), due to the need to effectively control the acquisition and renewal of medical equipment. The main objective was to ensure the monitoring of the growth of the equipment fleet and avoid situations of insufficiently justified and sustained purchases of equipment that may subsequently lead to duplication of the same and to unoptimized levels of its use, resulting in a fleet of equipment unsuited to reality (ACSS 2014, 28). However, the Charter only focused on medical devices in the public sector.

The first known attempt to fully characterize the MRI scanner Charter in Portugal, both in the public and private sector was presented in 2011 and published in 2012 (see Maia 2012). Further research followed and new data was presented at the European Technology Assessment Conference in Prague (March 13-15, 2013) and published in 2013 (see Maia 2013; Maia and Moniz 2013). At that time, 139 MRI scanners were identified in Portugal, distributed mostly in the private sector (Figure 2-11):

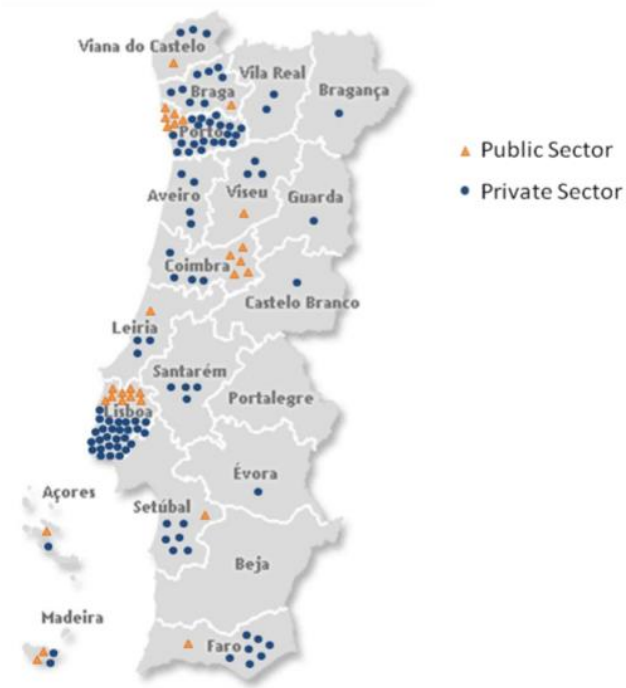

Figure 2-11 Distribution of MRI equipment in Portugal, by District, 2013
(Source: Maia 2013a)

A publication updating the numbers of MRI concluded that there were 150 MRI units installed in Portugal by June 2013 (Ribeiro, O'Neil, and Maurício 2013). According to the study, MRI scanners distribution by district is dispersed, with a greater concentration on the coast, especially in the urban centres of Lisbon and Oporto. In Lisbon district there are 50 units (33.3%); Oporto has 37 units (24.6%); Coimbra 11 units (7.3%); Braga 9 units (6.0%), and Faro and Setúbal have 6 units each, representing 4.0%; the Autonomous Region of Madeira, Santarém and Viseu has 4 units installed, each representing 2.6% of the total. Vila Real, Aveiro and Leiria with 2.0% have 3 items of equipment each; the districts of Castelo Branco, Évora, Viana do Castelo and the Autonomous Region of the Azores have 2 items of equipment each, accounting for 1.33% of the total; Bragança and Guarda have 1 equipment (0.66%). The districts of Beja and Portalegre did not have any equipment installed (ibid. 2013, 42). The study did not present the distribution of MRI in terms of the legal nature of the institutions by district, mentioning only that the majority is located (80%) in the private sector and a minority of 20% in the NHS (ibid. 2013, 47).

Considering the importance of MRI in the diagnosis and evaluation of stroke, and the high rate of occurrence of this event in the Portuguese population, this technique assumes a higher importance at a national level. The superiority of MRI in the diagnosis and assessment of the extent of injury resulting from stroke (particularly the advanced techniques of diffusion, perfusion and angiographic techniques), comparatively to CT images, is recognized and recommended by the "Guidance Document on the Greenways Acute Myocardial Infarction and Stroke" (Alto Comissariado da Saude 2007). However, geographically and along the coastline, it is possible to identify niches of MRI equipment, with higher concentrations in Lisbon and Oporto districts, and as we move to the country's interior, MRI equipment tends to be scarce, and in some regions, nonexistent.

HTA in the Portuguese context

The history of HTA in Portugal is relatively recent. In the literature, the first paper that directly addressed the topic was published in 2000, mentioning that HTA is not very developed or addressed in a systematic way in Portugal. It noted there was a growing interest in the area, especially by researchers in universities, particularly the National School of Public Health, which had shown a growing interest in economic evaluation of health technology, providing important national studies in this area (Pinto, Ramos, and Pereira 2000). In addition, it is only since the mid-1990s that economic evaluations in areas such as pharmaceuticals, heavy equipment, and medical devices have begun to be carried out, and, their impact on policy is uncertain. Pharmaceutical manufacturers are now required by law to present economic evaluations for related reimbursement decisions. Although the medical association has begun a process of introducing practice guidelines, which may have implications for assessment of the efficacy and effectiveness of health technologies, doctors are not keen on such implementation. The MoH announced the intention to create a national (or regional) agency responsible for HTA, where economic evaluation studies will be a fundamental part of the assessment (ibid.). This overview was reinforced one year later, in 2011, in a study conducted in 16 European countries, concerning the status of HTA. The study concluded that in the Portuguese context, although only some studies and analysis were done in the field, it was possible to attest to a growing interest in issues related to HTA (Banta and Oortwijn 2000b).

In 2011, in a discussion published in a book on three different perspectives for the health future in Portugal, the idea of an HTA agency was still under discussion. It was put forward by Adalberto C. Fernandes, who stated: "It is critical to move forward towards the creation of a national agency of health technologies assessment, independent of political power, with technical and scientific autonomy, appropriate and highly qualified. This entity, in line with best international practices, would have the best conditions to assess and for innovation involving the parameters of the cost-effectiveness the principle of cost-opportunity and taking into account the limited resources and the need to qualify the choices" (Barros, Fernandes, and Fernandes 2011).

A report by the European Observatory on Health Systems and Policies and Nova School of Business and Economics, concerning Portugal's health system, stated that Portugal does not have a tradition of HTA studies, with the exception of pharmaceutical products (Barros, Machado, and Simões 2011). In addition, there is no economic evaluation applied to medical devices, and there is clearly room for further efficiency gains in the delivery of health care in Portugal, where the role of HTA is currently limited to pharmaceutical products (ibid.).

In June 2015, the MoH launched the National System for Health Technology Assessment (SiNATS) by decree-law No. 97/2015 (01.06.2015), which integrates all public and private entities (Ministério da Saúde 2015).

Infarmed is the entity responsible for SiNATS management (article 2º, 2), via the Health Technology Assessment Directorate (DATS), and for ensuring the management and operation of the Information System for Health Technology Assessment (SIATS) (Infarmed, n.d.); *Decreto-Lei n.º 97/2015 - Sistema Nacional de Avaliação de Tecnologias de Saúde* 2015, art. 4º.1). The information collected and stored in the SIATS and the studies that support HTA decisions are publicized in terms to be defined by Infarmed's governing board (ibid. art. 4º.6). HTA is to be performed by an HTA Commission (CATS) that supports SiNATS (article 2º, 6), in order to guarantee scientific independence, which is fundamental for ensuring evaluation exemption (ibid.). The CATS gathers experts from outside Infarmed and, in addition to providing scientific advice, the experts can be called to give independent opinions on other stages of the process. Thus, the existence of CATS will allow for the necessary peer-to-peer discussion, to ensure the accuracy and transparency of these assessments (Martins et al. 2014, 66). This way, according to Infarmed, there is a clear separation between the HTA studies, which will be carried out by CATS, and the decisions that need to be taken considering the results of the assessment (such as recommendations for use and/or funding) (ibid.).

CATS is one of Infarmed’s nine specialized technical committees, which according to Infarmed, “shall be advisory bodies to Infarmed, composed of personalities with qualifications and experience in their respective areas, and shall act with technical and scientific independence, in accordance with their respective competences. The operating rules of the technical committees are defined by regulations and administrative support is provided by the Infarmed services, where they operate” (Infarmed, n.d.).

The regulation of CATS was established in 2016, by Deliberation n. 662, approved by Infarmed, which stated: “CATS is composed by a group of personalities with qualifications, experience and specialized training, namely in the areas of medical, pharmaceutical, economic and statistical sciences”. (*Deliberação n.º 662/2016 : Regulamento Da Comissão de Avaliação de Tecnologias de Saúde (CATS)* 2016, 12097), and in addition by “persons invited from among health promotion associations, patients' associations, professional associations of doctors, pharmacists and dental practitioners, the consumer associations as well as members of institutions of the Ministry of Health” (ibid, 12097). CATS is composed of a President and two vice-Presidents, and 135 members (Infarmed n.d.) whose remuneration is established by Dispatch n.º 11012/2016 and supported by Infarmed’s budget (*Despacho n.º 11012/2016* 2016). As established in Article 2º, among others, CATS is in charge of “issuing opinions on matters related to the evaluation and reappraisal of health technologies, within the scope of their financing, use or installation by the NHS, namely on the added therapeutic value and the cost-effectiveness ratio, among other evaluation criteria", and is to "Collaborate in the national contribution to European or inter-national work on health technology assessment by participating, at the request of Infarmed, in joint European assessments, and promote the use of their results at national level" (ibid, 12097). CATS meet once a year, and extraordinarily whenever convened by its President or by Infarmed's Board of Directors. Concerning experts and Working Groups (article 5º), the experts responsible for preparing opinions on matters within the competence of CATS are appointed by the Steering Committee of Infarmed, from among the members of CATS, and carry out their work in coordination with the Executive Committee and DATS. In addition, the creation, composition and coordinators of the working groups shall be approved by Infarmed's Governing Board (ibid, 12098). The main changes proposed by SiNATS are summarized in Table 2-4.

The information collected by SiNATS will be used for cost-effectiveness reassessments for public funding decisions, but it will also allow recommendations to be made for the efficient use of resources and health technologies. Therefore, it is intended to ensure that this assessment will be carried out throughout the life cycle of the technology in question (ex-post assessment), thus ensuring the availability of information on cost-effectiveness profiles to health professionals and decision-makers, the access of citizens to technologies that present a better profile, and the allocation of public resources to those that ensure greater efficiency (Martins et al. 2014, 70).

Until March 2020, few studies have been performed and published[8]. On the topic of medical devices reimbursement the following five are available: "Medical devices for self-monitoring of people with diabetes", "Expanding cameras", "Medical devices to support ostomy patients", "Medical devices to support patients with incontinence or urinary retention", "Food and food supplements for extreme prematurity" and "Elementary formulas intended for children with allergy to cow's milk proteins (APLV)".

[8] In Infarmed website: https://www.infarmed.pt/web/infarmed/entidades/dispositivos-medicos/avaliacao-de-tecnologias-de-saude/comparticipacao-de-dispositivos-medicos, accessed June 2020.

Table 2-4 Challenges of HTA and SiNATS proposal
(Source: Adapted from Martins et al. 2014, 73)

Current Scenario	Proposed SiNATS Scenario
Technologies assessed: Pharmaceuticals	Technologies to be assessed: Pharmaceuticals, medical devices and, possibly other.
Ex-ante evaluation: - Relative Effectiveness - Cost-effectiveness	Ex-ante evaluation: - Relative Effectiveness - Cost-effectiveness - Other dimensions (ethical, social, etc.)
Decisions on: - Price - Funding/reimbursement - Expenditure limits (contracts)	Decisions on: - Price - Funding/reimbursement - Expenditure control and limits (contracts) - Risk sharing - Additional monitoring of use - Weighting for public contracts - Conditions of use - Recommendations for use and acquisition
	Ex-post evaluation - Analysis of adjustments to funding - Recommendations for use/acquisition
	Participation in the HTA European model - European Network for Health Technology Assessment (EUnetHTA) - Protocols with HTA agencies from other EU Member States - Participation in the creation of the Health Technology Assessment Network (HTAN) at the European Commission level

In summary, SiNATS carries out the technical, therapeutic and economic evaluation of health technologies, supported by an information system that collects and makes information available to all entities to decide on the economy, effectiveness and efficiency of the use of a health technology (Martins et al. 2014, 77). SiNATS' objectives are (ibid., 65):

- to maximize health gains and citizens' quality of life.
- to contribute to the sustainability of the NHS.
- to ensure the efficient use of public resources in health.
- to monitor the use and effectiveness of technologies.
- to reduce waste and inefficiencies.
- to promote and reward the development of relevant innovation.
- to promote equitable access to technologies.

Prior to the work being developed in HTA, other forms of TA have been developed in Portugal (Böhle and Moniz 2015). In 2009, at the Faculty of Sciences and Technology of Universidade Nova de Lisboa (FCT-UNL), the Doctoral Programme on TA[9] was initiated. It is the first PhD that offers a degree in

[9] https://sites.fct.unl.pt/doutoramento-avaliacao-tecnologia/, accessed June 2020.

TA, and offers the opportunity to develop projects in diverse fields such as health, emerging technologies, transports and mobility, environment, etc. The PhD programme has the support of the Interdisciplinary Centre of Social Sciences (CICS.NOVA) at the FCT/UNL. In 2010, experts connected with the PhD program and the doctoral students established a national TA network: the Grupo de Estudos em Avaliação de Tecnologia (GrEAT). Since the Portuguese parliament had already shown intentions of establishing a TA unit, as mentioned in the Resolution of the Portuguese parliament nº 60/2009 of 10.07.2009, one of GrEAT's initial activities was to establish contact with the Portuguese parliament (GrEAT n.d.). The same resolution mentions the intention to promote the steps that will allow the future accession of the Assembly to the European Parliamentary Technology Assessment (EPTA) (Assembleia da República 2009).

To some extent, this accession was established via the Observatory of Technology Assessment (OAT), founded in 2015. Located in Lisbon, the OAT is an applied TA research unit at CICS.NOVA, and it is the only research unit dedicated to TA in Portugal. It is constituted by members of the above-mentioned PhD program and several other researchers working on TA in Portugal. Since its creation, OAT has managing GrEAT, and since 2017, has been an associated member of EPTA[10]. OAT is in permanent cooperation the Portuguese parliament[11].

2.6. Remarks

The literature review conducted in this chapter has shown that European health systems face challenges in terms of cost constraints. Effective cost containment and efficiency in the use of resources has been a concern in most of the European health systems, especially in the public sector. In this context, decisions to purchase expensive medical devices need to be properly justified, since an element of waste of resources is derived from inappropriate investments in medical devices.

With a very recent history, MRI is a medical device that has been able to win its position of importance, being considered to be a state-of-the-art image provider. As Luiten said, "The discovery and development of magnetic resonance imaging is one of the most spectacular and successful events in the history of medical imaging" (Luiten 2003, 1). In general, MRI scanners are acquired due to their technological value: MRI does not depend on ionizing radiation to generate images and the contrast used has fewer side effects. Having specific characteristics that are not available in other imaging

[10] EPTA has 13 full members (Austria, Catalonia, Denmark, European Parliament, Finland, France, Germany, Greece, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom) since 2017, and 9 associate members (Chile, the Council of Europe, Japan, Mexico, Poland, Portugal, Russia, United States, and Wallonia) (Grunwald 2019).

[11] https://cics.nova.fcsh.unl.pt/observatories-and-laboratories/observatory-of-technology-assessment-oat, accessed June 2020.

modalities, such as being non-invasive, not using ionizing radiation, and permitting additional diagnostic insights through relaxation parameters, MRI is gaining territory in the imaging field. In some cases it has a significant superiority over other imaging modalities and therefore has been considered a substitute for many diagnostic procedures (Ostensen 2001). MRI has gained its importance in terms of medical imaging techniques due to its flexibility and sensibility to a broad range of tissue properties, but also due to its relative safety since it does not uses ionizing radiation to acquires the images (Brown et al. 2014). For this reason, it is considered safer to be used for diagnoses in people of almost every age, and especially for pregnant women.

From the conventional 1.5T – 3T, the limits of the largest strengths of electromagnets in MRI has expanded to 7T. This leap has widened the applications of MRI, and thus further developments are expected in the future. In addition, trends such as cryogen-free cooling systems, merging of image modalities, and the use of Artificial Intelligence such as machine learning make the diffusion of innovative health care technologies such as MRI a complex process, influenced by a variety of factors, related both to the technologies themselves and to the socioeconomic environments (Hisashige 1994, 402).

The cost associated with the purchase and maintenance of MRI scanners is still high, making financial commitment a requirement when an MRI scanner is to be bought. Also, due to MRI’s potential for obsolescence, a considerable economic risk for the purchaser is at stake. When it comes to purchase, the most critical choice concerns the magnet type and strength, and the market shows a preference for superconducting magnet-based scanners.

In Portugal, the latest data available (June 2013) shows that 150 MRI units are installed in the country, and most of them are located in the private sector. There is an imbalanced geographic distribution of the devices throughout the country, and there are no effective methods for regulating the distribution of health equipment in the private sector; in fact the lack of planning rules has allowed a gap to grow between public and private investments.

An evidence-based strategic purchase is therefore required. To achieve this aim, it is necessary to provide the decision-makers with valid information and evidence on the medical, social, economic, legal and societal aspects related to the health technologies to be purchased, in order to aid their decision. This can be accomplished by means of HTA and TA studies.

In general, while HTA is more focused on economic aspects, studies with a strong focus on the societal context of technology or the interactions between technology and society (Oortwijn et al. 2004) and its “unintended side-effects” (neither intended nor anticipated) (Grunwald 2009, 1113) have actually been the topic for classic Technology Assessment. However, the tools that TA and HTA apply don’t have a “sharp distinction” regarding content, thus both HTA and TA should learn from each other (ibid.;

Wolbring 2005; Maia 2015). Considering the limited financial resources of health care systems it can be foreseen that the demand for TA and HTA will grow enormously (Perleth and Wild 2001, 58). While HTA may be used to filter out ineffective but costly interventions, TA may play a greater role in steering health care technologies in a socially more acceptable and desirable direction. For this reason, TA and HTA should be understood as complementary rather than competitive tools, based on the shared intention to give input for a more needs-based R&D health technology policy and a more patient-oriented health care provision (ibid.).

In Europe, due to the varied natures of the health systems (which vary in terms of organization and financing), HTA is organized and implemented differently. These differences lead to different learning processes and experiences that can and should be used for mutual learning in terms of the development and use of HTA. In Portugal, the establishment of an HTA agency is recent and can be seen as a strategy to facilitate control of healthcare spending, since HTA is a key tool to improve the management of scarce resources. However, after framing the current situation, some remarks can be made about the implementation of HTA in Portugal.

- **Concerning the independency of the HTA agency;** It is expected that an (H)TA institute is autonomous, meaning that it should be independent from external interests, but also with regard to its self-concept and commitment (Grunwald 2019). In order to increase transparency and credibility, a clear separation of the evaluation and reimbursement decision processes should be established. Although an HTA Commission (CATS) was set up with external experts, its members were selected by Infarmed. The experts' related costs are covered by Infarmed. Since authorization, regulation, distribution and surveillance of pharmaceuticals and medical devices are concentrated within Infarmed (Chipman 2016, 4), the link between reimbursement decisions, assessment and funding allocations is unclear and remains a challenge to resolve (ibid., 11).
- **Concerning the lack of inclusion of social and ethical aspects in the intentions and assessments:** Although the intentions of SiNATS include a broader approach to the assessment of technologies, besides those related to effectiveness and cost-effectiveness, the inclusion of a social and ethical dimension in the assessment, for instance, is not pursued.

TA is in general characterized by a mix of empirical research and prospective thinking. By assessing technologies and providing evidence on their value, TA and HTA contribute to problem solving, not by providing actual solutions but by providing a set of knowledge, guidance, and orientations on procedures or recommendations to both political and social levels. They act as an interface between technology and society, a bridge between evidence and policy-making or decision-makers, in order to assist decision-making processes. Therefore, it is important to understand the decision-making process itself and the way decision-makers decide, in order to better contribute with sound and useful TA/HTA studies.

Decision-making processes can be complex and interpreted in different ways. In the literature one can find different theories and models to describe and analyse the decision process. When it comes to strategic decision-making, rationality plays a central role, and the DM is presented as rational. However, reality shows that although the assumption of rationality remains, the decision is more intuitive than purely technical in nature (Shafir and Leboeuf 2002). And because the DM deals with constraints in searching for information, for instance related to the limits of their cognitive capacities, a bounded rationality is more feasible to apply. Other approaches to decision-making consider decisions that take place in an organization, where the participation of subordinates can have different impacts.

In the context of rational thinking, decisions can be deconstructed and analysed in terms of steps. Decisions can be classified according to different parameters such as the degree of the presented difficulty, the environment that surrounds it, the approach taken, the type of decision-makers involved, and so on. Regarding this last aspect, leadership behaviour will influence the decision process in terms of participation in the process by other elements of the organization.

From the literature review, it was possible to identify several factors that can affect the decision-making process. These influences can be sourced from the environment where the decision takes place, namely organizational pressures and interests as well as internal influences. The latter concerns personality characteristics, competences, and former individual experiences, for instance.

To make a decision is to make choices. In turn, making choices requires us to make a selection from the options that are available. To do that, it is necessary to have a combination of different knowledges in order to mobilize competencies. In terms of competences, staff dealing with procurement-related issues need to be appropriately qualified, experienced and trained, since supply systems management, and particularly procurement, are complex processes that require a good mix of knowledge, skills, and experience.

On a daily basis, health professionals are required to make decisions within a multiple foci (e.g. diagnosis, interventions, therapeutics, interactions, evaluations), using a diverse knowledge-base, with multiple variables and individuals involved (Smith, Higgs, and Ellis 1991,89). Each professional (stakeholder) in the Radiology Department has a specific role to play and tasks to perform for the Department to run efficiently in favour of the patient. Each one of these stakeholders has for this purpose a specific set of knowledge and skills that allows them to perform their role in the Department. It will be these knowledges and skills that will be determinants of how the stakeholder will make decisions, and thereby how in general the Department will behave and develop.

Considering the literature review, and the Portuguese case-study, it is important to identify the decision-makers that are actively involved in the decision process, influencing and shaping it. It is expected that the purchase of MRI scanners in Portugal, independently of the sector where the decision takes place (public or private), is done by a DM who acknowledges their cognitive limitations. By doing so, a consultative process should take place, supported by transparent and neutral evidence, such as that provided by TA and/or HTA studies. This way, evidence-based decision-making is facilitated.

It is also expected that the process is to be influenced by the decision-maker's own personality, and here intuition, probably assuming different forms, will play a role. It is therefore expected that the DM will mobilize their different knowledges, and that they will play a similar role, or have an equal influence, in terms of the decision-maker's competencies. To characterize such knowledges is also important in order to analyse which professionals in the Radiology Department are in possession of them.

3. METHODOLOGY FRAMEWORK

"Asking the right questions takes as much skill as giving the right answers."
– Robert Half

This chapter aims to provide a methodology overview used in the research, in order to obtain and analyse data so that the research questions could be addressed, and the hypothesis tested. The chapter is divided in three sub-chapters: the first (Introduction) addresses the methodology setting, by presenting the research questions and hypothesis and their connection to the topic of decision-making. The second presents the research approach and design chosen for the collection, analysis and interpretation of data. provides A short summary of the chapter is provided in the final sub-chapter (Remarks).

3.1. Introduction

The technological focus of the research is the MRI scanner. The field of research is therefore very well delimited, since only institutions, either in the public or private sector, equipped with at least one MRI will be considered for the study. The decision process of an MRI scanner purchase will be analysed at the meso and micro level (hospital/health organization and radiology department). The group of potential decision-makers who were involved in the purchase decision of MRI technology are considered to be the population of the study. From the literature review, the following research question was defined: ***What is the influence of HTA in the decision-making process for MRI purchase?***

The following research questions (RQ) will be addressed during the research:

RQ 1: Who are the decision-makers involved?
RQ 2: What competences are involved in the decision process?
RQ 3: How is the decision-making process characterized?
RQ 4: Which are the main drivers for the technology purchase?
RQ 5: Which factors influence the decision (e.g. relationships, other stakeholders, personal characteristics, etc.)?
RQ 6: What kind of evidence was used?

Considering that in order to decide, a set of knowledges need to be mobilized by the decision-maker, it is important to understand how these knowledges can influence the decision. It is assumed that they will play a similar role in the process. In addition, the following hypothesis will be tested:

In the decision-making process, the different knowledges have an equal influence on the decision-maker competences.

3.2. Research Approach and Design

This sub-chapter aims to provide a framework regarding the collections, analysis and interpretation of data that will allow to answer the questions and test the proposed hypothesis. The research approach and design were influenced by three major factors: the way the research is conducted (paradigm), the way data is collected and therefore the research method adopted.

The concept of philosophical worldview was introduced by Creswell (2019) as a way to express the general orientation about the world and the nature of research that researchers hold, since in his opinion, it is the type of the research's beliefs that will lead the choice for the strategy of inquiry. Other authors use a different designation. Collis and Hussey (2014), for instance, understand research paradigms, as a framework that guides how research should be conducted, taking into consideration people's philosophies and their assumptions about the world and the nature of knowledge. According to Teddie and Tashakkori (2009), a paradigm worldview includes philosophical and socio-political issues. The present research is included on a pragmatic worldview, since it is problem-centred and it considers consequences of actions, that take place in a real-world practice (Creswell 2014). In addition, the pragmatist researchers look to the "*what* and *how* to research, based on the intended consequences—where they want to go with it. Mixed methods researchers need to establish a purpose for their mixing, a rationale for the reasons why quantitative and qualitative data need to be mixed in the first place" (Creswell 2014, 11).

Considering research methods on strategies of inquiry, three strategies were chosen to collect data:

- in order to characterize the decision-making process, a questionnaire was applied to the decision-makers (Questionnaire A)
- and interviews were conducted, in order to corroborate and complement information received from the previous mentioned questionnaire,
- in order to identify the necessary competences by the potential decision-makers in Radiology Departments, a closed questionnaire was used (Questionnaire B).

The adopted strategies lead to two different research methods. Questionnaire A and interviews led to quantitative and qualitative research simultaneously, and Questionnaire B led to a quantitative research. In general, quantitative and qualitative research are often perceived as opposites from one another, in a sense that they are perceived as incompatible, since they have origins in two different paradigms. Creswell makes a simple definition of the first two mentioned methods by saying that "often the distinction between qualitative and quantitative research is framed in terms of using words (qualitative) rather than numbers (quantitative), or using words (qualitative) rather than numbers (quantitative), or using closed-ended questions (quantitative hypothesis) rather than open-ended questions (qualitative interviews questions)" (Creswell 2014, 4). However, if a researcher finds him/herself in the middle of these two methods, then he/she is dealing with a mixed method, since it incorporates elements of both qualitative and quantitative approaches (Creswell 2015), which is exactly the case of the present research.

Concerning the research design a cross-sectional design was established, since, according to (Bryman 2012:58) and Burns and Burns (2008) a cross-sectional design entails the collection of data on more than one case and at a single point in time in order to collect a body of quantitative or qualitative data in connection with two or more variables. The research framework design for the present research is schematized in Figure 3-1:

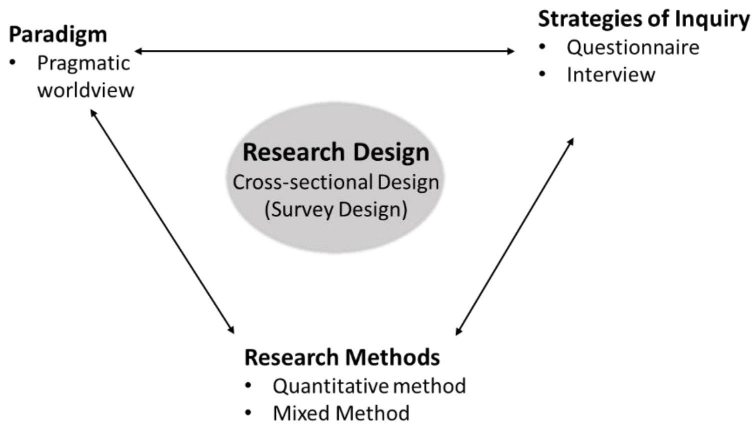

Figure 3-1 Framework design
(Source: Adopted from Creswell (2014, 5)

In order to have a clearer understanding of the adopted research methodology, the following sub-chapters will focus in more depth on the used research methods: quantitative and mixed methods, and the respective strategies of inquiry, and data analysis strategy.

3.2.1. Research Methods

3.2.1.1. Quantitative Method

An hypothesis is a proposition than can be tested for association or causality against empirical data (Collis and Hussey 2014). The empirical data will be collected using a quantitative survey, as a strategy of inquiry, a systematic method for data collection with the aim of predicting populations attributes or behaviours (Teddie and Tashakkori 2009). The questionnaire “Competences for decision-making”[12] aimed to assess the necessary competences by the potential decision makers, in a Radiology Department. Since the aim was to give an equal opportunity for the population, to be selected for the research, random sampling was chosen. One of the major advantages of a random sampling relies on the fact that the results can be generalized from the sample to the population within a computable margin of error (Teddie and Tashakkori 2009).

In terms of data analysis strategy, Structural Equation Modelling (SEM) and Factorial Analysis (FA) were selected. SEM is a collection of tools for analysis connections between various concepts in cases where these connections are relevant either for expanding our general knowledge or for solving some problems (Blunch 2013, 5). It provides the appropriate and the most efficient estimate technique for a series of separate multiple regression equations estimated simultaneously (Hair et al. 2019). SEM is a general term that has been used to describe a large number of statistical models used to evaluate the validity of substantive theories with empirical data, being one of its primary advantages to be used to study the relationship among latent constructs (Lei and Wu 2007).

Since SEM is a set of tools for verifying theories, one can start with an *a priori* theory (expressed in a modulated representation), and them use SEM to test the model against empirical data (Blunch 2013, 5). Thus, SEM will be used to validate the hypothesis.

SEM hypothesizes how sets of variables define constructs and these constructs are related to each other. Its goal is to determine the extent to which the theoretical model is supported by sample data (Schumaker and Lomax 2010). Although SEM is more a confirmatory technique rather than an exploratory technique, the aim is to confirm the proposed model without neglecting the possibility that the analysis can lead to modifications of the original model.

SEM is characterized by two basic components (Hair et al. 2019): a) the structural model: it is the *path* model, which relates independent to dependent variables and b) the measurement model, that enables the use of several variables (indicators) for a single independent or dependent variable.

In its approach, SEM analysis uses different steps in an ordered way (Lei and Wu 2007) (Kline 2011a). These steps can be represented as Figure 3-2 shows. This will be the approached used in the research, in order to analyse the proposed model and test the hypothesis.

[12] Detail information concerning the questionnaire development will be given in Chapter 4.

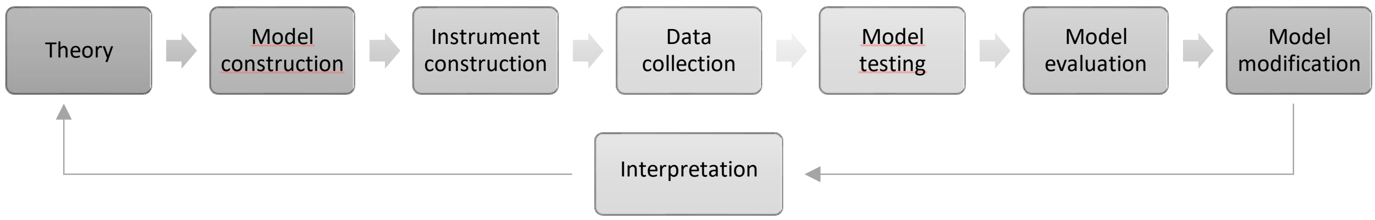

Figure 3-2 Approach for SEM analysis
(Source: Kline 2011a)

FA techniques include two different but complementary approaches: the exploratory factor analysis (EFA) and the confirmatory factor analysis (CFA). EFA is a widely used and is a broadly applied statistics technique in social science (Costello and Osborne 2005) which "explores the underlying structure of correlations among observed variables in an attempt to reduce the dimensionality, wherein a small(er) number of factors significantly account for the correlation among the set of measured variables" (Onwuegbuzie, Leech, and Collins 2011, 354), meaning that it reduces data sets comprising a large number of variables into a smaller number of factors, identifying the underlying factor structure or model (Burns and Burns 2008). For this reason, EFA is exploratory by nature and used in early stages of research to gather information about and/or explore the interrelationship among a set of variables (Pallant 2005, 172).

CFA is more complex set of techniques used to test hypothesis or theories concerning the structure underlying a set of variables (ibid.). CFA is a hypothesis testing technique (Verma 2013), by allowing "testing of the hypothesis that a relationship between observed variables and their underlying latent construct exists" (Onwuegbuzie, Leech, and Collins 2011, 354).

CFA aim is to confirm that the model obtained in EFA is robust (Burns and Burns 2008). In order to conduct the CFA, SEM will be used. The use of SEM in social sciences in widespread (Hoyle 2008) as it is widely used in different other disciples (Kline 2011a) and its used healthcare related issues, is commonly used. For instance Santor et al. (2011a) used CFA and Item Response to assess instruments used to evaluate Primary Care. It can also be used to reduce items through a EFA approach or to improve new versions of questionnaires by means of CFA (Larwin and Harvey 2012; Azevedo 2015).

There are several reasons behind the choice of SEM (Schumaker and Lomax 2010) one is due to the fact that is was needed to use multiple observed variables to better understand the possible relations between them and SEM allows for variables modulation and confirmation. Another aspect is related to the fact that measurement error and statistical analysis of data are normally treated in a separated way. In this research, latent and observed variables as well as measurement errors need to be included in the analysis. The third reason is due to the fact that is was needed to have an analysis of a theoretical model derived from a complex phenomenon. SEM software programs have evolved over the last years, allowing a user-friendly use.

3.2.1.2. Mixed Method

A mixed method research is an approach of inquiry that combines or associates both qualitative and quantitative forms, aiming to get the best benefits from the two methods. Therefore, it combines elements of qualitative and quantitative research approaches for the broad purposes of breadth and depth of understanding and corroboration (Johnson, Onwuegbuzie, and Turner 2007), since the use of only one method could be insufficient for gaining an understanding of the problem because of the inherent weaknesses of each approach. Quantitative research does not adequately investigate personal stories, experiences or points of view and qualitative research does not enable a generalization from a small group of people to a bigger population. Therefore, combining both methods provides a good rationale for using mixed methods (quantitative research provides an opportunity for generalization and precision and qualitative research offers an in-depth experience of individual perspectives) (Creswell 2015, 15).

Both quantitative (closed-ended) and qualitative (open-ended) data were gathered, integrated and interpreted based on the combined strengths of both sets of data (Creswell 2015, 2). By choosing so, mixed methods go beyond the collection of qualitative and quantative data, since they imply the integration of both data, in the interpretation phase. According to different authors, an explicit justifications for combining quantitative and qualitative methods for collect and analyse data should be provided (for instance: Bryman (2006) and Creswell and Clark (2011), since data collected from different methods cannot just be simply added together in order to produce one set of data (Brannen 2005). There are several reasons in the literature to justify the choice for using a mixed method (see for instance Bryman 2006, Fielding and Fielding 2008 and Brannen 2005). In the presented research, the rational setting behind the use of mixed methods was the following:

- Triangulation/Corroboration: quantitative and qualitative research will be combined to triangulate findings in order to see how mutually they are corroborated.
- Completeness: bring together a more comprehensive account of the area of enquiry using both quantitative and qualitative research. The elaboration, illustration and clarification from one method will be used with the result from the other.
- Offset: both quantitative and qualitative research have their own strengths and weaknesses. Combining them will allow to offset their weaknesses and to draw on the strengths of both.
- Explanation and corroboration: used to help explain findings generated by the other.

Since the use of the quantitative and qualitative methods was already predetermine by the researcher, the design method is considered a fixed mixed method (in opposition of the emergent mixed one)

(Creswell and Clark 2011) and because both forms of data are collected at the same time and in a parallel way, the design is considered to be a single-phase design (Creswell 2015).

Since two different set of data are collected (quantitative and qualitative), they need to be merged and interpreted in order to have a clearer and complete notion of the results (Tashakkori and Teddie 2009). This merging is important, since it will allow the interpretation to be made from different angles and different perspectives. The mixed method adopted in this research is the Convergent Parallel Design, meaning that the implementation of qualitative and quantitative saturation occurs during the same phase of the research process. Keeping these strands independent during analysis but mixing the results during the overall interpretation (Creswell and Clark 2011, 70). Therefore, two parallel strands co-exist: one with a qualitative design and another with a quantitative one (Teddie and Tashakkori 2009; Tashakkori and Teddie 2009). The diagram of procedures within the convergent design is illustrated in Figure 3-3.

When approaching mixed methods, there are two concepts to take into consideration when referring to representativeness: sampling and integration. On the one hand, it is important to consider the way the sample will be chosen. *Sampling* refers to the procedure for selecting participants (in qualitative and quantative research) (Creswell 2015). A sample is a population sub-group that should represent the main interest of the study. Sampling assumes a rigorous procedure, either in qualitative or quantitative approach. It implies the choosing of the dimension (number of participants) – sample size – and therefore the methods to obtain it. In general, in quantitative sampling, one must have in consideration the best strategy for sampling and because “sample” is a concept related to statistical representativeness, therefore a formula should be used in order to determine the desired sample size (ibid.).

In the present research, different factors had to be considered in advance, in order to choose the sampling method, namely availability of the participants and their willingness to participate. Also, since the research aimed to collect data about specific experiences of decision-makers, in order to explore a perceived issue – the decision-making process of a medical device purchase. The strategy used was a nonprobability sampling, chosen out of convenience, meaning that a purposive sampling was used, since a relatively purposed number of decision-makers were selected, in order to provide particularly valuable information related to the research questions under examination (Tashakkori and Teddie 2009). Participants were selected taking into consideration their role and involvement in the decision-making process of MRI scanner purchase. Decision-makers have intrinsic interest and can help to develop explanations about what accoutred during the decision-making phase. Because it is a non-probability sample, it is not reasonable to attribute the results to the entire study population (Henry 2009). It was not the aim of the research to have statistical representativeness of the subjects. The aim of the sample in this research is to select participants who can best provide information in order to aid a better understanding of the central phenomena at stake (the decision-making when purchasing MRI technology).

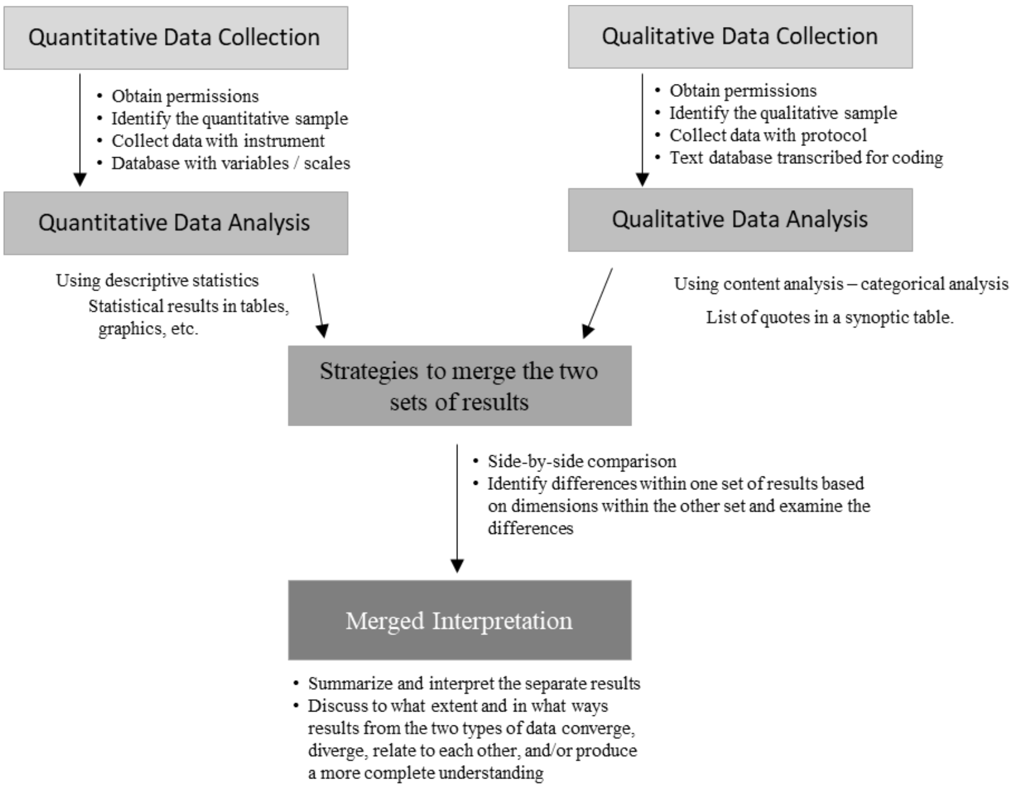

Figure 3-3 Steps for the Mixed Methods Study

(Source: Adapted from Creswell 2015 and Creswell and Clark 2011)

The challenge in mixed methods is to combine quantitative and qualitative sampling. When dealing with mixed sampling one could identify the origin of the subjects as a first obstacle (ideally, they should come from the same population). In this research, all participants came from the same population (they were all decision makers involved in the purchase process) and for different unit of analysis, which is considered to be positive since the goal is to compare different perspectives. The second obstacle is the size of the different samples. In this research, the aim is not to generalized results from the sample to the population, therefore, it is accepted the differences between both samplings: quantitative and qualitative (Creswell 2015, 78).

A small subject dimension is enough to have a social representativeness of a small number of individuals, by considering two major aspects: diversification and information saturation (Guerra 2006, 20). The term "saturation" is however subject of many meanings and different interpretations. Sometimes saturation is claimed without the researcher being able to prove it (Morse 1995), or to provide for a description and how it was achieved (Bowen 2008). For this reason it is associated to a lower level of transparency (O'Reilly and Parker 2012) with regards to the point when it is achieved.

In order to achieve saturation the adequacy of the sample should not be determined only having in consideration its size, but more specially the sample adequacy should be consider the "appropriateness of the data" (O'Reilly and Parker 2012, 195). This appropriateness can be achieved if some criteria's are taken into account. Morse (2000, 4) describes several factors that one should take into consideration when estimating the number of participants required to reach saturation. These factors include for example: the scope of the study (the broader the scope of research question, the longer it will take to reach saturation), the nature of the topic (if the topic is obvious and clear then the information obtain in the interview is easily obtained), quality of data (it depends on the participant and in its ability to reflect on the topic), the study design (which influences the number of interviews per participants and therefore data collection) and also the use of "shadowed data". The use of this data is very important since it can aid information on the "experiences and the domain of the phenomena beyond the single participant's personal experience" and it can provide "some explanation of the rationale for these differences" (ibid., 4). Teddie and Tashakkori (2009) consider that in qualitative research design, using case studies of individuals, the estimated sample size required can be from approximately from 6 to 24 cases.

Saturation is considered to be reached when no new or relevant information emerges and therefore new data does not add novelty to the constructed theory (Creswell 2015; Given 2008; Teddie and Tashakkori 2009) which means that the collection of new data will not shed any further light to the one already analysed (all the perceptions that might be important are already covered). Since the information, given by participants is becoming redundant. On the other hand, since data is collected with quantitative and qualitative methods, integration can be challenging. Integration refers to the way of combining the data in relation to the mixed method design used (Creswell 2015).

There are four possible ways to integrate the data: merging, explanation, building and embedding (Creswell 2015). Since the presented research as adopted the convergent design, the most suitable way to integrate both data sets is by merging the data (as represented in Figure 3.3.) which implies that results are presented side-by-side (parallel way) with the presentation of quantitative results followed by the qualitative (or vice-versa).

3.2.2. Strategies of Inquiry

The combination of data collection using two strategies is one of the more commonly used strategies in mixed methods (Teddie and Tashakkori 2009) thus, and due to the potential sensitive nature of the questions, a self-administered questionnaire was combined with face-to-face interviews (Leeuw 2008, 318). Interviews in qualitative studies, aim to "provide an in-depth understanding of people's experiences, perspectives and histories in the context of their personal circumstances or settings" (Spencer et al. 2003, 3), semi-structured interviews were conducted with the purpose of gathering information that could not be collected only with the self-filling of the questionnaire.

3.2.2.1. Questionnaire

Aiming to collect two sets of data, two questionnaires were designed (Questionnaire A and Questionnaire B). Having in mind the strategy in which participants would use self-report to express their opinion and experiences (Teddie and Tashakkori 2009), regarding the decision-making process of an MRI Scanner purchase, Questionnaire A: "Technological decision-making process" was designed (Appendix 3.1). The questionnaire included open and closed questions. For some of the closed questions, the answer was requested to be given according to a Likert-scale. The structure of the questionnaire is resumed in Table 3-1:

Table 3-1 Structure of the questionnaire

Aim	Aspects focused		Related questions
Drivers for technology acquisition	Motivation and aim(s)		Question 1, 2
Characterization of the decision- making process	Process	Use of evidence	Question 3, 4, 5, 6, 7, 8
		Steps of the process	Question 9
	People	Stakeholders involved in the process and their importance	Question 3, 10, 11
		Perception of the process	Question 12, 13, 14

In order to identify the decision-makers involved in the process, a triangulation by geographic poles was used, meaning that a first contact was established by telephone, email or in person, with the responsible person of the radiology department, in Lisboa, Porto and Évora. In most case were the Radiographer Coordinators in the public sector and the Director in the private sector. The aim of the study was explained as well as the conditions that needed to be observed in order for a person to be eligible to be included in the study. Thus, in order to meet the inclusion criteria to be defined as DM, it had to be clear that the person was actively engage in the decision-making process with a specific role. Excluded were the individuals who play a secondary role, namely as advisers or just signing some documents. Once the DM was identified, she/he was invited to participate, with a formal request. Depending on the DM availability the participation in the study was made through the self-report of the questionnaire only or combined with an interview (described in 3.2.2.2). In the end, a snowball procedure[13] took place in order to identified further DMs involved in the process. Anonymity, privacy and confidentiality were assured during the inquiry.

[13] Considered to be a non-probabilistic sample, since the researcher initially established contact with a smaller group of people who are relevant to the research topic and then uses these to establish contact with others (Bryman 2012, 616)

In sum, data regarding the perceived decision-making process by 40 decision makers was collected, in order to generate in depth information, which could lead to a reconstruction of characterization of the decision-making process (Tashakkori and Teddie 2009). The list overview of participants can be seen in Appendix 3-2.

Competence is a latent variable, meaning that it cannot be measured directly and as such it has to be measured indirectly, by resorting to the use of observed variables or indicators (Kline 2011b, 9), as they are manifest variables (Blunch 2013; Lei and Wu 2007). To measure "competences" two approaches can be considered: self-report measures or the simulation of decision situations (Shiloh and Rotem 1994). The second option was not taken into consideration because, although they can be more objective than self-reports, generalizations beyond the specific decision presented can be questionable due to their artificially and distance from real life experiences (ibid.). Thus, to accomplish the aim of the present research, self-reports were the instrument chosen to assess the potential decision makers "competences". Questionnaire B: "Competences in Decision-Making" (Appendix 4-3) was developed as a closed-question questionnaire, were the answers were given using a Likert scale.

According to Varvasovszky and Brugha (2000, 341), "stakeholders can be defined as actors who have an interest in the issue under consideration, who are affected by the issue, or who – because of their position – have or could have an active or passive influence on the decision-making and implementation processes. They can include individuals, organizations, different individuals within an organization, and networks of individuals and/or organizations, i.e. alliance groups." Thus, in a Radiology Department, four professionals were identified stakeholder and therefore as potential decision-makers: the Radiologist (Physician), the Radiographer[14], the Clerk (Administrative staff) and the Operational Assistant (or Porter).

The majority of the Radiology departments in Portugal, with at least one MRI scanner installed (inclusion criteria) were contacted by phone, email or presential in order to be invited to participate in the study. A letter of invitation was additionally sent (Appendix 3-3). In order to accomplish requirements from the Radiology departments, the questionnaire was either send by post or personally delivered in paper at the Radiology Department. In some cases, an email was sent to the Coordinator/Director of the department with the request for further distribution of the questionnaire via a web address where the questionnaire was online (Survey Guizmo platform). Particpants invited to fill in the questionnaire the ones mentioned above.

The participation of the respondents was free, and no sort of incentives was given to participate. The questionnaire had an average time of 10 minutes to be answered. Anonymity, privacy and

[14] Also designated as Radiologic Technologists, Diagnostic Radiographers or Medical Radiation Technologists.

confidentiality were assured. Further information on the questionnaire (Questionnaire B) will be developed in Sub- chapter 4.2.

3.2.2.2. Interview

Interviews are one-to-one interactions between the interviewer and the interviewee (Teddie and Tashakkori 2009) that allow a more detailed data collection, since the interviewer can ask for more details or clarifications, being face-to-face interviews are the most flexible form of data collection method (Leeuw 2008). Being a frequent method used in exploratory-descriptive studies (Fortin 1999), the semi-structured interview was chosen, due to, on one hand, the possibility given to the interviewer to develop and guide the interview in the most adequate direction, by exploring a specific topic, if needed (Savoie-Zajc 2003) and on the other hand, because it is associated with interpretative and constructivist paradigms, since it tries to understand the meaning of the phenomenon under study as it is perceived by the interviewees, using the dynamics of the co-construction of meaning that is established between the researcher (interviewer) and the interviewees (ibid.).

A guideline for the interview was established, based on the questionnaire structure (Appendix 3-4). Although the interview is held in a more informal setting, the guideline helps to assure that the interview topics are focused, but providing the interviewer some liberty to explore a topic or further develop another issue raised by the interviewee (Marconi and Lakatos 2002). In total, 27 interviews were conducted from March 2012 to May 2014 (Appendix 3-2).

Concerning *data analysis strategies*, in order to extract meaning from the collected data, descriptive statistical methods and content analysis were undertaken, in a parallel way. Parallel mixed analysis is according to Teddie and Tashakkori (2009) probably the most widely used data analysis strategy, also associated with triangulation. The descriptive analysis was performed using EXCEL software, in order to summarize and describe a set of data in quantitative terms (Onwuegbuzie, Leech, and Collins 2011, 354). Content analysis refers to the a set of communication analysis techniques aimed at obtaining, by systematic procedures and objectives of description of the content of messages, indicators (quantitative or not) that allow the inference of knowledge related to the conditions of production / reception (inferred variables) of these messages (Bardin 2009, 37). It is therefore a strategy that serves to identify a set of characteristics essential to the meaning or definition of a concept (Fortin 1999, 364), an empirically grounded method, exploratory in process, and predictive or inferential in intent (Krippendorff 2013, 1).

The content analysis is composed by two dimensions: a descriptive dimension which tells us what the interviewee answered and an interpretive dimension resulting from the questions posed, which subsequently allow to achieve inference rules (Guerra 2006). From the treatment of the messages, one can infer knowledge about the sender of the message or about its environment, for example, Bardin

(1979) clarifies that inference is no more than an intermediate procedure through which the "description" (enumeration of the characteristics of the text, summarized after treatment) to interpretation (meaning given to these characteristics) is made explicit and controlled.

In order to guarantee the quality of the speeches and to ensure that, at the time of its transcription, the researcher could be as reliable as possible, the audio recording of the interview was chosen. Subsequently, most of the interviews were full transcribed, and others whose large parts did not add any value to the research were only partially transcribed. Since all the interviewees spoke in the first person, the transcription was completely faithful and reliable to what was said, thus a transcription verbatim of the interview (word by word) was made. The transcribed data mirrors the interview content, thus it can be treated in a finer way (Guerra 2006; Savoie-Zajc 2003). The word processor Word 97 (Windows XP), was used for this purpose. All interviews were coded in order to maintain the anonymity (DM1, DM2, DM3…)

A deep and careful first reading of the interviews was carried out, where the pre-established thematic areas were identified, and since these were semi-directed interviews, the sub-thematic areas that emerged during the interviews were also identified, aiming a better organization of the text. As a result, two main thematic areas were identified: drivers for technology purchase and characterization of the decision-making process.

Synopses of the interviews were then organized in a table, were the first column represents the main thematic areas previously identified (Appendix 4-1). For Guerra (2006), the synopses are no more than syntheses of the speeches given by the interviewer, containing the essential message of the interview, being still literally faithful to those given by them. It is nothing more than descriptive material, where it is possible to identify the themes and problems of the interview. In order to obtain such synopsis, MAXQDA software was used.

The previous analysis was followed by categorisation, which is defined in a simplistic way, as nothing more than the transition from raw to organised data. Bardin (1979) defines categorization as, an operation of classifying the constituent elements of a group, by differentiation and then by regrouping them according to gender (analogy), with the criteria previously defined. Categorical analysis is in practice one of the most used analysis strategy, within content analysis. Considered to be a descriptive but not yet interpretative analysis, the variables whose dynamics are potentially explanatory of the phenomenon that the researcher intends to explain are identified, making a measurement for an explanation and for the typical ideal construction that one wants to see in depth (Guerra 2006). According to Bardin (2009), the categorical analysis intends to take into account the totality of a "text" that is subsequently subjected to a classification, according to the frequency of presence (or absence) of items of meaning. It is thus a taxonomic method, since the categories allow the classification of the elements of meaning constituting the message.

In order to proceed to the definition of the categories subject to be analysed, Serrano (1998) perspective on the graphic representation of the thematic subjects was followed (Appendix 3-5), considering the following categories and respective sub-categories (Table 3-2):

Table 3-2 Categories and related sub-categories for content analysis

Categories	Sub-categories
Organizational settings	Drivers Aims
Characterization of the decision-making process	Decision-makers Evidence Influences Steps

3.3. Remarks

The present study is considered to be:

- Exploratory, since there is few or no knowledge about the research issue and the aim is to test and confirm hypothesis in relation to the empirical evidences. A case study is the chosen technique in order to have access to quantitative and qualitative data.
- Descriptive, since the characteristics of a selected problem is to be identified and information collected. Has a result quantitative data will be obtained.
- Analytic, because it intends to establish a meaningful model of the reality studied, producing a theory or even propose to introduce concepts and theories intermediate.
- Deductive, since in the research, the theoretical and conceptual structure are developed and them tested by the empirical observation. Therefore, particular cases are deducted from general inferences.

In terms of research design, two strategies were chosen, aiming different objectives:

- To characterize the decision-making process, a questionnaire was developed, and interviews were conducted in a parallel way. A mixed method was chosen to collect (in a single-phase design), analyse and interpret results (in a convergent parallel design). Sampling issues were considered, namely saturation of information, when participants were selected by convenience in a snow-ball approach. In terms of data analysis strategy, descriptive statistics was chosen as well as content analysis, namely categorial analysis.
- To assess competences for decision-making, a quantitative approach was selected, using SEM analysis. A questionnaire retrieving only quantitative data was developed. In terms of data analysis strategy, FA (namely EFA) was chosen, followed by SEM (namely CFA and path analysis).

FA is used to uncover the latent structure of a set of variables, in order to select / confirm a sub-set of variables from a large set for modelling purposes. Therefore, FA was used for two main purposes: to develop a psychometric measure using EFA and to validate these psychometric measures using SEM, namely CFA and path analysis.

4. DECISION-MAKING: PURCHASE OF AN MRI SCANNER - RESULTS OF SURVEY ANALYSIS

"It is reason, and not passion, which must guide our deliberations,
guide debate and guide our decision."
– Barbara Jordan[15]

The literature review presented in the previous chapters, showed that the decision-making process can be either very simple or complex, can involve multiple decision-makers or be a one-person standalone decision, and can also be influenced by several factors, external or internal to the decision-maker(s), making the process more or less evidenced-based.

The aim of this research is to characterize the decision-making process related to the purchase of MRI, in the Portuguese context. In the above quote, Barbara Jordan argues for reason or rationality as a guide to decisions and judgments. Can one find this rationality in decisions taken to purchase MRI devices in the Portuguese health system?

This chapter will provide results from the questionnaire applied to those actively involved in the decision-making process of an MRI scanner purchase. In some cases, it was possible to complement the questionnaire with a semi-structured interview, in order to collect more detailed information on the process. This chapter is organized in three main parts: in the first part (sub-chapter 4.1.), the characterization of the decision-makers that contributed to the study will be presented, as well as results regarding the decision-making process itself (here quantitative analysis of questionnaire A will be presented). In the second part (sub-chapter 4.2.), results retrieved from the content analysis of the interviews will be presented, with references to the principal direct quotes. The quotes are identified with the decision-maker's code followed by the quote line number (e.g. DM1 34). The third and last part (sub-chapter 4.3.) is dedicated to the discussion of results presented in the previous sub-chapters (4.1. and 4.2.).

[15] Barbara Jordan was an American politician and a leader of the Civil Rights Movement. In 1972, she was elected to the U.S. House of Representatives, the first woman in her own right to represent Texas in the House.

4.1. Questionnaire results

4.1.1. Characterization of the decision-makers

In total, forty (n=40) decision-makers answered the questionnaire related to the decision-making process. Among these, 27 also provided complementary information during a face-to-face interview. Appendix 3-2 provides an overview of the decision-makers that participated in the research, after coding in order to maintain anonymity.

In terms of participants in the study, fourteen (n=14, 35%) decision-makers are from the public sector and twenty-six (n=26, 65%) are from the private sector. Regarding the gender dimension, in total twenty-nine (n=29, 72.5%) are male and eleven (n=11, 27.5%) female. The public sector is more gender balanced than the private sector[16] (Figure 4-1).

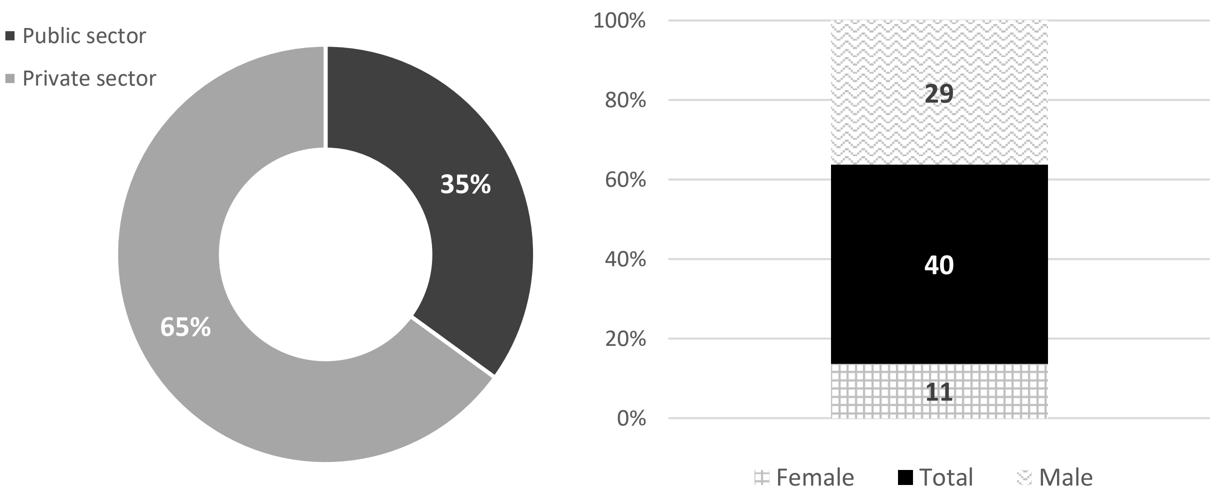

Figure 4-1 Distribution of the decision-makers, by sector and gender

In terms of working title, most decision-makers are Radiology Department Coordinators (n=22, 55%), followed by Radiology Department Directors (n=6, 15%) and Clinic Owners / Administrators (n=5, 12%). All Radiology Department Coordinator positions are held by certified Radiographers, and all Radiology Department Director positions are held by a Radiologist. The position of Clinic Owners /Administrators refers to private practice owners who also play the role of administrators (Figure 4-2).

[16] From the public sector, six decision-makers were female and eight males. From the private sector, five were female and twenty-one were male.

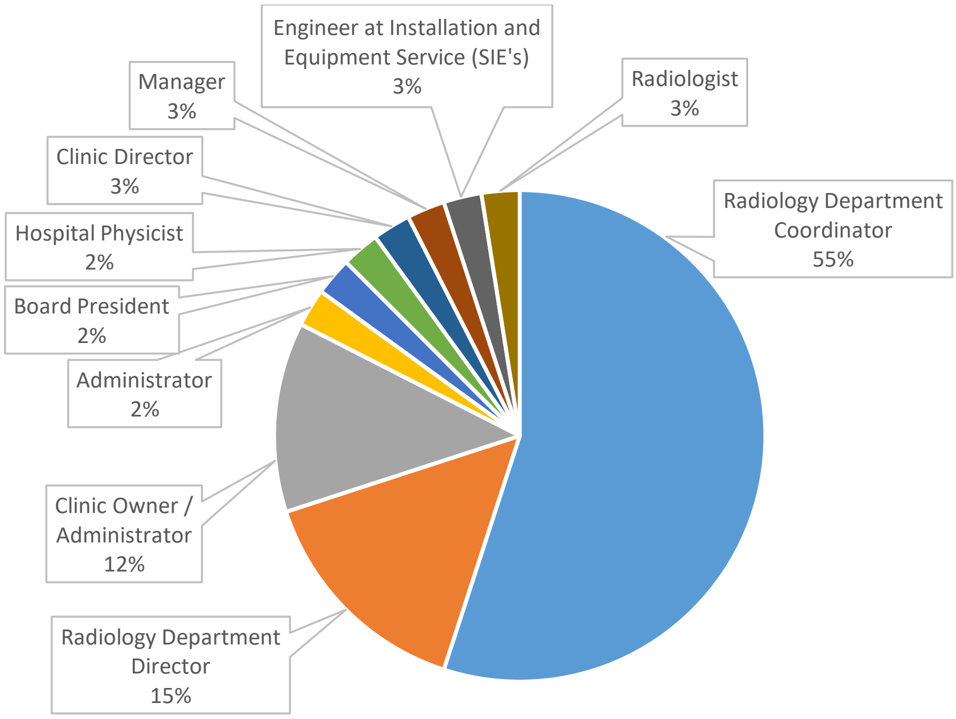

Figure 4-2 Distribution of the decision-makers, by working title

Invitations to participate in the research were made to several decision-makers across Portugal, but acceptance rates were higher in the Lisbon region (n=30, 75%) (Figure 4-3).

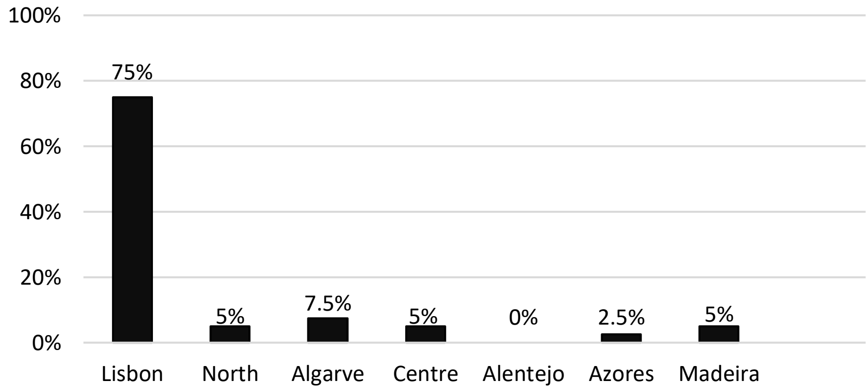

Figure 4-3 Distribution of decision-makers, by regions

4.1.2. Characterization of the decision-making process

Which were the main drivers in the decision-making?

Results show that half of the decision-makers (n=20, 50%) identified technology development as the main reason to buy an MRI scanner. This was the main driver for initiating the decision process (Figure 4-4). The possibility to have better expansion capacity, by offering new or specific exams not yet offered by the Radiology Department, is the second reason identified (n=15, 37.5%). To be competitive in the Radiology sector is the third motive identified (n=5, 12.5%). It is interesting to note that the answers for this third driver were provided only by decision-makers in the private sector.

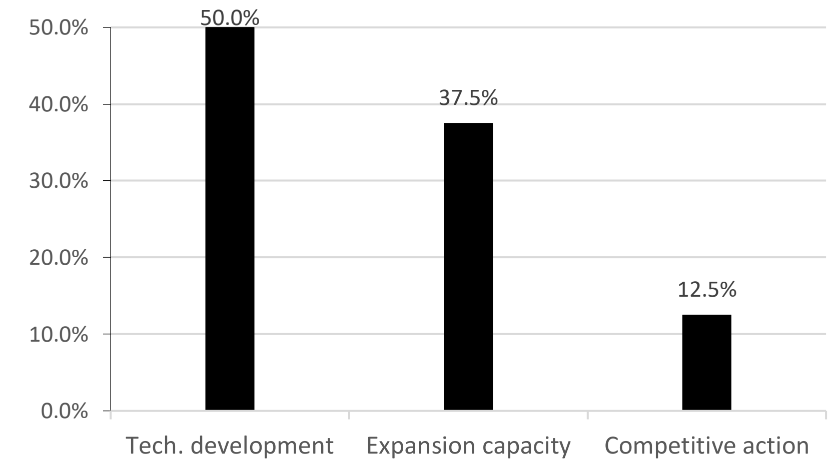

Figure 4-4 Strongest reasons for the MRI scan purchase

When asked about the most important objectives or aims taken into consideration for the acquisition of the technology by the Radiology Department, results indicate (Figure 4-5) that to provide for health care quality is the most important objective, followed by the need to satisfy clinicians' preferences (Radiologists). Less important objectives are to satisfy patients' preferences or to maximize revenue.

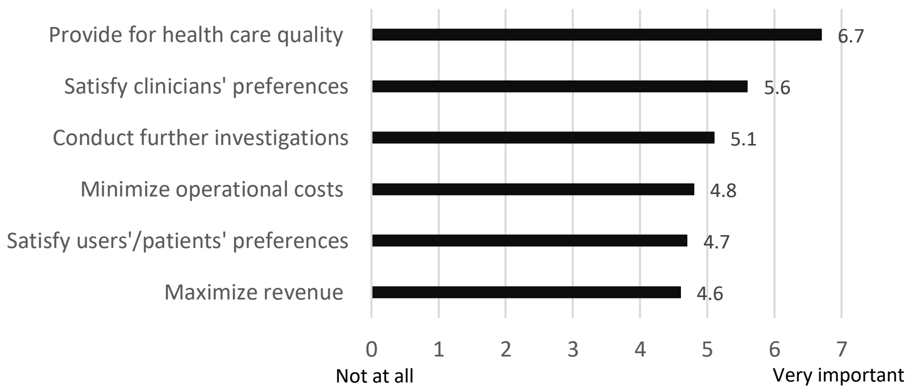

Figure 4-5 Main aims considered for the MRI purchase

Is the process of decision-making evidence based?

The participants were asked if any kind of indicator was used during the decision process. Results show (Figure 4-6) that 95% (n=38) responded positively that they used indicators, and only 5% (n=2) replied negatively. However, when asked which indicators were more relevant, the same two participants provided answers, meaning that in reality, they also used indicators. Thus, all participants did use indicators when deciding.

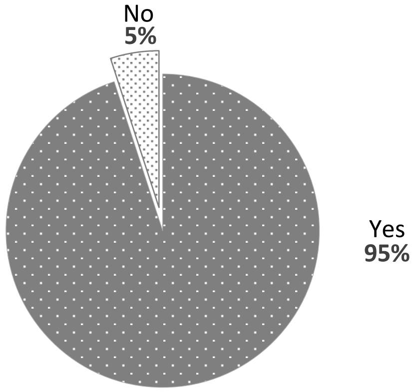

Figure 4-6 Use of any kind of indicators in the decision process

Participants were then asked to identify the three most important indicators used in the technology decision. Results show (Figure 4-7) that "costs" was the most relevant indicator, followed by the supplier characteristics, namely for instance ease of relationship, openness, previous experiences, etc., and by the technical characteristics of the technology collected by direct search. Least important are the

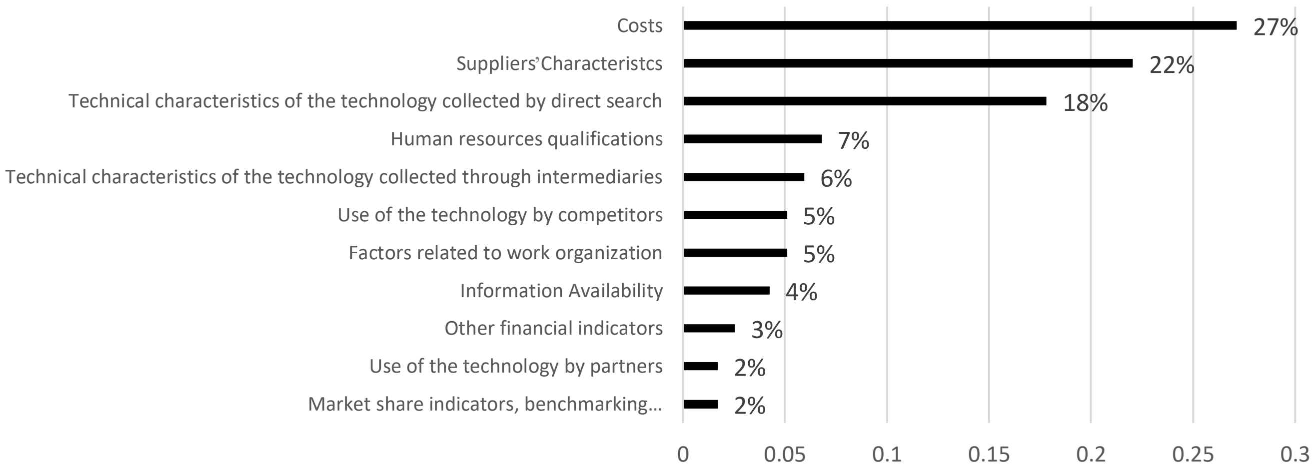

Figure 4-7 Most relevant indicators used in the decision process

When asked about when the indicators were used, results show (Figure 4-8) that decision-makers mainly use indicators before the decision is made (80% "several times"), with a decrease in use after the decision is made (45% "sometimes" and 27.5% "several times"). These results show that importance is given to indicators. Thus, when asked about the main role of indicators, results show

(Figure 4-9) that decision-makers use them mainly to check market trends, competitors' development, to analyse competitive capacity, scientific advances, or even to check the development of the technology. In sum, the indicators are most use to foresee the future. Indicators are also used to confirm, justify and characterize the decision made.

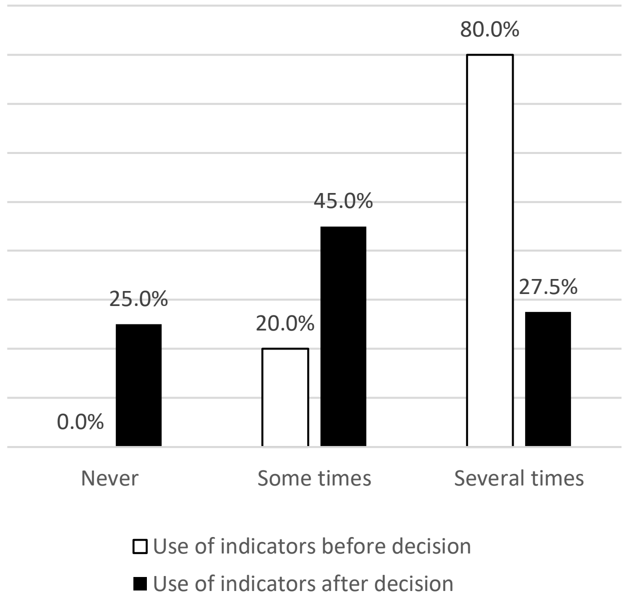

Figure 4-8 Use of indicators before and after the decision process

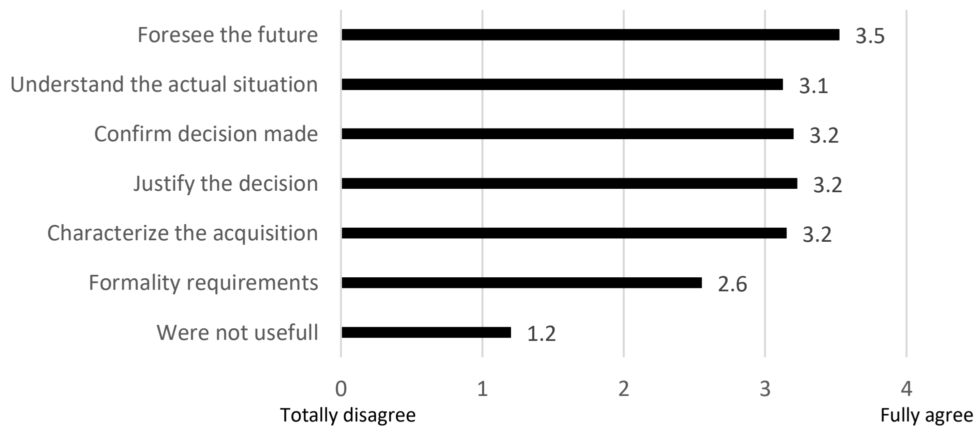

Figure 4-9 Indicators importance in the decision-making process

The decision-makers were asked to identify studies that were made before and after the MRI scanner acquisition. They were also asked to identify the persons responsible for conducting such studies. Some of the interviewees stated that no study was conducted, while others provided some examples. Since it was an open question, the answers were analysed and categorized. Table 4-1 provides an overview of the results:

Table 4-1 Studies overview performed before and after decision

<table>
<tr><th rowspan="2"></th><th colspan="2">Before the decision</th><th colspan="2">After the decision</th></tr>
<tr><th>Study</th><th>By whom</th><th>Study</th><th>By whom</th></tr>
<tr><td>Related to the technology</td><td>- Acquisition costs
- Costs per exam
- Maintenance costs
- Market assessment
- Viability studies
- Blind image quality studies
- Expert consultation
- Providers assessment</td><td rowspan="2">• Area Manager
• Installation and Equipment Services
• Department Director
• Radiographer Coordinator
• Administration Board
• Financial Department</td><td>- Cost per exam
- Acquisition costs</td><td rowspan="2">• Manager
• Department Director
• Radiographer Coordinator
• Installation and Equipment Services
• Administrators</td></tr>
<tr><td>Related to the Department</td><td>- N. of exams per year
- N. exams in waiting list
- N. exams done by third-party
- Economic viability studies
- Assessment needs
- Human resources needs assessment
- Technology needs assessment
- Radiation security studies
- Cost-benefit analysis</td><td>- N. exams in waiting list
- Marketing impact
- Satisfaction with the quality provided by the company in terms of technical assistance
- List of problems /malfunctioning of the equipment
- N. of performed exams
- Analysis of strengths and weaknesses</td></tr>
</table>

The studies made are mainly related either to the technology or related with the status of the Radiology Department. In terms of technology the studies rely on the costs related to the technology acquisition and its maintenance and the exam costs. The market assessment refers to the availability of the technology in the country (offer) and its location. When it comes to the studies related to the Department, several decision-makers indicated that the number of exams kept on hold in a waiting list (in cases where the facility already has one MRI), or the number of exams done by a third-party (when the facility has no MRI they rely on protocols established with other health facilities/radiology departments to perform the required exams), were used as an indicator to assess the need to acquire the technology and therefore to justify the decision. The same indicators are also used to confirm the decision, after the technology acquisition.

One question was left open, in order to understand if the decision-makers used some other indicator not mentioned before. The aim of the question was to understand if the decision-makers mentioned any type of HTA study. There was no mention, either before or after the decision, of the use of a technology assessment study, for instance by Health Technology Assessment entities, or similar.

Influence of others in the decision process

In order to understand if other people participated in the decision, some questions were asked aiming to characterize other decision-makers involved or other people that influenced the decision. One question related to the importance of potential stakeholders in the decision process. When asked about a set of people and their importance in the decision process, results show (Figure 4-10) that the most important decision-maker is the Radiographer Coordinator, followed by the Financial and Accounting Responsible person. The less important ones are the patients and the users.

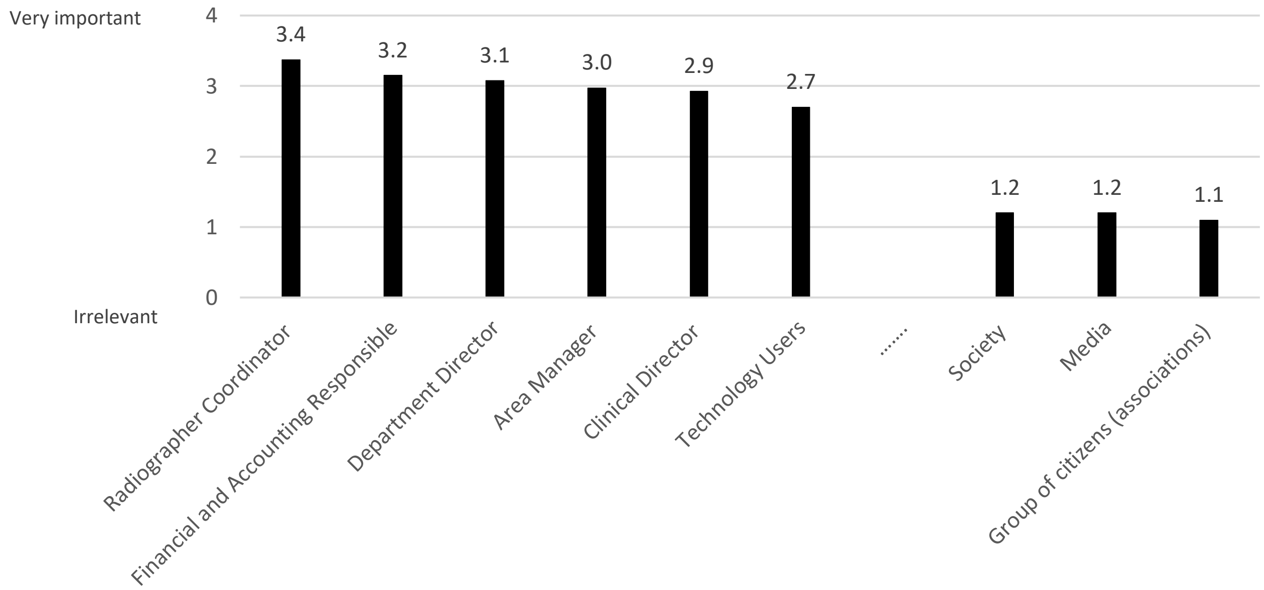

Figure 4-10 Stakeholder's importance during the decision-making process

When asked about the importance of the indicators previously identified compared with the people, the majority answered (Figure 4-11) that the indicators were more important than people's contributions (61.5%, n=24), therefore in the justification needed, indicators play a bigger role.

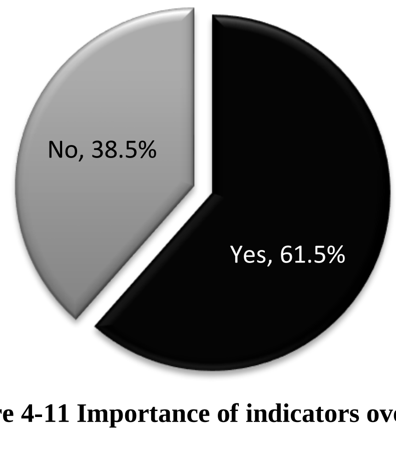

Figure 4-11 Importance of indicators over people

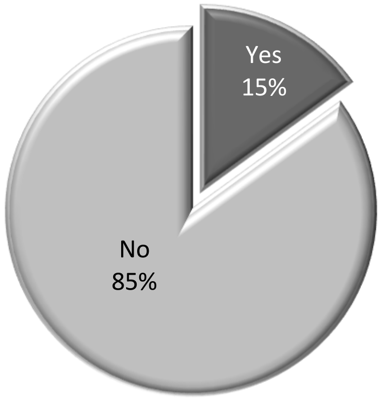

Figure 4-12 Results to the question "Were you the final decision-maker in the process?"

Although most of the decision-makers participate actively in the decision process, it is interesting to realize that they were not the ones finalizing the process, which means that they were not the final decision-makers in the process. Only 15% (n=6) assumed this role (see Figure 4-12).

It was them asked who had the final decision in the process. The answers were coded[17] and the results represented in Figure 4-13. Here one can see that the final decision is mainly taken by the Administration Board (n=28, 70%), followed by the Director of the Imagiology Department (n=8, 20%).

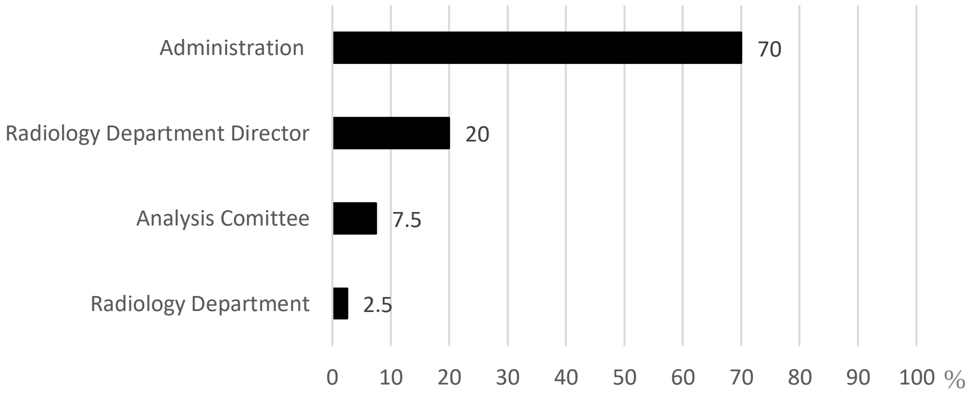

Figure 4-13 Results for the question "Who was the final decision-maker in the process?"

Which procedures/steps characterize the process?

Decision-makers were asked (in an open question) to enumerate the steps of the decision-making process. The answers were analysed and clustered in order to have a final simplified representation of the process, as illustrated in Figure 4-14.

[17] In terms of coding, “Administration” refers to the General Administration Board (public sector) or managers or single administrators (private sector).

The process starts in the Radiology Department, with the identification of a need to have the MRI technology, in order respond to the needs of the Department. Some studies are then performed to assess economic viability and market assessment. Sometimes visits are made to departments with already established technology, for more detailed contact with the technology. This is also an opportunity for decision-makers to exchange opinions with colleagues. If the technology is purchased in the public sector, the mentioned studies are then sent to the Administration Board for approval. Due to its high acquisition costs, the purchase intention needs to be approved by the Health Ministry. A report is written mentioning all technical specifications it is desired to have in the new equipment (characteristics of the equipment). Criteria for posterior assessment of the technology are established, as well as a ponderation attributed to each criterion. In the public sector, this document is usually written by a group of decision-makers, namely the Installation and Equipment Services (SIE), together with Radiographer Coordinator, Radiology Department Director and Area Manager. In the private sector it is usually the owner or the Radiologist Coordinator, with possible collaboration from the Radiographer Coordinator.

In the private sector, the process is simple: the supplier companies are directly contacted, and the report with the specifications is sent to some companies in order to collect offers. Once offers are gathered, negotiation with potential supplier companies takes place (factors like costs and maintenance are discussed and negotiated). A selection and decision is taken on the equipment to buy. Finally, the equipment is bought.

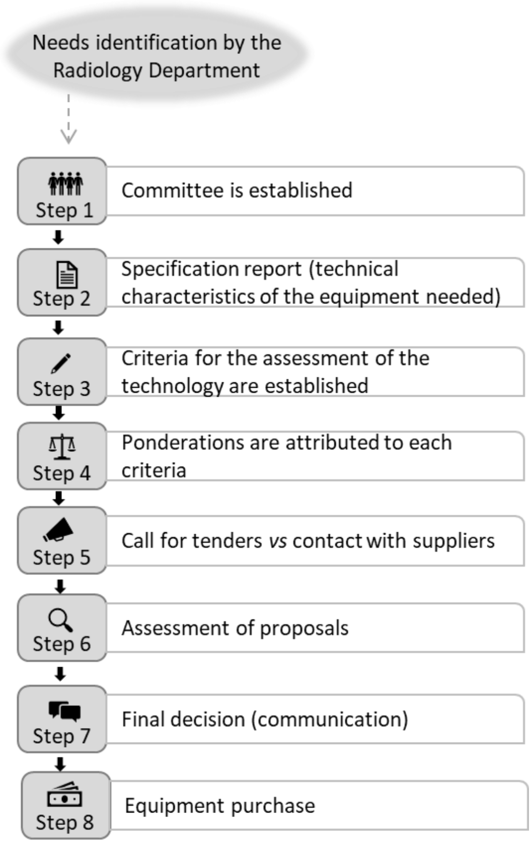

Figure 4-14 Results for the question "Please describe the main decision-making process steps”

In the public sector, the process is much more bureaucratic. A tender document is established and sent to the Legal Department for approval; the tender document is then sent to the Purchasing Department that will gather all the required information; the tender document is then sent to the Administration to be published in the Official Journal (Diário da República) for public tender.

The Purchasing Department receives all the proposals submitted, compiles all the information and sends it to the SIE. The SIE assesses the proposals and fills in a comparative map with different ponderations attributed. The result is sent to the Radiology Department; Radiology Department approves or not the result and sends the assessment back to installation and equipment services. If the assessment was positive, SIE sends the process to the Purchasing Department, who asks authorization from the Administration. The Administration sends the report results to all companies who submitted a tender for acknowledgement and any contestation. In case of a contestation, if legal, the Legal Department will address it; or if technical the SIE. When all is satisfactory, the Purchasing Department and the Finance Department issue an order form.

Perceptions of the decision-making process

In terms of the satisfaction of others considering the decision made, on average, from the radiologists to the radiographers, from the technical to the clinical leadership, and even the Administration (or board of directors), all were seen to be quite happy with the scanner purchase (Figure 4-15):

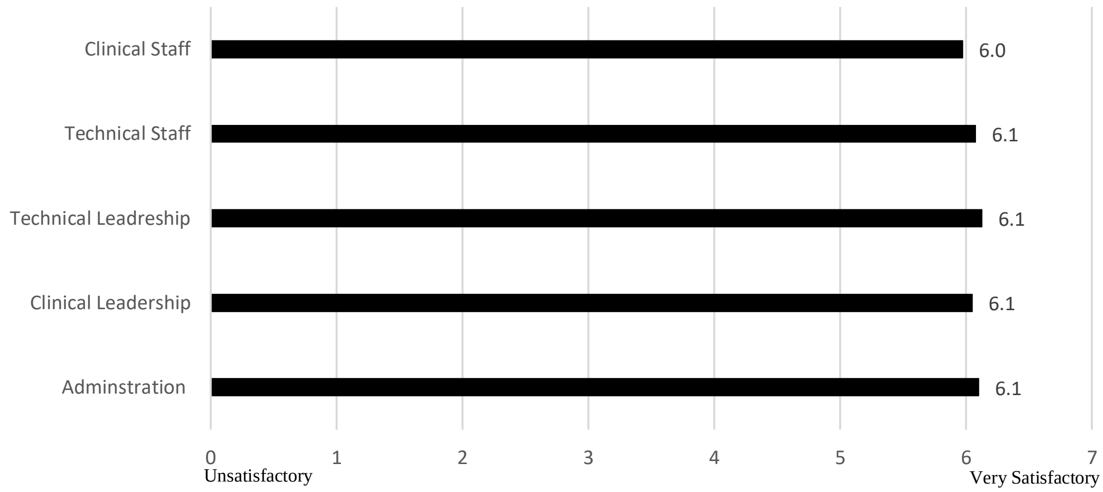

Figure 4-15 Satisfaction perception of the stakeholders

The interviewees were asked how they perceived the process of decision-making (Figure 4-16). Overall, twenty-nine respondents said that the decision was never a solitary process, and eight said that sometimes the process was a solitary one.

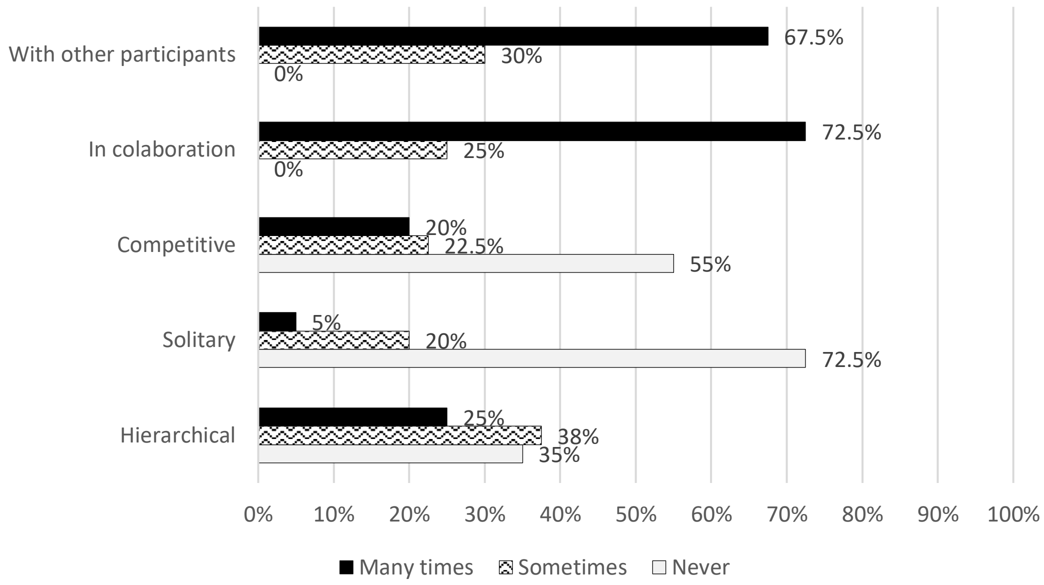

Figure 4-16 Results for the question "How do you perceived the process of decision-making?"

According to the results, the process was never “stand alone”, since the respondents answered that they had collaboration “many times” (72.5%, n=29) and “sometimes” (25%, n=10) and. The process was undertaken with other participants “many times” (67.5%, n=27) and “sometimes” (30%, n=12). The process is also perceived as a hierarchical one, since 38% (n=15) of the interviewees perceived it as “sometimes hierarchical” and “many times hierarchical” (25%, n=10). 35% (n=14) perceived the process as “non-hierarchical”.

4.2. In-depth analysis of the decision-making process of an MRI scanner – interview results

In order to expose and explain with further details the results of the interviews, an in-depth analysis was performed on their content. Direct quotations will be used to illustrate specific issues. The synopses of the interviews is compiled in Appendix 4.1, where the names of the companies and the interviewees were replaced by codes (e.g. AA, WW, XX…). The analysis is presented according to the categorical analysis identified in Chapter 3.

One of the first aspects that was important to understand were the drivers that led to the purchase of the MRI scanner. In a constantly changing and developing technological world, it is easy to understand that the evolution of the technology and its development were one of the main existing drivers. Radiology departments needed to stay competitive by means of the introduction of an MRI scanner or other advance technology:

Whether in public or in private, it is a brutal investment and these investments have to have objectives. And those objectives are for sure, when you invest, whether in a resonance or another equipment, to improve performance, so we can make new clinical approaches. (DM12 93)

The developments of MRI techniques and their unique characteristics were in some cases seen as an alternative for traditional exams:

(...) the global universe of medicine began to do much more resonance than before... little by little it began to replace a little bit of other techniques by resonance. (DM10 333)

Using the image superiority of MRI in preference to others, led to the necessity of having such equipment, if a Radiology Department wanted to be competitive in the imaging sector:

At the time it looked like the resonance was going to explode, as it should have exploded, in a way, before the financial constraints we all know about came into play, so we thought we had to have that, otherwise we'd get a little technically amputated. (DM11 64)

Especially in the private sector, competitiveness is seen as an important aspect, taking advantage of the new technological advances available in the market: *"(...) it is also part of a private entity to be able to say that it does [MRI exams]. There was some interest here..."* (DM12 206), and also to have some differentiation from its fellow private practices: *"We also wanted to differentiate ourselves by the state-of-the-art equipment, which is the best at the moment*." (DM8 7)

This differentiation in terms of technology is also intertangled with profit, a necessity to the private sector, as mentioned by one of the interviewees: *"It is still not the most important factor, because if we provide high quality health care and it is not profitable... it does not make sense... unfortunately... it may shock some people, but it is true!"* (DM8 11), even if the decision of having MRI scanners is not always consensual: *"The argument of it was to increase supply and generate greater demand (...) to capture those clients from downtown Lisbon to there. Now, if we should have two resonances there? I don't think so."* (DM9 299). Of course, competition exists if Radiology departments are geographically located nearby, offering similar services, which was not the case at the time, for some private practices: *"The competition here did not even exist, because there was no more in the area."* (DM11 66).

In the public sector, competitiveness was not considered to be a driver for the MRI scanner purchase, due to the management models of the health public sector, as explained by an interviewee:

(...) this competitiveness is a bit complicated in our hospital and management model, because deep down there is not exactly a competition between hospitals. Hospitals have a geographical

area of implementation, they serve a certain population and this population is practically forced to go to that hospital, isn't it? (DM4 25)

In the case of a Radiology Department who already had an MRI scanner installed, the main driver for the new acquisition, or replacement, was related to the obsolescence of the existing technology:

> *(...) the resonance that we had was quite old, probably no longer had the technology with the capacity to respond to what they (radiologists) needed.* (DM13 23)

> *(...) things have evolved brutally and, therefore, although the resonances have a chance to evolve in terms of software, hardware, coils; if they have obtained some updates, the service's own clinicians already felt some deficit of quality and capacity to perform different tests on that machine and, therefore, they began to think about acquiring new equipment.* (DM10 337)

Concerning the aims or objectives that supported the purchase decision, the private sector strengthens that due to their organizational model, where to maximize revenues was seen as an important aim. However, this does not apply to the public sector, which sees maximization of revenues as a low priority, as mentioned by two interviewees:

> *(…) this is the least [aim] because this is a public service, a public service has very little revenue maximization.* (DM14 245)

> *Everybody knew the MRI wasn't going to be profitable.* (DM11 80)

When asked if conducting research investigations was an objective, negative reactions were found mainly in the private sector: *"Carrying out new investigations in a private practice? I think it is of very little importance. This is not where I am going to do scientific studies."* (DM7 54). Due to the business model of private practices, investigation finds no space to be developed: *"Time for investigation? There isn't!"* (DM5 65).

Knowing that according to the World Health Organization, patients should be considered at the centre of health care systems, and their voices heard, interviewees were asked about patients' preferences, and the possibility to satisfy users' preferences, as an objective when they were choosing from different MRI scanner models. Reactions demonstrated that this was not considered at all, as the following quotations demonstrate:

> *Satisfy the patient? Not at all. No. The patients don't even know what it is [MRI].* (DM2 52)

> *I think that patients don't have an idea, and in Portugal even less, don't they?* (DM4 41)

> *(…) is not his preference, it's our preference, the poor guy has no preference.* (DM5 125)

I am a health care provider; I am a skilled worker and the tool I work with is the patient. So, it is very important ... but it is not him that I have to satisfy. My real client is the doctor who sends him. (DM7 44)

It is much more important to satisfy the doctor. because in an indirect way I am satisfying the patient. (DM7 44)

Further aims, not yet mentioned in the course of the interview, were asked about, and one decision-maker mentions that the purchase of an MRI also aimed to empower internal human knowledge:

Some had experience, some had come from great internships, for example in the United States, with very clear ideas of what they would like to do. That was our impulse. So we weren't worried if there was a corner there, if we wanted to be better than that. (DM11 124)

We had people who thought we were technologically very well prepared to go ahead with a technique, and why not take advantage of this know-how (...)? (DM11 146)

(...) the will to grow and to have human resources was the basis. (DM11 122)

One decision-maker describes the aims of the purchase in a very simple and realistic way:

The choice of equipment was very rational: what do we need? It's better to be a good thing, tested and top of the range, but why can't it be top of the range? Because this will last 10 years and the top of the line at the beginning the management is chaotic (...). We wanted to buy something that was somehow reliable, that gave security to people and professionals and that it could do all the exams that we wanted. (DM16 19*)*

When it comes to the characterization of the decision-making process, one aspect that it is important to understand was the <u>importance of potential decision-makers</u>. Radiographers are seen with a dual importance. From one side their inputs are seen as valuable for the process: *"In practice, the decision was made according to our indicators because there was some talk between open equipment and 3 Tesla, and we said that there was no need. Because if not, perhaps it would have been acquired"* (DM10 193), but from the other they can be overlooked in terms of importance: *"Equipment doesn't last long... 12, 14 years... and some are dragged to the end... and then they are bought in packages and the Radiographers don't say anything... it's business...."* (DM19 24).

Not seen as important were the Area Manager and the Clinical Director, as the following quotations illustrate: *"The Area Manager, is not so important because he has no knowledge (...) we're the ones who tell him what's important."* (DM2 202), and, *"There is the area administrator, but she is not, who indirectly, I mean, did not have to take care, but..."* (DM5 9) *(...) "No, she didn't even sit with us."* (DM5 11). Concerning the Clinical Director: *"It's irrelevant, as long as they authorize it, then the whole* *decision-making process no longer... it does not even get there."* (DM2 210)*; "The clinical director of the hospital did not interfere..."* (DM5 345), although *"In the specification report is required to participate"* (DM4 59).

When asked about the importance of experts, only two interviewees considered them important:

> *Experts, why? Because they were obviously important, because as you know the installation of a resonance is not easy, in structural terms, in terms of noise, etc., etc., etc., etc… So, we had to listen to experts to know where we could put it, if we could buy it, if we bought the resonance, how could it be installed, where, so that there were no problems then, isn't it? (...) So experts were heard.* (DM11 212)

> *We have a partnership with the technical institute in the field of physics, so I think so. It was important too.* (DM1 217)

Although the importance of patients is identified, *"Important, because we want to provide quality service, the importance comes from there."* (DM9 214), patient involvement is not even considered by most of the interviewees, as the following quotations show:

> *Wait, does not mean that we do not take into consideration, but we have not asked users.* (DM12 321)

> *No, not at all. What consultation? Can you see me at the national health service… we would… who? We were going to ask an unfortunate with a brain tumour if he wanted an MRI? He'd say, "Have it done anywhere if I need it." No, people had their own problems solved.* (DM5 59)

> *Is not his preference, it's our preference, the unfortunate has no preference.* (DM5 125)

In order to understand if the decisions taken by the interviewees were <u>based on evidence</u>, it was asked if indicators were used to aid their decisions. Results show that indicators were used due to their importance: "*It is essential to have indicators to inform people, and people made the decision based on these indicators!"* (DM7 173), but also to a somehow mandatory aspect, *"Due to the legislation, we have to do this in this way, so we have to use indicators."* (DM3 137) and; *"Of course they have to be evaluated. All things need to be all measured to the micro-second, to the millimetre, to the cent... things must have profitability."* (DM7 116).

When asked about the most important indicators, and having some options as examples, several decision-makers mentioned suppliers as a strong indicator, mainly when it comes to the established or future relationships, as emphasised by DM3:

(...) Whether we like it or not, a supplier who, in whom we have trust, that can provide us with guarantees in terms of technical assistance, speed of service, quality of service, not being a point directly evaluated, is always a point taken into consideration. (DM3 113)

Thus, for most of the interviewees, the relation with their suppliers is seen as important, as mentioned by DM1: *"Another important aspect is that there was a good relationship with the technical and brand management team."* (DM1 166), and; *"We had already acquired various equipment from that company and always had a good relationship, both with the engineers who work there and with the management of the company itself in Portugal."* (DM1 170)

Especially it was mentioned that the standardization of technology provided by the same company was seen as strategic, as the following quotations illustrate:

Maybe the standardization of imaging suppliers. (DM3 143)

To facilitate further in terms of technical assistance and contract terms, to try to have a brand uniformity. As the previous resonance was already of this brand, perhaps we were already used to... (DM3 147)

(...) the idea of having one company providing technical assistance for everything, greatly facilitates, and in terms of contract costs it also facilitates. (DM3 151)

The fact that we have the PACS from XX. (DM13 158)

At the time we already had a history with ZZ and at the time we bought the equipment from ZZ... and that weighed on us then! (DM8 10)

An option was made for Y and I think the option made for Y at that time... Anyway, I'm taking a little risk saying this, but... I think it was a political option. We had previously bought an equipment package from Y ... where a lot of money was spent... there was a big connection with Y at that time and there was some connection there. By the way, the equipment adjudication was a little bit strange (...). There was a series of negotiations with Y at the time as there was already other equipment's. So that was more a question of managing some (several) costs that we had and a question of maintaining the good relationship that we had with Y. (DM37 5)

(…) although the W wasn't the cheapest - at the time, in terms of values, it wasn't the cheapest - but it was the one that fulfilled the needs and, at the time, it was very important because, in that year, we had also acquired the scheduling software, and all that was W... and it made perfect sense to have as much W equipment as possible so that we would have so much consumables. (DM13 101)

To possess a technology park provided by the same company is seen as a strategic decision, since it allows decision-makers to make better negotiations in terms of acquisition prices for new equipment, better offers for material supply, and above all better maintenance conditions.

It was interesting to see that for some, the supplier choice is also connected to some kind of loyalty: *"Company X is an important partner of the group, so if we had acquired another brand..."* (DM17 2). But for others, this does not play a role: *"We ended up buying from the supplier from whom we had never bought anything. That was not important."* (DM11 128)

Costs were other indicators also strongly mentioned by decision-makers. For most decision-makers, to acquire an MRI at the lowest cost was very important, mainly due to the financial constraints and pressures to reduce costs. In fact, for some, costs helped to shape the decision, as the following quotations illustrate:

> *My concern was to choose the best equipment at the best price, and it stopped there practically.* (DM7 72)

> *There is brutal financial pressure on people and the decision is being taken now only… I can tell you that not so long ago, just two or three hours ago, I was talking to a colleague from our area, she was saying that the decisions, that the decisions in her hospital, the decisions on equipment and materials took nothing into account, nothing! They said, "We would like it to be black, to be like this and to be like that." And then someone else came along and said it is like this and that, "How much does it cost? It's cheaper? I'll buy it!" Do you understand? Okay, everything you asked there, what does it matter? Cost! And that is it!* (DM12 454)

> *(...) what we were going to look for, was from all those who had the characteristics we wanted, the one that was cheapest.* (DM6 12)

> *The financial aspect overlaps with this. Meaning, we all had a say, just as we have in any meeting, we all have a say. But then we'll do the math.* (DM15 115)

> *Basically, the costs, the characteristics and, the fact… with the suppliers W. We had TAC, ECO, everything. So that was it.* (DM6 62)

> *The option for the open one was tied to the cost. The open is cheaper.* (DM18 2)

> *Then there is a process of negotiation with the companies and as always that here the main factor was always the cost factor...* (DM8 9)

> *There was a need to put in a resonance that costs as little as possible.* (DM19 6)

Costs associated with a maintenance contract were also an indicator:

> *(...) the maintenance contract, which is fundamental, as you know. And the price of the maintenance contract also had a gauge of, of, for the choice of equipment. Therefore, there were several gauges, there is the price, and there is the maintenance contract, the delivery times also (...).* (DM5 275)

In summary, financial indicators such as costs are important considerations in the decision process, as mentioned by DM5 "*(...) the financial indicators are important. But they just had to make a decision, lower limit, upper limit, point, over. But there is no doubt that it is pivotal, that that goal is pivotal."* (DM5 395)

The characteristics of the technology were also an indicator that decision-makers mentioned as important: "*(...) from all this technology that is state-of-the-art, a person must see the software; it is essential to know what it is that - in terms of vanguard - could be done."* (DM6 155), and, *"It was decided to buy an MRI, it was necessary for everyone, the choice of the MRI had more to do with the technical part*." (DM10 496).

The mentioned characteristics are also related to the patient and their needs, for instance with claustrophobia, and noise experienced during the exam:

> *(...) claustrophobia: the shorter the equipment, the less noisy, etc.; that was something that also weighed a little. (...) all this thinking about the patient. Therefore, the users are important. Not exactly their opinion...* (DM6 171)

> *I was forced to think in a relatively different way and give the patient a lot of importance, for a reason that I will tell you in a moment, and I did not know it could be so important, especially in terms of magnetic resonance imaging (...) I came to the conclusion that AA is the only brand that had some things that I then realised were very important: bigger diameter of the tunnel, shorter tunnel and sound insulation. This machine produces 80% less noise than the others.* (DM7 46)

One final indicator mentioned is related to factors associated with work organization issues, especially to the aim of reducing waiting lists for an MRI exam:

> *(...) it was seen that we had a brutal waiting list and that with only one piece of equipment we couldn't address this.* (DM2 68)

> *And studies were made on the number of exams that were not done - and, it had to do with waiting lists for exams and so on - to calculate that, later, with the arrival of the new equipment, whether or not it would be worthwhile.* (DM10 61)

The lack of such indicators was seen as a critical point by DM5: *"If the board of directors does not have instruments, and now more and more, does not have analytical computer tools for that, it is screwed!"* (DM5 177)

When asked if there were any other indicators used to assist the decision, not mentioned so far, one interviewee mentioned the image quality perceived by those who would need to interpret the images: *"(...) it was used as a more subjective indicator, which was the evaluation of image quality with the naked eye of radiologists."* (DM7 173)

In addition to the use of indicators, it was asked if studies had been conducted to assist the decision process, and if so, when they were performed. Results show that some studies were indeed performed, for instance as mentioned by DM15: *"(...) every year, we carry out a viability study to see if something is necessary or if there is actually too much expenditure."* (DM15 49). For some decision-makers there was no need for a study, when the situation was clear:

> *(...) all of us, subjectively and objectively, all of us knew that with the 0.5 Tesla device this was exhausted, both in quality and in quantity of exams, there was no chance. Everyone knew that the hospital was sending out a large, large number of exams, others, diagnoses were of poor quality, because the equipment was no longer satisfactory. Now, this was an evident fact, it was evident, there was no study (...) there are indications according to the population served by each hospital unit, and the level of the hospital, if it is an A4 hospital, if it is an A1, if it is an A2, depending on the level of the hospital, then it can have a 64 plans CT, CT of I don't know what. MRI of 3 Tesla, MRI of 1.5, so many angiographies, and so many radiographers working in that service. This is planned.* (DM4 51)
>
> *Twenty years ago, no market studies were performed. It was sensitivity, at that time it was sensitivity.* (DM5 311)

Market research was not considered by the decision-maker: *"We only saw the characteristics of the devices when we went to see the devices in loco, we did not do any kind of specific study."* (DM6 49).

The interviewees mentioned that there was more of a necessity to perform studies in the private sector, and pointed out that such studies had no importance in the public sector:

> *In the private sector it has to be done, it's mandatory"* (DM5 155) *(...) "in the national health service (...) would be a loss, I can even understand… there is no need to do a market study, when the market is inside, isn't it?"* (DM5 165)
>
> *"Yes sir, you want this device? You prefer it that way? But it costs much more. So, what is it that will make the equipment more profitable, to justify the higher cost?" That, at the level of public service is rarely done, because there is not even… nor do the service directors have the*

> *staff, or the independence, nor their own staff have these management studies available, in hand, that can be used to base decisions on.* (DM4 93)

Results of the interviews showed that there is a lack of knowledge among decision-makers on the variety of studies that could be conducted to support purchasing decisions, as well as a lack of knowledge, and competence, and also available time to perform such studies. Although some evidence, for instance in terms of technology performance studies, could be retrieved from other countries, decision-makers at almost all levels do not look for international evidence to support their decisions.

When it comes to potential <u>influences that could have had an impact on the decision process</u>, in general decision-makers see the importance of involving others in the process. This included colleagues from other Radiology Departments: *"Very important. Because, in this specific case, it was not the colleagues from the Department itself; it was other colleagues who had equipment that were giving us feedback on things."* (DM6 132); colleagues in general who had experience with the technology: *"Colleagues too, there were some colleagues who were important, especially those who already had experience in this area out there. There were not many of them."* (DM14 379); and even from abroad *"I asked some people, "Look, you work, you deal..." for their opinion. Sometimes we do… even abroad we would call."* (DM5 367).

Even friends and family who are in possession of knowledge can be useful for the decision: *"We weren't exactly hiring anyone. Economists who helped us, friends, family".* (DM11 118).

Some interviewees mentioned the importance of consulting with others, as DM12 says:

> *We may not even have much weight, but we like to put the word out. And I think that's important because it motivates people.* (DM12 442) *(...) "I might even not pay so much attention, but to get near a colleague and say, "Hey, what do you think, we have to buy an antenna, like this or like that?", and he says, "Like that!" - and I might not agree, but I asked.* (DM12 444)

The decision-makers had diverse opinions regarding the importance of people in addition to the indicators previously identified. For some, indicators were considered more important, as DM3 and DM 11 explain:

> *Yes, deviations. So, they were more important, yes, despite everything the indicators are more important.* (DM3 236)

> *If the financial indicators had given us, without any doubt that the business was not viable, people might very much want us not to. There are always many aspects to this. Of course. Answering black or white in these things is very difficult because there are several shades of grey in between. If it wasn't economically viable, period, no matter how much we wanted it.* (DM11 242)

For others, although indicators were considered important, people and their influence were considered to have equal status: *"(...) it's a strange relationship...because the indicators were built by the people, by these people. So, one thing couldn't exist without the other."* (DM16 17), and *"Because all these people, are people like me, who were involved in the process. So, they're all important, but they're just as important as the people who have been discussing the process, as what's in the process from a technical point of view."* (DM5 391).

For some, people were considered to have more importance, as the following quotations illustrate:

> *Theoretically, it should be the indicators, but not here. So, it's a "nes" [mix of "no" and "yes"].* (DM10 218)
>
> *That's a no, they weren't more important than people. Why not? Because here, as you know, there is no serious financial cost discussion.* (DM3 236)

As seen before, personal characteristics can act as internal influences in the process. In order to understand the role of internal influences, the decision-maker was asked to make a self-perception of the process. According to the results, some decision-makers felt they had a consultant role, as mentioned by DM 1:

> *Yes, consultant. (...) They always left me, always… and when we went to negotiate, many times they even said: "Look at this coil, we... the standard is this; but if we buy this coil, this one and this one, the cost adds "n" Euros" - at the time, Escudos – "do you think it's worth buying, or not?", "Are there are many exams for this, or not?"* (DM1 282) *(…) And I think they considered what I told them. Of course, a financial manager only sees numbers.* (DM1 303)

DM42 said: *"I did not have a role as a first-line decision maker, so to speak, but I did have a consultant role in that decision"* (DM42 6). Others felt that the decision process was made in collaboration, for instance DM42:

> *My participation in this process is clearly technical. I certainly changed my opinion about the possibility of investing or not, but the decision and reflection is always made by radiologists. In this respect, I am not responsible for the decision. My participation is always complementary in order to prepare the most technical aspects ... the specifications, to know what the relevant characteristics for the choice are and let us say control the process, in fact. I mean, I participate in the control of the process, the technical aspects and I am part of the final decision, so the final decision of the chairman of the selection committee, who is normally the radiologist, I make part of the final decision from that perspective , concerning the technical aspects.* (DM42 5)

Although group decision-making was seen as important, some interviewees also mentioned the limitations of this kind of process:

> *I think it's very important, and group decision-making is increasingly important. I speak for myself; I am from the area and know what I know, and know that I am limited in other areas, which I do not know. And the financier knows very well how to do accounting, but they don't even know what our area is all about. (DM12 408) (...) I have trouble deciding or have, I mean, I can have my idea, but let's try to talk to people. But then I start listening... half-a-dozen is enough. Hearing too much sometimes shuffles the system. Because every monkey on its branch. And sometimes it's hard for us...* (DM12 418)

When asked if the decision process was perceived as hierarchical, opinions were diverse, as illustrated by DM12 and DM 5:

> *(...) decisions are taken from the top! The rest are peanuts.* (DM12 474)

> *There was no hierarchy, the people who were there, let say, there is a choice by a group, and that group works homogeneously (...) each one of us assesses the others, his partners, for the one who is most competent in an area. I don't know, for example, when choosing the heart coil, obviously I didn't say anything.* (DM5 403)

Responsibility in the process and the burden associated with the decision was also perceived differently by the decision-makers. DM12 mentions, for instance, that the decision at stake is not a simple one, and brings along many aspects that need to be controlled and considered. A potential mistake could be costly:

> *In a decision like this, where we are playing with rare technological strands here, we are talking about cutting-edge technology, or we are talking about the need for restructuring, shall we say, of infrastructure, where there is always a need for constructions (...) . I can tell you that I even had to lift the ceiling further from the floor because of the cage. The cost is also brutal, is it not? All that, of course, must be weighed, and the decision must be measured well. We may be failing miserably, and then it's a bummer.* (DM12 238)

DM5 and DM12 mention that if the decision is being taken in the public health service where money is scarce, then investments such as the purchase of an MRI scanner are associated with greater responsibility:

> *When I acquire, I have to give justification for sure. In fact, if everything went wrong, I could go to court, couldn't I? Imagine if there was a scam in that, right? And we were distorting the whole process.* (DM5 339)

> *I can decide, let's put the hypothesis that it was I who decided to buy the resonance, "Look, I want a pink resonance!", and then we saw that after all the pink was a bad option, and should have been yellow. We're sorry, as often it's said, no one ... I mean after, there will be a director, a ... "Oh man, you screwed up!", "I did!" I mean, in the public sector it's not quite like this, right?* (DM12 420)

In general, interviewees perceived the satisfaction of others as positive. Some mentioned that despite positive feedback, when it comes to hospital management, the perception is somehow limited, as they are usually in search of more. DM4 and DM14 quotations illustrate this: *"The hospital management is never completely satisfied; it always wants more"* (DM4 99)*;* and *"The hospital management are never very satisfied"* (DM14 401). This dissatisfaction can be seen, to some extent, as a negative pressure on the process of decision-making.

However, radiographers in general are perceived as being very happy with the acquisition of the scanner. Related to this feeling is the perception by the decision-makers that the introduction of such technology in the Radiology Department implies the possibility of their professional development, as illustrated in the following quotes by DM11: *"Even because some learned to do MRI, so there was more of a possibility for them to evolve professionally"* (DM11 266); and *"Opens up other work prospects"* (DM11 268).

When it comes to being the final one to decide, it was interesting to see that most of the interviewees see themselves as an active decision-maker in the process; however the formal decision is not up to them, due to hierarchical issues, as illustrated by the following quotations:

> *The final decision-maker always ends up being the Department, which ends up signing. Because we make the technical report and they end up being the last to sign the technical report, although it still goes through the board of directors and goes through the purchasing service, but basically the decision that the board of directors or the purchasing service, or the financial services take, is whether to buy or not. There's never a hypothesis of, "No, this decision is wrong, another type of equipment is better!".* (DM3 244)

> *It is the board of directors that has to decide, but I do not know if it was the director of the purchasing management service, who communicated the decision to them. It is not the decision, the result.* (DM5 431)

> *It was a decision made with my help, but mainly by the administration. It is not the administration that says, "This is it!" But it's the administration that says it; it's based on the information that's been passed on, largely by me and the clinic director*. (DM8 8)

But the last decision-maker is the administration. (...) From a financial point of view only. (DM15 83)

This means that the decision process is conducted at the medium hierarchical level and communicated to the superior level to be formalized.

To characterize the decision, interviewees were asked to summarize the main steps that in their perception took place. In general, all decision-makers described the same steps, with some providing more details than others.

In some cases, in the private sector, there was only one decision-maker. For the majority, the process started with the assembly of a group of decision-makers, representing several areas of the Radiology Department or the Hospital/private practice:

DM14: The director of the service took part, I took part, the administrator took part....
Interviewer: From the area?
DM14: From the area, and the engineer took part.
Interviewer: The engineer that belongs to the Service of Installation and Equipment [SIE]?
DM14: From the SIE (DM14 203)

There were the three members of the board of directors (...). And it was delegated to the other members, which are the financial and the manager. Then it was the medical director and it was me. (DM15 87)

In some cases, there was disapproval of the members that constitute such committees, as DM15 mentions: *"He is an economist, he is an economist, and he is the marketing manager…they do not understand anything about health.* (DM15 101).

In the following step, a report is written, where all technical specifications that are wanted or wished for in the equipment are described, as well as the criteria for posterior assessment of the technology and its related ponderations. This applies to the public sector, as described by DM14:

An inventory was conducted on the needs for the equipment and all the criteria that had to be part of the bidding process, ok? So, from the point of view of quality, from the point of view of financing, from the point of view of the technical characteristics of the equipment, so this was something that we were always very careful about and was part of the requirements for the purchase of the equipment. (DM14 209)

And also to the private sector, as described by DM8: *"The general technical characteristics of the equipment have been stated."* (DM8 6).

More details on the criteria attribution was developed by some decision-makers:

> *We always made a weighting with the price, in this case it was worth 30%, the technical quality was worth 40%, with the various characteristics that we asked the companies to respond on. Then percentages, technical assistance after guarantee, mainly in terms of value, we also evaluate. In this case we evaluated only the value, but in some cases, we also evaluate components of quality of technical assistance and guarantee. And then the evaluation of these factors all gives a final score that will lead us to choose this equipment over the other.* (DM3 63)

> *(...) a percentage that was assigned to each of the fields, ok? I don't remember anymore; I can't remember precisely how it was. It was probably 40% for the equipment requirements, 20% for the quality requirements, 10% for the funding, there must have been something like that.* (DM14 229)

The writing of the specification report is usually a process undertaken in a group, as the quotations illustrate: *"In the script it is required to participate (Service Director)"* (DM4 59); and *"The specifications are the result of the opinions of various members of the technical service, the medical directorate, the installation and equipment service."* (DM4 61).

In the public sector, the following step is characterized differently from in the private sector, due to legal obligations, namely the necessity for a public tender: *"(...) because from 195 thousand Euros, if I'm not mistaken, but more or less, all competitions are mandatory by public tenders. Below that value, we can decide if it is public tender or if we only contact the firms we choose."* (DM3 81).

The call for tenders is not mandatory in the private sector: *"Only the public sector needs to open a contest. The private sector does not need to publish anything at all."* (DM13 226).

The call for tenders is mandatory, to be published in the Official Journal (Diário da República), as stated by DM14: *"Had to be opened in Diário da República"* (DM14 231). But before the call is submitted, a legal assessment is made, in order to make sure that all aspects are legally accounted for, as explained by DM3 and DM5: *"In order to ensure that everything is within the rules, with no complaints or errors in the legislation, it goes to the legal department."* (DM3 173); *"And then there was the participation of legal advisors, who are outside the hospital. They were hired by the hospital, so they are not part of the hospital."* (DM5 29).

In the private sector, decision-makers send the specification report directly to companies, who then send their offers, and sometimes make invitations to visit already established equipment, as reported by two of the interviewees:

> *As long as they have the indicators of what we want, they have different approaches: either they send a report; or instead of mentioning one type of equipment they mention three or four located nearby, so that a person can see a little more... "Oh, this one I did not know. Maybe..." and instead of one option they give several; sometimes they have a direct approach with the service, they come here and talk to us directly, "So, what do you* really *want?". "Well, don't you want this and that?" and that's it, to present things more in accordance with what we want.* (DM10 199)

> *In the market, there are four companies worth it, especially in heavy equipment. These are the four we have talked to. From there, considering a business plan, they made their presentations. We made a short list of these four, and selected two, so it would not be so complicated.* (DM11 108)

When contacting companies, decision-makers often negotiate with them: *"An equipment package was purchased ... and at the time the acquisition of the technology park was negotiated with 3 firms."* (DM8 5), according to their specific needs: *"In our specific case, was the negotiation of the maintenance conditions; both for this equipment and of the remaining technological park that we had"* (DM6 102). The cost of the equipment is also negotiated, as DM18 explains: *"XX proposed a piece of equipment for about 500,000... and I said... 'if I have something I can buy for minus 120,000...' and he said to me, 'Hey but I offer you an ultrasound', and I don't know what else and so on... and I... 'Wait a moment...'... I called the WW guys and said: 'My friends, XX offers me an ultrasound... and they said, they can also offer me...', and I... that's it... it's just a matter of negotiating!"* (DM18 11).

In the public sector, after the call for tenders is published, companies are able to submit their offers for appraisal by the committee: *"Applications are sealed and opened by the jury members. Afterwards they are evaluated."* (DM14 233). The assessment takes into consideration the ponderations attributed to each criteria of the specification report: *"The one who got the best ranking was the one who won."* (DM14 235).

Negotiations are very limited in the public sector, as described by DM3, due to the legal aspect of the tender:

> *It is part of the negotiation, many times the private ones end up having much more power of negotiation with the firms, that is, they have two proposals and they end up being able to negotiate with this and with another one, and they try to lower the price, to have better conditions, to have other characteristics of offer of the equipment. We end up being much more restricted to what we initially asked for, what the firms respond to, and after that there is very little negotiating power.* (DM3 295) *(...) "The private sector has much more bargaining power than we do."* (DM3 297)

An overview of the different steps is presented by some decision-makers:

> *All is done by a central management department: - gathering of all equipment characteristics; - contact with firms requesting proposals based on previous info; - firms send proposals; - comparison of tenders - technical characteristics; - analysis of group synergies - what are the advantages of certain equipment within the group; - counter-proposals - e.g. maintenance contract values; - choice – decision.* (DM16 6)

> *Establishment of the demand and difficulty in meeting demand; Direct contact with company A for the supply of technology (there was no contact with any other company); Sending suggestions from the technology team; Comparison of what is proposed by the firm with technological characteristics identified as being the desired ones; choice of technology.* (DM17 7)

> *Administration, and the clinic director, and the coordinating CA (3 partners); choice of open technology (0.35T) for the difference in cost of acquisition and maintenance; market research with a visit to Congress on the specific technology (by the Radiographer Coordinator). Three firms contacted: AA, BB and CC.; Negotiation between firms; Choice of the firm that offered the best conditions.* (DM18 5)

As in the public sector, the process is well defined in terms of its steps.

In the course of the interviews, several decision-makers made references to transparency in the decision-process. In the public sector, since all information is published in a call for tenders, the process is considered to be transparent, as described by DM5:

> *Better this way: The result of the contest was this! and that was it, and that followed the legal procedures there, everything is written in Diário da República. There is one thing, at this moment nobody can play in service, for the acquisition, there is strict legislation, to follow. Therefore, we are not inventing. That's all written down, you have to be aware of it.* (DM5 433)

However, this transparency is not so clear when comments from other decision-makers are analysed:

> *One of the things we did, when we made the equipment purchase was always, to discuss. How much money we had for financing and then what we could put into that financing package, and how we could manage that with the individuals in the company. And often, it was in these Board discussions, in the Area Board discussions, with a more strategic discussion that they got packages... and that they were able to put some extra things there. Software, or some other...*
> *(Interviewer: Or other equipment?)*
> *Or other equipment, that's how we got it.* (DM14 223)

XX did not give any CT scan on the purchase of the resonance; and other things like that. While WW and AA were eager to do so. TT allowed me to pay for the device for seven years and still put the computers in here and I don't know what else! And I told them, "But I don't want computers and I don't want to pay in seven years! I want the best MRI device!" Do you understand? If I had been buying for a hospital, I probably would have been flexible to all these things. With the difficulties of equipping the service, eventually even with a Mercedes on the outside, I would have solved the problem differently, you know?! It has nothing to do with buying for a private individual or buying for... Here, it's me saving from my own pocket. I'm the one who's paying so I have to be very sensible: if I want to buy an MRI, I don't want to buy an MRI and a CT scan; as there are no free lunches, I can't believe that XX gives me a free CT scan if I buy an MRI - it doesn't give me anything! I'm paying for both obviously! Is it or isn't it?! So, I have to think. Probably what they wanted was for me to replace the CT with a Porsche. Do you understand my idea? (DM7 106)

Just see who the people are and where they are... and what equipment is in other places... and here in Portugal it's more complicated... and it's not only here in Portugal... even because many of the companies don't even need to worry about who are the decision makers of the departments... in radiology...(...) this is a very complex world... (...) you see business of 6 and 8 million... that's why after radiographers... many radiographers... radiographers and radiologists... it's not just the radiographers... they're travelling... they go here, they go there, they go everywhere... there's no free lunches! (DM 38 26)

The private sector is independent and autonomous when it comes to the purchase of medical devices. The process is mainly undertaken by means of negotiations, which are not always transparent, as illustrated by the following quotations:

First there is a phase that is, our financial capacity allows that budget. Then within that budget, what are the possible options? Within those possible options, what are the cost variables? And in these cost variables, we're going to consider the price of the equipment, we're going to consider the maintenance price and we're also going to consider what are the cherries in the cake, which we say to have fun with: in terms of negotiation what can we take away to potentiate that space, without spending more money, ok? In this case, what we wanted there, that we got, was an ultrasound, in quotes, for free, since nobody gives anything for free. I mean, when the resonance gives a free ultrasound, it's putting it in the price of the resonance. Those things are always like that, anyone who doesn't believe this is naive. You try to maximise that, because if you don't force it, they won't give. (DM11 102)

The equipment for nuclear medicine for Hospital Y was being negotiated at the same time, and therefore it was a sum, in which what was "sold" by the firm was that this resonance would *come out almost for free. Which is a lie. A complete lie, and we knew it: that was a lie. It probably didn't even get cheaper than the other one. But for the administration... That's what they told us. Faced with this scenario...* (DM9 167)

In an overall assessment of the decision-making process, a comment and criticism that emerged during the interviews is related to the time frame in which the decision took place. Some of the interviewees mentioned that the process was far too long, as the next quotations illustrate:

It was a long process that lasted 2 years. (DM43 10)

I have to buy an MRI for Hospital X, for example, a heavy thing. Choice committee, come doctors, come technicians, come financiers, come area managers, come all these people. Everyone has their own ideas, don't they? We debate, we debate, we debate! We spend, this has a cost, this whole process has a cost, which if we were to count it is brutal! And then, normally, the decision is motivated so that we can negotiate the best, why all this? So that we can negotiate as well as possible. (DM12 424) (...) That drags on, a process, a very complicated thing, which has a process cost that is later more expensive than the financial effort. (DM12 430) (...) Well, the salesmen themselves are the first to say, "Man, they ask me for a 20,000-euro discount on that mammography device or that TAC, but then they lose years of discussion to decide." And we (taxpayers) pay. (DM12 432) (...) In the private sector it's like this: well, is it black or yellow?", "Yellow!", "How much will it be?", "Half a dozen." It's a quick fix. And sometimes, this is not the case, but I can tell you that there are private places where you don't even consult. (DM12 434)

Some found the process to be very calm:

We decided to order the resonance, we had no patients scheduled, there were not even conventions [reimbursements] for the resonance, it was a very calm and serene situation. It was like this. The work was carried out calmly, the equipment was assembled, everything was very calm. (DM12 293)

Others showed some disappointment with the decision or with the process itself, as illustrated with the following citations:

In order to be able to negotiate prices, in order to win a few thousand... we awarded everything to the same company... and the one with the lowest value in the top-of-the-range equipment and work (constructions). So, as you can imagine, we won some, we lost others... but it was the package... and once it's a package... the acquisition gets a little distorted from what we wanted... (DM43 8)

> *It was political... (the decision) There were some choice processes here that did not really follow... the normal procedures due to parallel politics...* (DM43 11)

> *(...) things are not always bought for the usefulness of the equipment... for what the equipment can best serve... for a certain profile of hospital need... (...) because there were interests from other businesses (...) and MRI equipment sounds like stones in some people's shoes... MRI has gaps, because I couldn't buy all the software, because then there are updates... the price goes up... but there's no money... [the decision] has nothing to do... with the quality of what you want... or the profile for what you want predominantly...* (DM43 13)

> *... one thing is what is in contest... then when they win, they deliver another...* (DM19 25)

But others were very happy with the decision:

> *MRI is a very expensive investment. The clinic had never had resonance, and for us it was very important... and at the time we considered this a risk, but it was an absolute success.* (DM18 18)

When decision-makers were asked if they would have changed anything, if they were able to go back in time and take the decision again, several comments are worth quoting:

> *That's why I'm saying that these things are never usually a bed of roses, even when we think we've been to the max, we've got the max in everything… Later, we find out that maybe that excellent business was not that good, because the margins that these companies deal with (I don't know if they still do) are gigantic and therefore everything is very relative. So, if you ask me, "Are you completely satisfied with what you've done?", I am, I've done the best I could. Was it impossible to do better? From what I know now, after I don't know how many years, no. I could have done better.* (DM11 274)

> *I would have simplified the structure of the technical information of MRI.* (DM16 21)

> *I tell you very honestly: if it were today, I would not have put the resonance. We're taking a loss...ok, it's paid for, all right, but... (...) We have to do the math. Regardless of whether we are health professionals... this is a trade! And this works the way a restaurant works! If users don't come here, we are certainly screwed. There's no turning back!* (DM18 13)

This chapter presents results from both a questionnaire and semi-structured interviews. The strategy adopted in the present research follows a mixed methods approach, with the rationale to combine elements of quantitative and qualitative research. The rationale behind this is the possibility to deepen the understanding and corroboration of the collected data, since the use of only one method could be insufficient to provide a good understanding of the decision-making characterization. As seen by the results, although quantitative data provides an opportunity for generalization and precision, qualitative interviews offer an in-depth experience of individual perspectives, with diverse points of view. The results will be merged and discussed in the next chapter.

5. COMPETENCES IN DECISION-MAKING: MODEL TESTING USING SEM

"Nothing is good enough unless is optimal"
- Herbert A. Simon

The aim of this chapter is to assess the proposed competency model among professionals in the Radiology Department, following the steps already identified in the previous chapter (Figure 3-3, in Methodology). The several taken research steps are described in the following sub-chapters.

5.1. Theory and Model Construction

Demands and constraints in health system makes this field very challenging for decision-makers. Not only they need to master and update their knowledge on technology, they also need to make sense of the vast evidence-based information available in the sector. In order to ensure a good decision-making outcome when it comes to technology purchase, not only decision-makers need to consider the previous mentioned factors, but they should also balance society collective challenges and patient demands. In such context, decision-makers need to master more than certain defined managerial skills.

In order to establish a competency referral, according to Boterf (2008) it is necessary to start with the compilation of the different knowledges. In the literature review (see Chapter 2) it is possible to find empirical evidences that, on the one hand competences can influence decision-making, thus the health organization performance, and on the other hand, personal characteristics (intrinsic to each individual) of the DMs can also affect the decision process. Therefore, several variables are related to competences in decision-making.

"Competence" is a latent variable[18] since it cannot be measure or observed directly, meaning that it is an explanatory variable presumed to reflect a continuum that is not directly observable (Kline 2011b, 9) but can only be defined by a set of other variables, such as the different knowledges, that measure something in common (designated as component variables). Since these component variables, can be observed and measured (Hill and Hill 2002) they are also designated by manifest variables (Blunch 2013) or independent variables. Competencies are therefore operationalized at the "Knowledge" levels. The different knowledges can be described as: knowledge per se, how to do, how to be and how to learn, which correspond respectively to the skills acquired in training, the skills acquired in the performance of the profession, attitudes that the professional assume in his daily life and cognitive

[18] Variables can also be designated as unmeasured variables, factors, unobserved variables, constructs, or true scores (Bollen 2002).

abilities that allow to learn, reason and process information. A possible relationship between the different "knowledge" and how they can lead to competences is schematized and represented in Figure 2-5. The relation between the different knowledges is only a *possible* one, since it was not assessed. Due to the lack of certainty between the connections, it is necessary to measure their strengths in a numerical form. This can be achieved using, a statistical technique used to establish whether there is a tendency for groups to be inter-related, when a large number of variables is considered (Bryman 2012). Having in mind that decision-making can be influenced by the competences held by the DM and by the competences influenced by the knowledge she/he acquires, the hypothesis needs to be tested:

> *In the decision-making process, the different knowledges have an equal influence on the decision-maker competences.*

5.2. Instrument construction

From the literature analysis and considering the specificities of a Radiology Department, a general list of competences was elaborated (Appendix 5-1) and several indicators (Appendix 5-2) listed having as a referral a) for the set of theoretical knowledge it was considered the knowledges necessary to develop work in the Radiology Department and the competence profiled established for each profession (based on previous work developed by Maia 2011 and Maia and Moniz 2011), and b) for the other three sets of knowledges (How to do, How to be and How to learn) literature review was made regarding these knowledges in general decision-making. The group of the four sets of indicators is designated “component variables” (Hill and Hill 2002).

The first part of the questionnaire refers to a brief socio-demographic characterization of the respondent. The second part of the questionnaires was used to operationalize the variable “Competences in decision-making”. A set of 29 items referring to four different knowledges were divided and aggregated according to the type of knowledge they refer to, as follows: Knowledge – questions 1 to 7; How to do – questions 8 to 14; How to be – questions 15 to 21 and How to learn – questions 22 to 29 (Appendix 4-2). All items were presented in a closed format, were respondents were asked to indicate the extent of their agreement with a statement, by means of a Likert scale, ranged from “Do not agree / does not apply” (1) to “Fully agree” (5).

To assess the adequacy of the questions and comprehensibility of the questionnaire to measure the latent variable “competence”, a pre-test was performed (Leeuw 2008). The questionnaire was distributed in person, in one Radiology Department, to the four potential decision makers. The analysis of the results and the feedback given by the respondents was used to improve the questionnaire.

The assessment of the questionnaire in terms of reliability to measure the latent variable considers two aspects: item analysis and internal consistency. The item analysis is composed by two parts: the calculation of correlation Inter-Item and the calculation of correlation Item-Total and the internal consistency that refers to the Cronbach's α assessment (Hill and Hill 2002). The analysis was performed using IBM® SPSS software version 21, a package of programs widely used in the social and behavioural sciences (Landau and Everitt 2004) for analysing and presenting data.

The Inter-Item correlation relates to the correlations between each item and each of the other items. It is assumed that each item measures something that it has in common with the other items and, what is measured, in common with these items, is indeed the latent variable that we want to measure. These correlations should be strong (0,4 – 0,7) and the obtained values significantly positive (Hill and Hill 2002). Table 5-1 presents the correlation between the 29 components of competences. All correlations are positive, however, not all cases present a value between 0,4 and 0,7. Some present a low value, meaning that most probably they are not correlated between them, such is the case of Item "Conducting activities autonomously".

Table 5-1 Inter-Item Correlation Statistics

Inter-Item Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Medical Science	1.000													
2. Physics	.752	1.000												
3. Radiobiology and Radiation Protection	.641	.789	1.000											
4. Electronics and Clinical Instrumentation	.565	.707	.756	1.000										
5. Management and Administration	.373	.415	.398	.493	1.000									
6. Communication and Behavioural Sciences	.438	.376	.447	.456	.538	1.000								
7. Informatics	.449	.397	.416	.456	.481	.550	1.000							
8. Exams protocols	.649	.669	.568	.533	.362	.364	.423	1.000						
9. Internal quality assessment measures	.201	.200	.219	.251	.421	.291	.260	.368	1.000					
10. Projects and activities execution	.257	.249	.214	.265	.407	.294	.262	.425	.749	1.000				
11. Rationalization measures	.258	.240	.271	.310	.375	.360	.207	.362	.651	.650	1.000			
12. Take measures in useful time	.334	.264	.342	.347	.355	.400	.372	.413	.421	.449	.557	1.000		
13. Innovative solutions proposal	.316	.289	.236	.289	.464	.317	.292	.457	.599	.654	.650	.468	1.000	
14. Information critical analysis	.337	.288	.409	.377	.267	.373	.380	.389	.285	.246	.416	.558	.312	1.000
15. Principles of Ethical Conduct	.324	.343	.375	.323	.217	.246	.329	.397	.127	.130	.198	.373	.112	.487
16. Auto confidence and determination	.341	.338	.361	.341	.254	.288	.343	.395	.269	.228	.286	.354	.240	.503
17. Open communication	.231	.190	.262	.234	.189	.323	.295	.312	.202	.162	.279	.327	.223	.481
18. Conducting activities autonomously	.142	.131	.141	.140	.149	.157	.167	.147	.113	.126	.140	.166	.121	.200
19. Initiative for problem resolution	.264	.213	.294	.228	.254	.286	.331	.361	.275	.237	.365	.468	.291	.500
20. Resolution of problems with creativity	.261	.214	.228	.267	.269	.290	.347	.292	.266	.239	.304	.328	.338	.398
21. Organization task ahead	.104	.101	.167	.150	.186	.252	.215	.183	.238	.191	.318	.331	.304	.418
22. To be listened to and taken into account	.227	.231	.250	.250	.178	.206	.213	.292	.192	.198	.260	.231	.198	.324
23. Potential implication of problem resolution	.321	.335	.312	.310	.317	.252	.283	.350	.322	.338	.374	.408	.389	.390
24. Responsibility for decision	.223	.208	.261	.225	.124	.189	.191	.325	.105	.121	.226	.347	.100	.469
25. Availability for research projects	.226	.247	.263	.293	.326	.179	.287	.288	.282	.372	.267	.330	.286	.367
26. Adherence to innovations and technology	.346	.302	.339	.346	.316	.302	.365	.400	.135	.224	.213	.402	.229	.423
27. Integration in team works	.155	.163	.253	.252	.223	.213	.232	.245	.149	.183	.253	.386	.166	.409
28. Share information and knowledge	.207	.189	.257	.240	.226	.213	.189	.288	.089	.076	.204	.378	.132	.508
29. Use of equipment with knowledge	.286	.260	.330	.323	.207	.210	.271	.352	.096	.088	.218	.373	.163	.487

	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
15. Principles of Ethical Conduct	1.000														
16. Auto confidence and determination	.604	1.000													
17. Open communication	.604	.523	1.000												
18. Conducting activities autonomously	.190	.207	.214	1.000											
19. Initiative for problem resolution	.551	.523	.499	.245	1.000										
20. Resolution of problems with creativity	.354	.520	.397	.225	.626	1.000									
21. Organization task ahead	.309	.288	.383	.187	.522	.455	1.000								
22. To be listened to and taken into account	.289	.349	.364	.178	.393	.392	.340	1.000							
23. Potential implication of problem resolution	.376	.393	.440	.185	.434	.382	.444	.480	1.000						
24. Responsibility for decision	.571	.444	.520	.214	.596	.481	.489	.373	.434	1.000					
25. Availability for research projects	.304	.304	.248	.150	.329	.351	.271	.318	.360	.351	1.000				
26. Adherence to innovations and technology	.465	.391	.386	.184	.442	.362	.330	.361	.396	.493	.561	1.000			
27. Integration in team works	.413	.390	.437	.167	.445	.305	.346	.330	.381	.504	.414	.525	1.000		
28. Share information and knowledge	.542	.460	.519	.188	.502	.399	.443	.386	.394	.676	.430	.596	.652	1.000	
29. Use of equipment with knowledge	.475	.422	.421	.203	.501	.407	.388	.333	.372	.595	.365	.623	.477	.663	1.000

The Correlation Item-Total, corresponds to the correlations between the values attributed to each item and the total score for the total of items (Field 2018, 826). It is assumed that each item contributes for the formation of concordance to be measured. Statistically, a strong correlation exists if the result is in the range of 0,4 – 0,7 between each item and the total. In a reliable scale, all items should correlate with the total. If any of these items present a value inferior to 0.3, it means that they don't correlate with the overall score from the scale, meaning that they should not be considered for the further result analysis (ibid.). Results from the Correlation Item-Total are presented in Table 5-2, were it can be verified that only one item does not have a strong correlation: the variable "conducting activities autonomously" (0,283). By analysing results from both correlations (Item-Total and Item-Item), it is seen that the item variable "conducting activities autonomously" does not present a significant or relatively high correlation. Thus, the item does not contribute sufficiently to define the latent variable to be measured, and therefore was removed from the questionnaire.

The instrument will only be suitable for its purpose, if it proves to be *reliable* and *valid*. Reliability relates to the degree to which a measure of a concept is stable and validity concerns the degree to which a measure of a concept truly reflects that concept (Bryman 2012). In order to be *reliable*, the questionnaire as to provide nearly the same results when repeated the measurements under similar conditions. To be *valid*, it should measure exactly what is intended to measure and nothing else.

Table 5-2 Item-Total Correlation Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Medical Science	104.45	276.973	.570	.644	.913
Physics	104.43	275.128	.565	.786	.913
Radiobiology and Radiation Protection	104.00	276.826	.602	.735	.912
Electronics and Clinical Instrumentation	104.34	275.272	.598	.662	.912
Management and Administration	104.74	280.311	.544	.515	.913
Communication and Behavioural Sciences	104.40	282.965	.537	.509	.914
Informatics	104.26	281.956	.544	.483	.913
Exams protocols	104.33	271.273	.650	.631	.911
Internal quality assessment measures	104.87	279.189	.482	.646	.914
Projects and activities execution	104.98	278.346	.505	.692	.914
Rationalization measures	104.57	277.047	.562	.638	.913
Take measures in useful time	103.94	280.026	.626	.533	.912
Innovative solutions proposal	104.79	278.589	.536	.627	.913
Information critical analysis	103.92	281.269	.641	.543	.912
Principles of Ethical Conduct	103.44	284.465	.570	.607	.913
Auto confidence and determination	103.87	283.691	.600	.536	.913
Open communication	103.70	285.435	.548	.528	.914
Conducting activities autonomously	103.45	268.368	.272	.094	.933
Initiative for problem resolution	103.73	283.719	.630	.626	.913
Resolution of problems with creativity	103.98	285.177	.561	.541	.914
Organization task ahead	103.81	285.700	.470	.443	.914
To be listened to and taken into account	104.09	287.562	.469	.344	.915
Potential implication of problem resolution	104.07	283.668	.597	.471	.913
Responsibility for decision	103.47	285.394	.550	.631	.914
Availability for research projects	104.15	280.783	.511	.449	.914
Adherence to innovations and technology	103.78	281.102	.602	.598	.913
Integration in team works	103.74	284.150	.509	.506	.914
Share information and knowledge	103.44	286.051	.559	.698	.914
Use of equipment with knowledge	103.55	285.125	.562	.581	.914

If the questionnaire only measures one latent variable, then we can say it is unidimensional. The internal consistency is typically a measure based on the correlations between different items on the same test. It measures whether several items that propose to measure the same general construct produce similar scores. The internal consistency is typically a measure based on the correlations between different items on the same test, meaning that several items that propose to measure the same general construct should produce similar scores (Hill and Hill 2002). The internal consistency was measured using Cronbach's

Alpha, which is a measure of the intercorrelation of items. If the result is greater than or equal to 0.8[19], then the items are considered unidimensional for confirmatory purposes (Garson 2012). If the internal consistency is low, then the content of the items may be so heterogeneous that probably, the total score may not be the best possible unit of analysis for the measure (Kline 2011b, 69). Results show that the questionnaire presents an excellent reliability (Table 5-3).

Table 5-3 Reliability statistics - Cronbach Alpha results

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.932	.936	28

In the final version, the questionnaire is composed by 28 items, distributed by the component variables as follows: Knowledge – 7 items, How to do - 7 items, How to be – 6 items and How to learn – 8 items. The identification and characterization of the variables can be seen in Appendix 4-2. The final layout of the questionnaire can be seen in Appendix 5-3 (Questionnaire B – Competences in Decision-Making).

5.3. Data Collection

The questionnaire was applied during the period from June 2012 to June 2014. Geographically the questionnaires were distributed all over Portugal and in the public and private sector. In total, 399 questionnaires were collected.

To run a FA, the sample size should be carefully considered. According to the literature, there are many ways to test the sample size. For instance, in order to measure the latent variable, for Hill and Hill (2002) the questionnaire must be applied at least to a sample of 100 individuals. For Verma (2013) the number of subjects should be the larger of 5 times the number of variables. Considering that the questionnaire has 28 main variables, according to Verma's rule of thumb one should collect at least 140 (28x5) questionnaires. According to Kline (2011b, 12), a "typical" sample size in studies where FA is used is about 200 cases. For the analysis, the variables that will be analysed under FA should not present any missing value. Hence, 30 questionnaires were not considered valid. The final dataset has a total of 369 entries, which is still a sample number above average, needed for FA.

In terms of the socio-demographic characterization of the respondents (graphical representation can be seen in Appendix 5-4), the majority of the respondents were Radiographers (n=230, 62%) and

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[19] Some researchers use the less stringent cut-off of 0.7, while others (Garson 2012) consider the $0.7 <= \alpha < 0.8$ range to be suitable for exploratory purposes only.

Operational Assistant (n=63, 17%) followed by Radiologist (n=37, 10%) and Technical Assistance (n=33, 9%). 6 did not provide an answer concerning their professional category. Most of the respondents work in the public sector (n=211, 57%) followed by the private sector (n=158, 43%). The average of ages is 36 years, and there is a prevalence of female's respondents (n=233, 63%). In terms of academic qualification, the majority holds a graduation (n=230, 62%), followed by the 12nd Year of school (n=54, 4,6%) and a master's degree (n=25, 5,8%). Most respondents have less than 5 years' experience working in Radiology (n= 121, 32,8%), followed by 6 to 10 years' experience (n=77, 20,9%) and between 16 to 20 years' experience (n=52, 14,1%).

5.4. Model Testing

As seen previously, Figure 2-5 represents the relation between the different knowledges that lead to the acquisition of competences for decision-making. The proposed model needs to be investigated in terms of the relationship among the group of variables, in order to segregate them in different factors on the basis of their relationship (Verma 2013). This can be accomplished using FA, by reducing many variables into few underlying factors to explain the variability of the group characteristics. By potentially diminish variables numbers, the remaining will be correlated to each other (factor [20]) which will maximize the explanations of the set of all variables and therefore will allow the possibility to identify subgroups of questions to assess the variables, with a minimum loss of information. A factor can be understood as a sort of super-variable with its commonness expressed by the group of variables having high inter-correlations but low correlations with any other group (Burns and Burns 2008).

In order to make sure that data is suitable to be submitted to FA, some statistical test were performed in advance, using IBM SPSS® software (v.21). Their description is as follows:

A) Measure of sample adequacy

A reasonable sample size is one of the assumptions and requirements inputs for FA. The adequacy of the sample was assessed using two statistical measures generated by SPSS: the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy (Kaiser 1970; Kaiser 1974) and Bartlett's test of sphericity (Bartlett 1954). KMO is the mostly used method among researchers (Verma 2013). It varies between 0 (which indicates that the sum of partial correlations is large relative to the sum of correlations, indicating diffusion in the pattern of correlations (i.e. factor analysis is likely to be inappropriate)) and 1 (which indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct

[20] Some authors also refer to *factor* as *dimension* or *construct.*

and reliable factors) (Field 2018; Verma 2013). Table 5-4 presents the value for KMO measure, which shows a superb value[21] (0.942), meaning that the sample is adequate for running FA.

Table 5-4 KMO and Bartlett's Test

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.924
Bartlett's Test of Sphericity	Approx. Chi-Square	6251.813
	df	378
	Sig.	0.000

Bartlett's test of sphericity is a statistical test to assess the presence of correlations among the variables. It provides the statistical significance that the correlation matrix has significant correlation among at least some of the variables (Hair et al. 2019, 136). This test will be analysed in more detailed when accessing homoscedasticity. A statistically significant Bartlett's test of Sphericity (sig. < 0.05) indicates that enough correlations exists among the variables to proceed. The obtained result is significant, since it presents a value inferior to 0.05 (Table 5-4).

B) *Normality, linearity and homoscedasticity tests*

The analysis results retrieved from SPSS can be found in more detailed in Appendix 5-5.

Normality: The null hypothesis considers that the "sample distribution is normal", meaning that the sample values come from a population characterized by a normal distribution, and therefore there is no difference between observed values and expected normally distributed values. The Shapiro-Wilk test for normality showed that all variables presented a level of significance lower than the reference (0.05)[22], meaning that the data is not normally distributed, due to a lack of symmetry (negative skewness) of the data distribution. The null hypothesis for the normality test was therefore rejected.

The severity of non-normality is based on two dimensions: the shape of the offending distribution (kurtosis or/and skewness) and the sample size. Since the sample size is big (more than 200) the violation of the normality assumption should not cause major problems (Pallant 2005) and departures from normality may be negligible (Hair et al. 2019, 95; Field 2018). This means that parametric procedures can be used when the data is not normally distributed (Elliott and Woodward 2007). The

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[21] In terms of result, KMO should be greater than 0.5 for a satisfactory factor analysis to be proceeded (Burns and Burns 2008) and if the result present a value between 0.5 and 0.7 then it is mediocre. Values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are great and values above 0.9 are superb, concerning adequacy (Field 2018; Verma 2013).

[22] The highest probability generally accepted for statistics significance is ρ=0.05, meaning that the result would occur 5 times in 100, by chance. For this reason it is called the 5% level of significance or alpha level (α) (Burns and Burns 2008).

assessed distribution is affected by a kurtosis, in terms of shape and since the sample size is bigger than 200, the non-normality is not and impediment to continue the analysis.

Linearity: Linearity test aims to determine the relationship between independent variables and the dependent variable is linear or not (there should be a linear relationship between the free variable and dependent variable). ANOVA test was performed, and results showed a Sig value for deviation from linearity of 0.00, meaning that the relationship between these variables is linear.

Homoscedasticity: The assumption of homogeneity of variance assumes that all groups have the same or similar variance. Levene's test was used to assess if the variance of the population from which different samples are drawn, is equal. If the resulting *p*-value is less than the significance level (0.05), then the obtained differences in sample variances are unlikely to have occurred based on random sampling from a population with equal variances. Levene's *F* test was performed in order to understand if the dependent variables shows a similar level of (homogeneity) regarding the independent variable "professional category". The null hypostasis (H0: population variances are equal) is therefore rejected and one can conclude that there is a difference between the variances in the population. According to the further results, the null hypothesis is rejected for most of the dependent variables, but it is not for 5 variables, namely "rationalization measures", "open communication", "resolution of problems with creativity", "organization tasks ahead" and "integration in teamwork". Due to these results, Bartlett's test was also performed, since this test gives a more general overview and it is considered more accurate, then the Leven's test, in the face of non-normality (Garson 2012). Bartlett's test of sphericity tests the null hypothesis: H0 – the correlation matrix is an identity matrix. The result can tell us how significantly different our correlation matrix is from an identity matrix. Thus, it is desirable that the correlation between variables significantly differs from zero. However, it is not desirable if this correlation is too high. Results showed that Bartlett's test of sphericity is significant (less than 0.05) which means that the correlation matrix is not an identity matrix and therefore FA can be used (Verma 2013).

C) *Multicollinearity test*

Multicollinearity[23] refers to a situation in which two or more explanatory variables in a multiple regression model are highly linearly related. The independent variables should be independent from each other, meaning that there should be no linear relationship between these variables (null hypothesis). The variance inflation factor (VIF) was chosen to test multicollinearity.

[23] According to Hair et al. (2019), multicollinearity refers to the extent to which a variable can be explained by the other variables in the analysis, meaning that it represents the degree to which any variable's effect can be predicted or accounted for by the other variables. As it increases, the ability to define any variable's effect is diminished.

Several thresholders have been used as rules of tum to assess multicollinearity (O'Brien 2007). The thresholder of 10 was considered (Kutner et al. 2005), meaning that a VIF above 10 indicates the existence of multicollinearity. Results showed that the higher VIF value is 1.39 (H0 is accepted), meaning that the degree of correlation between these variables is very low, which is indeed a good result since some degree of multicollinearity is desirable, because the objective is to identify inter-correlated sets of variables, according to Hair et al. (2019).

D) Bivariate correlation

Bivariate correlation measures the relationship between two variables. It measures the strength of their relationship, which can range from absolute value 1 to 0. The stronger the relationship, the closer the value is to 1. The relationship can be positive or negative; in positive relationship, as one value increases, another value increase with it. In the negative relationship, as one value increases, the other one decreases (Field 2018).

According to Hair et al. (2019), the verification of the correlation between the variables is important for subsequent statistical analyzes, since, if all correlations are small (less than 0.30), equal (showing that there is no structure to group variables), or very high (greater than 0.80), subsequent statistical analyzes are inappropriate, such as FA for instance or even the modeling of structural equations. From the analysis of Pearson correlation, it is possible to observe that this is not the case, since most values are in between 0.3 and 0.8, thus the analysis can proceed.

E) Construct Validity

Since the questionnaire measures only one latent variable, the scale is unidimensional, and therefore it is necessary to map the dimensionality of the data set and calculate the item weights, which can be achieve with the used of EFA.

One could have also considered to apply principal components analysis in which a set of manifest variables (items) are transformed into new and fewer uncorrelated variables (principal components). But, in fact, this is not the aim. The aim is exactly the opposite, meaning that instead of the "new" variable being functions of the original manifest variables, they are considered to be indicators of underlying dimensions designated as "factors" (Blunch 2013, 51). In other words, the aim is to explain the correlations in the data set as a result of a few underlying factors and not to summarize several correlating variables in a few new variables.

In order to determine the number of factors that best describes the underlying relationship among variables, two conflicts need to be balanced: the need to find a simple solution with the fewer factors as possible; and the need to explain as much of the variance in the original data set as possible. There are different techniques that can be used to assist in the decision concerning the number of factors to retain, and according to Costello and Osborne (2005) information on the strength and weaknesses of these techniques are scarce. Common Factor Analysis and Principal Component Analysis (PCA) are two methods usually used in FA. Common FA tries to explain the covariance's or correlations of the observed variables by means of a few common factors and PCA is primarily concerned with explaining the variance of the observed variables (Everitt and Hothorn 2011). According to Hair et al. (2019, 140), the primary objective of Common FA is to identify the latent dimensions or constructs represented in the original variables. Another aspect to consider relies in the fact that in Common FA, the common variance between variables is considered and in PCA it is considered the total variance for the factor extraction. For this reason, PCA was the chosen method.

The first step is to assess communalities. In order to understand the concept of communality, it is necessary to understand first the concepts of communi-variance and specific variance (or unique). The total variance of a variable will have two components, when compared with the other variables: the common variance and the specific variance (which is unique for that variable). The unknown or aleatory variance is also specific of the variable. Communality is the proportion of common variance present in the variable. In case a variable presents low communalities, it should be eliminated (Hair et al. 2019, 137).

According to Burns and Burns (2008), PCA is used when the researcher wants to discover the nature of the constructs or factors influencing a set of responses and reduce the data set to a small number of factors. In the literature, the criteria to determine the number of factors to extract is it's not unanimous, therefore, due to the high subjectivity related to the extraction methods, both the eigenvalue and the scree plot were used as methods to choose the number of factors to retain.

The table of communalities shows how much of the variance in each variable has been accounted for by the extracted factors (ibid.). Analysing the first obtained table of communalities (see Appendix 5-6), one can see that the majority of the factors present a value higher than 0.50 which represent satisfactory quality of the measurement, since low communalities are not interpreted as evidence that the data fail to fit the hypothesis, but merely as evidence that other as yet unknown factors underlie the variation in that variable (ibid.). This means that variables with communalities less than 0.50 do not provide sufficient explanation (Hair et al. 2019). For this reason, 3 variables were extracted from further analysis[24]. When factors are extracted, new communalities can be calculated, which will represent the multiple correlations between each variable and the extracted factor. A new communality values were obtained as shown in Table 5-5, showing all factors with values higher than 0.50.

[24] "Organization tasks ahead", "To be listen and taken into account" and "Potential implication of problem resolution".

Table 5-5 Communalities after items extraction

Communalities	Initial	Extraction
Medical Science	1.000	.716
Physics	1.000	.871
Radiobiology and Radiation Protection	1.000	.777
Electronics and Clinical Instrumentation	1.000	.704
Management and Administration	1.000	.670
Communication and Behavioural Sciences	1.000	.720
Information Systems	1.000	.692
Exams protocols	1.000	.698
Internal quality assessment measures	1.000	.747
Projects and activities execution	1.000	.790
Rationalization measures	1.000	.727
Take measures in useful time	1.000	.529
Innovative solutions proposal	1.000	.693
Information critical analysis	1.000	.538
Principles of Ethical Conduct	1.000	.651
Auto confidence and determination	1.000	.611
Open communication	1.000	.600
Initiative for problem resolution	1.000	.667
Resolution of problems with creativity	1.000	.511
Responsibility for decision	1.000	.683
Availability for research projects	1.000	.624
Adherence to innovations and technology	1.000	.723
Integration in team works	1.000	.596
Share information and knowledge	1.000	.759
Use of equipment with knowledge	1.000	.636

Extraction Method: Principal Component Analysis.

The screen test produces a scree plot that represents the eigenvalues, and which supports the choice for the number of factorial axes to be selected. Eigenvalues measure the amount of variation in the total sample accounted for by each factor. The scree plot, suggested by Cattell (1966), is a graphical representation of the factors plotted along X-axis against their eigenvalues, on the Y-axis. The elbow curve[25] is a point of reference for the Cattell's scree plot. It indicates the point to drop all further components after the one starting the elbow (Verma 2013), as starting from this point the additional factors explain less variance than a single variance, i.e., these factors are factorial scree and therefore with no contribution for the analysis (Burns and Burns 2008). From the analysis of the scree plot (Figure 5-1), one can see a distinguished break up to the fifth factor, whereas after this factor an almost linear part of the eigenvalue curve follows.

[25] The point at which the curve of decreasing eigenvalues changes from a steep line to a flat gradual slope.

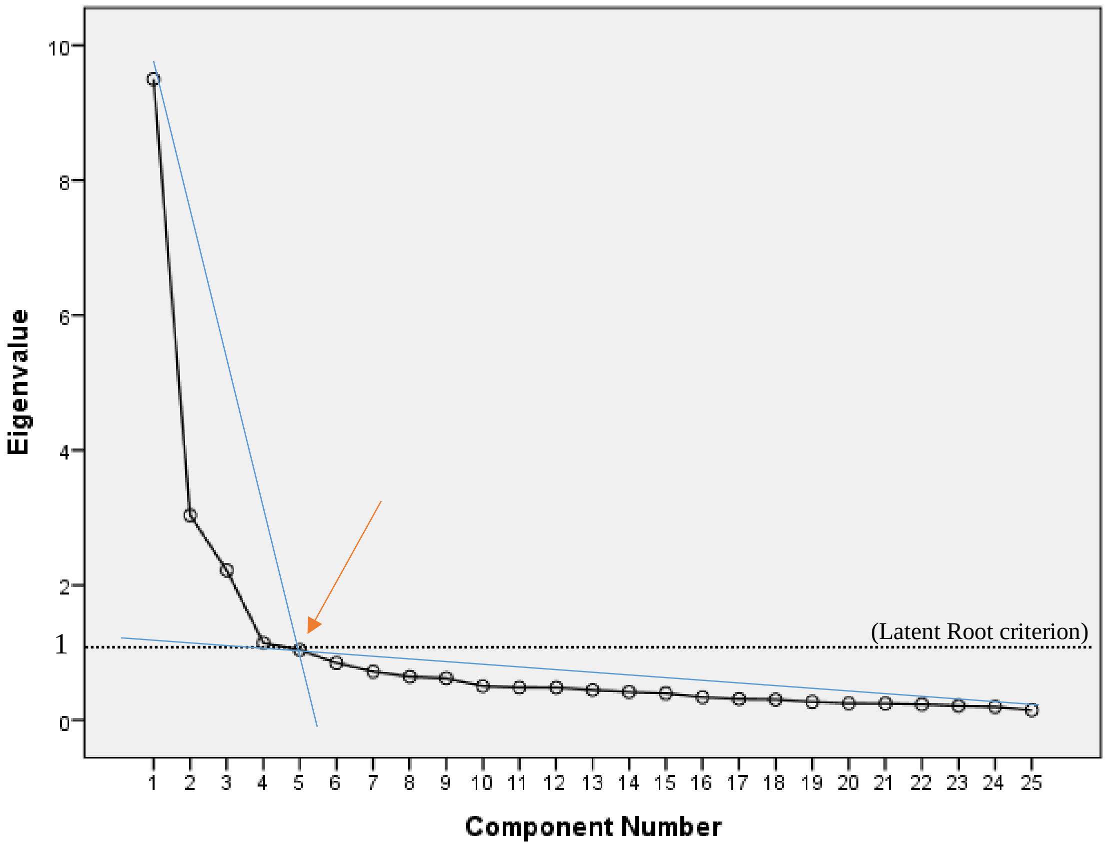

Figure 5-1 Scree plot representation

According to Burns and Burns (2008), a factor loading is the correlation between a variable and a factor that has been extracted from the data and an eigenvalue corresponds to the equivalent number of variables which the factor represents. Higher factor loadings suggest that more of the variance in the observed variable is attributed to the latent variable, therefore, if a factor has a low eigenvalue, then it is contributing little to the explanation of variances in the variables and may be ignored as redundant with more important factors. Components with eigenvalues greater than 1 are components which explain more variation than did an original item (ibid.).

In order to reinforce the graphic visualization assessment, the Latent Root criteria was also applied. According to Hair et al. (2019, 141), the Latent Root criterion is the most commonly usual technique to assess the number of factors to extract. The rational is that only individual factor should account for the variance of at least a single variable, if it is to be retained for interpretation. Therefore, the total variance explained analysis was calculated, dropping all factors with eigenvalues under 1.0, retaining all others. Preliminary results show that only the first five components should be retained (as requested with the condition eigenvalues >1) (see Figure 5-1). In conclusion, results from the Latent Root criterion and the scree test criterion showed that five factors are to be retained for analysis. The next step is to determine whether the factors are correlated, and how to interpret them.

According to Burns and Burns (2008), rotation is the step in FA that allows a better identification of the meanfull factors. By rotating the factors, there is an attemp to find a factor solution that is equal to that obtained in the initial extraction Appendix 5-6), however with a simpler interpretation. According to (Field 2018), rotation maximizes the loading of each variable on one of the extended factors while minimizing the loading on all the other. Thus, the aim of the rotation is to reduce the number of factors on which the variable under investigation have high loadings. The process is called rotation because it involves the rotating of axes on a series of scatter graphs until a more easily interpretable factor structure is obtained. In resume, this step will allow a clearer view on which variables relates to which factors.

Orthogonal factor rotation is the simplest case of rotation. Here, the axes are maintained at 90 degrees. If the axes are not contained to be orthogonal, then the rotation is designed as oblique factor rotation (Hair et al. 2019). If there are theoretical grounds to think that the factors are independent (unrelated) then an orthogonal rotation (varimax) should be chosen (Field 2018). However, if the theory suggests that the factors might correlate then, one of the oblique rotations (direct oblimin or promax) should be selected. In terms of method, because it is assumed that factors do not have any correlation between themselves, the chosen method is varimax.

As mentioned previously, factor loadings are according to (Hair et al. 2019, 146) the correlation of each variable and the factor. Loadings indicate the degree of correspondence between the variable and the factor, with higher loadings making the variable representative of the factor. Thus, the squared loading is the amount of the variable's total variance accounted for by the factor (ibid., 151). Burns and Burns (2008) mentions that by convention, the factor loading must be at least 0.60 in order for a variable to unambiguously represent a factor and Hair et al. (2019) categorizes factor loadings as ±0.30 to ±0.40 to be minimal and ±0.50 or greater to be practically significant. The rotated factor loadings were calculated, using 0.6 as factor loading and its analysis showed that 3 items did not present any correlation with any factor, thus they were deleted (Appendix 5-6). Since variables were deleted, it is recommended to remake the calculations. Thus, a new rotated component Matrix was obtained (Table 5-6), representing how the variables are weighted for each component and the correlation between the variables and the factor.

The rotated factors matrix only presents factor loadings higher than 0.6 and the variables are listed in order of size of their factor loadings. After the rotation of the factor structure, it is now clear that there are 5 factors representing the clusters obtained in the correlation matrix. The initial unrotated factor matrix can be seen in Appendix 5-6, were the factor loadings for each variable on each factor are presented.

A table with the Total Variance Explained was retrieved (Table 5-7) showing 22 factors extractable for the analysis, along with their eigenvalues. The percentage of variance attributed to each factor and the cumulative variance of the factor and the previous factor.

Table 5-6 Rotated Factor Matrix

Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
Initiative for problem resolution	.757				
Open communication	.741				
Principles of Ethical Conduct	.725				
Auto confidence and determination	.713				
Responsibility for decision	.707				
Resolution of problems with creativity	.643				
Physics		.909			
Radiobiology and Radiation Protection		.829			
Medical Science		.793			
Electronics and Clinical Instrumentation		.736			
Exams protocols		.704			
Projects and activities execution			.863		
Internal quality assessment measures			.850		
Rationalization measures			.794		
Innovative solutions proposal			.789		
Availability for research projects				.746	
Adherence to innovations and technology				.719	
Integration in team works				.671	
Share information and knowledge				.638	
Communication and Behavioural Sciences					.753
Informatics					.727
Management and Administration					.653

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

According to the results, only the first five components[26] will be retained (as requested with the condition eigenvalues >1). Therefore, according to Kaiser's criteria, five factors should be extracted for the data to be interpret in a satisfactory way[27].

[26] The terms factor, constructor or component are used interchangeably.
[27] KMO continues presenting an excellent value of 0.903 (see Appendix 5-6).

Table 5-7 shows that the percentage of variance decreases along components. The percentage of variance criterion was used to ensure that the derived factors explain at least a specified amount of variance.

Table 5-7 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.250	37.501	37.501	8.250	37.501	37.501
2	2.834	12.883	50.385	2.834	12.883	50.385
3	2.157	9.805	60.189	2.157	9.805	60.189
4	1.112	5.053	65.242	1.112	5.053	65.242
5	1.038	4.718	69.960	1.038	4.718	69.960
6	.789	3.588	73.548			
7	.659	2.997	76.545			
8	.610	2.774	79.319			
9	.489	2.221	81.540			
10	.483	2.195	83.735			
11	.458	2.081	85.817			
12	.417	1.896	87.713			
13	.390	1.775	89.488			
14	.356	1.620	91.107			
15	.326	1.483	92.590			
16	.298	1.356	93.946			
17	.275	1.252	95.198			
18	.248	1.125	96.323			
19	.246	1.120	97.444			
20	.214	.974	98.418			
21	.198	.899	99.317			
22	.150	.683	100.000			

Extraction Method: Principal Component Analysis.

Factor 1, 2, 3, 4 and 5 explain respectively, 37.50%, 12.88%, 9.80%, 5.05% and 4.72% of the variance - a cumulative of 69.96%. According to (Hair et al. 2019, 142) no absolute threshold has been established, however in social sciences, to consider a solution that accounts for 60 percent of the total variance is satisfactory. The new conceptual model is represented in Figure 5-2.

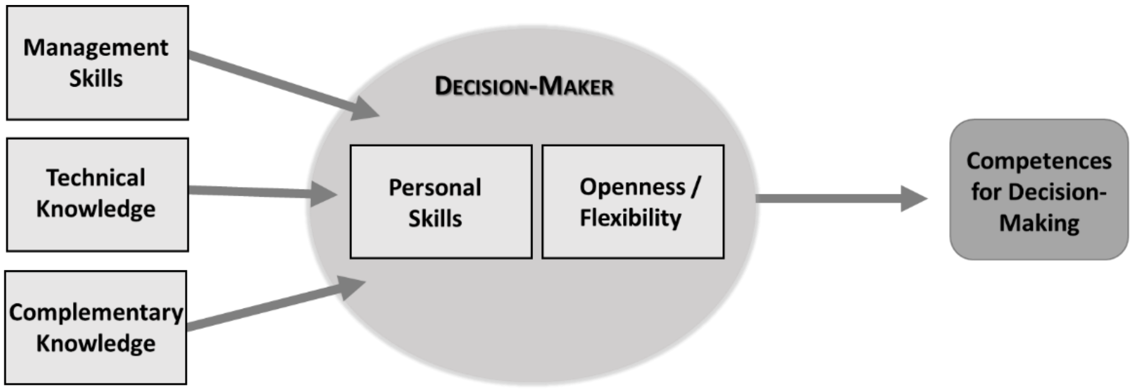

Figure 5-2 Conceptual model after EFA

5.5. Model Evaluation and Modification

To evaluate the conceptual model, the multivariate analysis statistics used was the Structural Equation Modelling (SEM). A "full" SEM analysis was performed meaning that the measurement model was assessed separately from the structural model (Hair et al. 2019; Garson 2012).

The structure model shows how the concepts are related among the others. According to Lleras (2005), a path analysis is primarily used to examine the comparative strength of direct and indirect relationships among variables. It attempts to explain "new" correlations among directly observed variables. One of its advantages is related to the fact that it forces the explicit specification of how the variables relate to one another, encouraging the development of a clear and logical theory about the processes influencing a particular outcome (ibid., 25).

According to (Hair et al. 2019), path diagrams are the basis for path analysis, where the strength of the relationships using only a covariance matrix or a correlation as input is calculated. Using the outcomes of the EFA, the theoretical proposed model was translated into a path diagram, as depicted in the model in Figure 5-3. Five latent variables are represented in an oval shape. Each one has a set of indicators that represent the observed variables or endogenous (enclosed by rectangles). Since each of the observed variable suffers influence from external factors they are associated to an error "ε" represented in a circular shape. The error ε, is the measurement error of the item in question. The arrow from the latent to the manifest (exogenous) variables represents a hypothesized causal direction. In some, in the model, it is possible to find three types of variables: observed (endogenous), manifest (exogenous) and latent. Having three indicators per construct is acceptable, particularly when other constructs have more than three (Hair et al. 2019, 666).

5.5.1. Assessment of the measurement model

The assessment of the measurement model was done by Confirmatory Factor Analysis (CFA), using IBM® ® SPSS® *AMOS* (Analysis of Moment Structures) software v.21 for the statistical tests. CFA specifies how sets of measured items represent a set of constructs (Hair et al. 2019) involved in a theoretical model. Thus, it shows how the theoretical specification of the factors matches reality (the actual data). The ability to evaluate the validity of the constructs (degree in which a set of measured items reflects the dimension that those items were supposed to measure) of a proposed measurement theory is one of the greatest advantages of CFA (Azevedo 2015, 63).

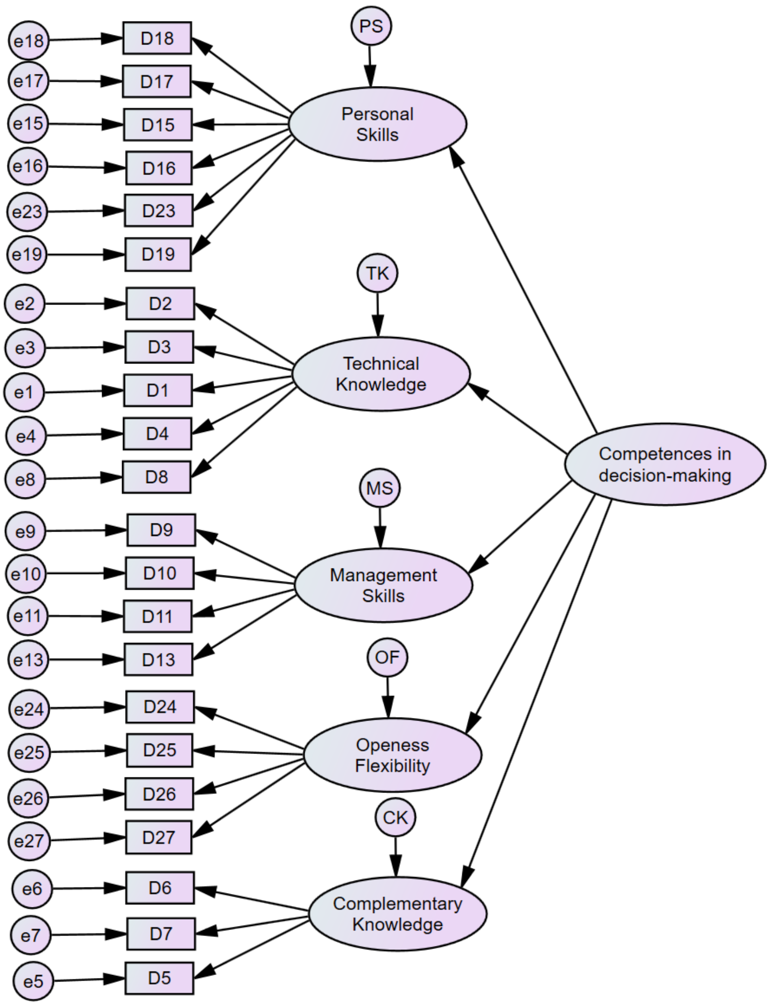

Figure 5-3 Structural Equation Model for competences in decision-making

The measurement model validity depends on establishing acceptable levels of goodness-of-fit (GOF) for the measurement model which indicates how well the specified model reproduces the observed covariance matrix among the indicator items (Hair et al. 2019). In a simple way it will determine how well the model fits to the data.

There are a variety of GOF statistics that can be used to assess the model fit and evaluate competing path models (Llenas 2005). If GOF values are acceptable, it can be concluded that the indicators adequately measure the intended constructs (Garson 2012). For this analysis, the following statistics were chosen:

- Absolute fit measures: Chi-squared (CMIN), the normalized Chi-squared (CMIN/DF), Goodness of fit index (GFI), Root mean square error of approximation (RMSEA) and the *p* of close fit (PCLOSE).
- Incremental fit measures[28]: Tucker Lewis index (TLI), Normed fixed index (NFI) and the comparative fit index (CFI) and the incremental fit index (IFI).
- Parsimonious fit measures: (PRATIO) and (PCFI).

The first analysis showed that the incremental and parsimonious measures have an acceptable value, however the CMIN/DF of 4.28 and the RMSEA of 0.09 (with 90% confidence interval for RMSEA of 0.09 to 0.10) are within the threshold limits (Table 5-8 – 1st Fit). The RMSEA takes into account the error of approximation in the population and asks the question of how well the model, with unknown but optimally chosen parameter values, fits the population covariance matrix. The CMIN is sensitive to large samples and any non-zero residuals will result in a significant chi-square.

Table 5-8 Adherence of the Structural Equation Model

Indices		Thresholds*	Value (1st Fit)	Value (2nd Fit)
CMIN	Chi-square value (Minimum of discrepancy function)	The lower the better	872.69	158.5
CMIN/DF	chi-square value / Degrees of freedom	1 - very good,]1;2] - good,]2;5] - not so good, >5 - bad	4.28	3.16
GFI	Goodness of fit index	<0.8 – bad, [0.8;0.9[- not so good, [0.9;0.95[- good, ≥0.95 – very good	0.82	0.94
TLI	Tucker-Lewis Index		0.84	0.94
CFI	Comparative Fit Index		0.86	0.95
IFI	Incremental Fit Index	0 = poor fit; close to 1= very good fit	0.86	0.95
NFI	Normed Fit Index	0 = poor fit; close to 1= good fit	0.83	0.93
PRATIO	Parsimony-adjusted Normed Fit Index	0 = poor fit; close to 1= good fit	0.88	0.76
PCFI	Parsimony-adjusted Comparative Fit Index	<0.6 – bad, [0.6;0.8[- good, ≥0.8 very good	0.76	0.72
RMSEA	Root mean squared error of approximation	>0.10 – inacceptable,]0.05;0.10] good, ≤0.05 – very good	0.09	0.08
PCLOSE	*p* value for H_0	<0.05 No fit; ≥ 0.05 Good fit	0.00	0.00

* According to Marôco (2018, 51) and Azevedo (2015)

In order to reinforce the model, a reduced model was developed. In order to make the model more robust, the first step was to omit non-significant variables (Annex 5-7). Thus, “Management Skills” was

[28] Comparative fit indices are also called “comparative fit indices” or “relative fit indices”.

omitted since it represented a standardized loading inferior to 0.5. New estimates were calculated, and the same exercise was repeated. Loadings inferior to 0.5 were omitted. In the end, additional 6 dimensions were not considered, due to a weak loading.

After the modification a new model fit was performed, showing that CMIN has improved as well as all other incremental and fit measures (Table 5-8 – 2nd Fit) except for the PRATIO although remaining within the acceptable value.

RMSEA yields appropriate conclusions regarding model quality and its possible to build confidence intervals around its values. The new RMSEA presents a value of 0.08, with a 90% confidence interval of 0.06 to 0.09, which argues for a reasonable fit of the conceptual model to the empirical data. Lower value of CMIN was obtained, supporting the proposed theoretical model being tested. Considering the null hypothesis (H0) that the data is independent of the model, against the alternative hypothesis (H1) that the data is not independent, to retrieve a p-value of 0.00 means that the level of adherence of the data to the model is high, because there is a significant association of the situation of the data with the proposed model (since $p \leq 0.05$). The same for the obtain p-value in the Chi-square. Hair et al. (2019, 687), mentions that standardized loadings estimates should ideally be 0.7 or higher to indicate convergent validity. Thus, the model is substantively meaningful. The reduced model is depicted in Figure 5-4.

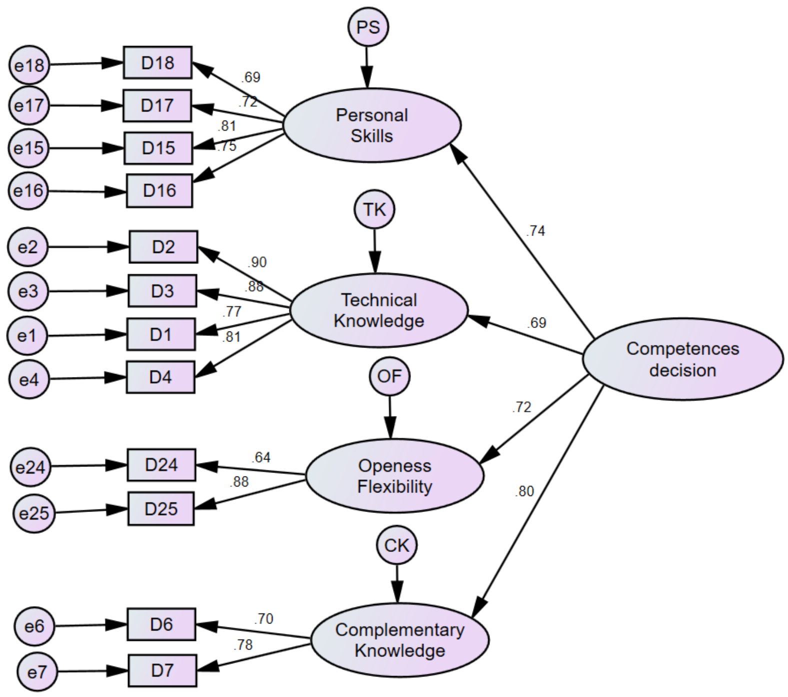

Figure 5-4 Reduced Structural Model of Competences for decision-making

5.6. Interpretation

The interpretation was made using the structural model.

5.6.1. Assessment of the structural model

As illustrated in Figure 5-4, the second-order factor, “Competences decision”, has four first-order competences-related factors: “Personal Skills”, “Technical Knowledge”, “Openness and Flexibility” and “Complementary Knowledge”. All the estimated paths are statically significant. The “Complementary Knowledge”, comprised of “knowledge in Informatics”, “Communication” and “Behavioural sciences” are the ones with more statistic relevance, followed by “Personal Skills” and “Openness and Flexibility”. To have knowledge in specific fields related to Radiology, such as physics, radiobiology and radiation protection, medical sciences and electronics and clinical instrumentation (“Technical Knowledge”) is the factor with lower statistics significant.

5.7. Remarks

A PCA with subsequent rotation (Varimax) was conducted on 25 items of a questionnaire concerning competences of potential decision-makers. Many correlations were in excess of 0.30 and both KMO and Bartlett’s test produced criteria and supported the application of PCA. Communalities varied from 0.871 to 0.511. Applying Kaiser’s Rule and Scree test, 5 factors were deemed important. Following rotation, Factor 1 was loaded on 6 items that reflected the personality characteristics of the decision-maker and accounted for 37.50% of the variance. Factor 1 was labelled “Personal Skills”. Factor 2 was loaded on 5 items and accounted for 12.88% of the variance. It was labelled “Technical Knowledge” as it deals with the different knowledge’s that a decision-maker should possess when making technological decisions in Radiology field. The third factor accounted for 9.80% of the variance and was loaded on 4 factors suggesting it was framing “Management Skills”. Factor 4 labelled “Openness and Flexibility” accounted for 5.05% and the 5th and last Factor “Complementary Knowledge” accounted for 4.72% of the variance.

The theoretical model was evaluated using CFA in AMOS. The first GOF showed that some regressions were not statistically significant. A new reduced model was obtained, by deleting the non-significant dimensions. New GOF results (2nd fit) were improved, making the reduced model and consequently the reduced questionnaire more robust $\chi^2(df=99)=309.33$, $p=0.00$; Root Mean Square Error of Approximation (RMSEA)=0.08 (LO 90=0.07 and HI 90=0.09); Comparative fit index (CFI)=0.93; Tucker-Lewis index (TLI)=0.92; Incremental Fit Index (IFI)=0.93; Normed Fit Index (NFI)=0.91; Parsimony-adjusted Normed Fit Index (PRATIO)=0.83 (with PCFI=0.77).

The reduced structural model of competences for decision-making is relevant to understand what kind of competences a decision-makers should have when it comes to make decisions in a Radiology Department. By deleting the six dimensions, the questionnaire to assess competences is now smaller, with a total of 16 questions (or items).

The analyse of the estimated standardized structural paths shows that all structural paths estimates are significant, but with different degrees, which implies that the different knowledge and skills do not have an equal influence on the decision-maker competence to decide. Thus, the hypothesis "*In the decision-making process, the different knowledges have an equal influence on the decision maker competences*", is rejected.

Considering the results, a new schematization depicting the relations between the different knowledge's and skill (competences) in terms of their influence for decision-making is presented in Figure 5-5.

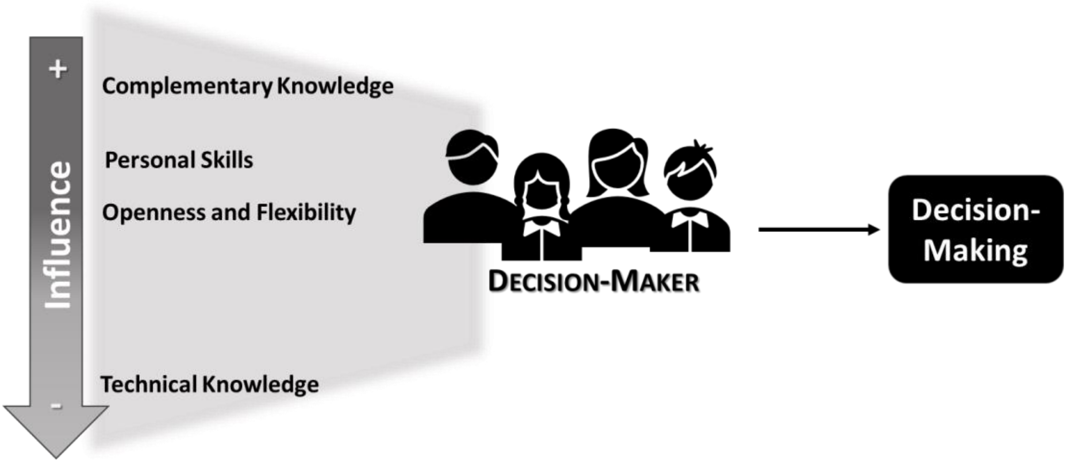

Figure 5-5 Factors influencing competences in decision-making

The use of a questionnaire to assess the competences necessaries for decision-making when it comes to the acquisition of medical devices in a radiology department became an important instrument to evaluate potential decision-makers that can be involved in the process. This fact contributes to the research main goal which is to characterize the potential decision-makers involved in the process.

6. DISCUSSION OF RESULTS

This research explored the decision-making process for the acquisition of MRI scanners in Portugal, using two sets of questionnaires and semi-structured interviews to collect data. The present chapter aims to discuss the results obtained in Chapters 4 and 5, in light of the literature review presented in Chapter 2.

In terms of motivations behind the decision-making process, results showed that **drivers that motivated the MRI scanner purchase** were firstly related to technology development. MRI offers unique technological characteristics, and its technological trends and the ability to expand capacity in terms of exams offered (especially in the private sector due to the different management model), is therefore of importance to the decision-makers. This motivation is closely related to the objective of providing quality health care, seen by the decision-makers as the **main aim for purchase** of the scanner. To be able to be competitive was also a driver for the purchase, in the private sector.

A strong objective for technology purchase is also related to the need to satisfy clinicians' preferences. To satisfy users' preferences was, however, not considered as an important objective for the purchase. In fact, this aspect was, to some extent, minimized by decision-makers, who do not see users / patients as stakeholders capable of having an opinion on this type of technology or its purchase.

In terms of the decision- making process, several aspects are important to be addressed:

- the identification and importance of actively involved decision-makers,
- the evidence that was used to support and legitimize the decision,
- the influences that the process was subject to, and
- the steps that were taken, which characterize the decision process.

Starting with the **identification of the decision-makers involved** in this study, the majority were from the private sector. Such a characterization of participants in the study is not surprising, since as seen in the literature review (Chapter 2.5.), the majority of the 150 MRI scanners installed in Portugal is located in the private sector. Most of the decision-makers that participated in the study were located in Lisbon. The probable rational for this result is that the researcher had more direct and professional contacts in this region, which facilitated the approach to the decision-makers during the snowball exercise (for the identification of decision-makers).

Results from the questionnaire showed that Radiology Department Coordinators (radiographer) and the Financial and Accounting Responsible person had with most perceived importance, followed by Radiology Department Directors (radiologists), and Clinic Owners or Administrators. It is interesting to note that in the snowballing process for the identification of active decision-makers to be interviewed, Financial and Accounting Responsible person were not mentioned, and results from the interviews do not fully support the questionnaire results. The importance given to patients, or the lack of it, was supported by both the questionnaires and interview results.

In terms of the **description of the decision-making process**, results showed that the process is well defined, as decision-makers identified specific steps in the process, in accordance with the literature review presented in sub-chapter 2.2.3. The process starts with the identification of needs, mainly by radiologists and radiographers, who are usually the initiators and the supporters of the new technology purchase and are those most actively involved in such initiatives.

The majority of decision-makers mentioned that the need to acquire an MRI scanner was a consequence of the need to respond to a high demand for MRI at hospitals, who due to the non-existence of technologies were sending patients to other hospitals or private practices to perform the exams. When the technology was already installed, then the driver was the need to relieve the intensive workload and reduce waiting lists. This scenario justifies why in the course of interviews, to conduct research using the MRI equipment was not considered to be as important as the other mentioned drivers, as this would imply dedicated time which is not available.

A committee is then established, primarily composed of the Directors and Coordinators of the Department, the equipment procurement and installation responsible persons, and by a representative of the finance department. Although, in some committees, the presence of the Area Manager or Clinical Director is mandatory, their importance is perceived by other decision-makers as minor, due to their lack of knowledge on the topic. The same applies for other members that also take part in the committee.

The committee is responsible for writing a report, where all desired aspects of the technology are described. A set of criteria is also established and for each criterion a ponderation factor is attributed, to facilitate the assessment of the potential devices to be purchased.

According to the literature review, it is expected that decision-makers make **use of evidence** when establishing the report's content. According to the results obtained, all decision-makers used indicators to support their decision. Indicators are seen by all decision-makers as important instruments to support the decision. Costs associated with the technology was the most important indicator listed in the questionnaire, but the interview analysis showed a major weighting on suppliers' characteristics. In terms of costs, not only acquisition costs were considered, but also costs associated with maintenance of the technology. It is important for all decision-makers to acquire the technology at the lowest possible price, mainly due to financial constraints, and in some cases external pressure from top management level to reduce costs.

The characteristics of the suppliers was, in addition to cost, an important indicator for the decision. It mainly refers to the relationship with suppliers. Decision-makers see this relationship as based on trust, and this is reflected in terms of technical assistance quality and the fast reaction from the suppliers when problems emerge. A strategy sometimes adapted by decision-makers is standardization of technology providers, meaning the attempt to purchase all technologies from the same supplier. Some decision-makers mentioned that purchases using a bigger technology package are considered a strategic business decision, often associated with political decisions, and the strategy is outlined by the top management level. Usually, such decisions do not take into consideration the opinion of Radiology Coordinators, seen, as mentioned above, as the most important decision-maker in the process. This negotiation is usually made around acquisition costs and maintenance contracts.

Another important indicator (ranked third) was characteristics of the technology. Up-to-date and recent software that allows different images acquisition and the study of different parts of the body are considered, but characteristics of the equipment such as dimension and length of the bore are also taken into account. The later is related to claustrophobia and noise exposure experienced by the patient during the exam. Overall, these indicators were mainly used before the decision was made, and not so often after the decision.

When asked about the importance of indicators, results show that the main reason to use indicators is related to the need to check market trends and competitors' development, to analyse competitive capacity and scientific advances, or even to check the development of the technology. In sum, the indicators are mostly important to foresee the future. They are also important to provide an overview of the present situation of the department. However, despite the identification of indicators being important, none of the participants mentioned performing a foresight, horizon scanning or benchmark study. In fact, few studies are performed before or after the decision and they are mostly related to the characterization of the actual situation of the Radiology Department (workload) and related to the technology acquisition costs and its maintenance.

No other studies were mentioned by the decision-makers. No-one mentioned the use of evidence related to the impact of the technology, either related to impacts inside the organization where the scanner would be installed, or broader studies such as impacts on the health care system, or even at a societal level. **No HTA study (national or international) was used to support the decision**. Studies (polls) on users' experiences, namely their preferences and needs, even at the financial level, were not considered.

The decision-making process is subject to different **external influences**. As already seen, political pressures such as those implied by the health system's request to keep costs as low as possible (in the public sector), or just the economic situation of the country leading to cost constraints (in the private sector), influenced the decision. Other external influences are also exerted, mainly via peers' consultation. Radiographers and radiologists, at national or international level, who already have experience in working with the technology, are frequently asked by the decision-maker to provide an opinion on the technology. Also, experts in the installation of MRI and physicists were consulted. Thus, consulting with others is seen as important by several decision-makers. This result goes hand-in-hand with the external influences previously mentioned in the literature review (sub-chapter 2.2.3.).

During the process, the main **internal influence** is derived from the decision-maker themself and their competences. The literature review ((sub-chapter 2.2.) showed that decision-makers need to combine different knowledges in order to mobilize their competences. It was hypothesized that: *In the decision-making process, the different knowledges have an equal influence on the decision-maker competences.* Using a SEM analysis, results showed that four factors have an influence on the decision-makers' competences to decide, however they do not share an equal influence.

The most significant influencing factor has to do with the possession of complementary knowledge namely how to interact and work effectively in different situations, and to have knowledge of the principles relating to the operation of computers and associated technology, which is particularly important in the search for information. The personal skills of the decision-maker is the second factor with influence on the decision-makers' competences. The initiative to resolve problems, to be able to establish open communication, and to have good listening capacities are important, as is the skill to be self-confident and determined to decide, even when it comes to hard choices. To be open and flexible to innovation and technologies with significant value for improving the performance in radiology and be available for research with added value and potential impact in the field is the third most important factor. The final factor is related to the technical knowledge in radiology: knowledge in physics, radiation protection and safety, medical sciences (anatomy, pathology, physiology, etc.), and knowledge of the principles and manipulation of electronic medical devices used in radiology are the most important. This result demonstrated that not all knowledges and skills have an equal influence on the decision-makers' competence to decide. For this reason, the tested hypothesis was rejected.

For the model test, four potential decision-makers were identified (sub-chapter 4.2.), and in light of the principal factor that influences decision-making, it can be concluded that both Technical and Operational Assistants should not be considered as decision-makers in the process, since they do not possess knowledges in physics, radiation protection and safety, or medical sciences (anatomy, pathology, physiology, etc.).

Looking to the content analysis of the interviews, one can see that in general, and according to the literature review in sub-chapter 2.2.3., decision-maker subjects in this study have several constraints: in terms of knowledge associated with a naïve or subjective interpretation of the evidence, but also biases created by their own expectations and/or distorted by administrative or other stakeholders' interests, leading to potentially unwise, non-evidenced choices. Intuition also plays a role as an internal influence. According to the results one can say that decisions are mainly cognitive based, meaning based on decision-makers' training, knowledge and skills. Although decision-makers do not use emotions and feelings, or even ethical and social values to base their decisions, results show that the majority base their decision on impressions and opinions collected from others rather than facts and evidence. This fact implies that a model of contingency is applicable to the studied decision, since a more participatory approach is considered. According to Vroom-Yetton's normative model, a decision-maker is classified as someone who consults with others individually, and after gathering all ideas and comments, decides on their own (Style CI).

In the overall process, questionnaire results show that the role of indicators was identified as a more important contribution than stakeholders' influences. Interviews showed in fact the opposite: people's opinions had more weight than indicators.

The above-mentioned factors illustrate that the writing of the specification report is influenced by several factors, both external and internal to the decision-maker. After the report is written, especially in the public sector, it is submitted to the legal department for approval, in order to be assured that legal requirements are considered. The report is then submitted to a call for tender formally published in the Official Journal (Diário da República). Applicants submit their sealed proposals that are then assessed by the committee, according to the pre-established criteria and respective ponderations. A rank is established, and the company located first is the one that the purchase is allocated to. In the private sector, as the call for tenders is not mandatory, the decision-maker(s) directly contact(s) companies, and suppliers of MRI scanners, sharing the report with them. In this phase, negotiations take place. In the public sector, such negotiations, in principle should not take place. However, results from the interviews showed that in some cases they do happen, undermining the process.

The final decision is one of the last steps of the decision process. According to the results, although 85% of the participants were active in the process and seen as key elements, they were not the final decision-maker. The administration board was indicated in most cases as the final decision-maker, followed by the Director of the Imagiology Department (or equivalent in the private sector). The decision process is therefore perceived by the majority as a hierarchical process, and most decision makers perceive their role as consultants.

Results show that the process is perceived by the majority as collaborative, since many times, different decision-makers take part in it. As seen in the results, in the majority of cases the decision takes place within a group (with the establishment of a committee) but others, namely peers external to the process, are also asked to participate by giving their opinion and sharing their experience with the decision-makers. Thus, the process is not seen as a solitary process.

In general, the process is also perceived as bureaucratic, time-consuming and long. This last aspect was pointed out as a major criticism of the process, and the few suggestions made by decision-makers concerning improvements of the process, was the need to simplify the process. In some cases, the process lasted up to two years. The time dedicated by the decision-makers to the process is not accounted for as a true characterization of the process. Despite this, decision-makers were happy with the end result and perceived that others, namely clinical and technical staff and leaders as well administration members, were also happy with the purchase.

However, results from the interviews show that the process is not transparent, nor as evidence-based as expected. For instance, some decisions are based on previous relationships with the supplier. These relationships are mentioned to be extremely important. The principal reasoning for this is related to quality assistance in the maintenance of the technology and streamlining of procedures. Thus, the strategy is to acquire a technology park from the same company.

In conclusion, in light of the literature review, and as mentioned in sub-chapter 2.6. it was expected that the purchase of MRI scanners in Portugal, independently of the sector where the decision takes place (public or private), was done by a decision-maker who acknowledges their cognitive limitations. By doing so, a consultative process should take place. This expectation was confirmed by the results obtained and described above.

It was also expected that decision-makers would support their choices with transparent and neutral evidence, such as that provided by TA and/or HTA studies. This expectation was not confirmed, since results show that no evidence was used from TA or HTA studies, conducted at national or international level.

It was also expected that the process would be influenced by the decision-maker's own personality, and that intuition, probably assuming different forms, plays a role. Indeed, results showed this to be accurate. The process does follow a bounded- rationality approach, where decision-makers are aware of their knowledge limitations, and prefer a participatory approach, collecting the impressions and opinions of others instead of collecting evidence. Thus, decision-makers were identified as having a consultant CI style.

Also expected was that different knowledges mobilized by decision-makers would have an equal influence, in terms of the decision-makers' competencies. This proved to be wrong, as it was tested that four different knowledges are in fact mobilized, but with different levels of influence. Such knowledges helped to identify the Radiology Department Coordinator (radiographer) and the Radiology Department Director (radiologist) as the most important decision-makers in the process, due to the knowledges they possess.

7. CONCLUSION

European countries are not equal when it comes to the organizational structures of their health care systems, or how the financial resources are obtained and allocated, or even in the way health care professionals are organized and provide services. Despite these differences they all have a common interest: to purchase medical devices that are cost-efficient, enabling provision of the best health care possible. In this context, there is a need to properly justify the purchase of expensive medical devices, since an element of waste of resources is derived from inappropriate investments in these technologies. Costs associated with the purchase and maintenance of MRI scanners are still very high, meaning that financial commitments are required when an MRI scanner is to be bought.

Data from 2013 shows that in Portugal, 150 MRI scanners are installed in the country, with the majority located in the private sector. There are no effective methods for regulating the distribution of health equipment in this sector, and the lack of evidence-based strategic purchasing has allowed a gap to grow between public and private investments.

In Europe, most countries have established agencies or institutions for HTA, which has been recognized internationally as a valuable tool that can provide a comprehensive review of a health technology, by providing not only clinical but also economic, social and ethical evidence on the consequences of the introduction of health technologies, in order to promote the rational use of resources.

The heterogeneity of European HTA institutions reflects the different European health care systems. Even though their researchers share the same methods and tools in order to provide the best unbiased information and evidence for the assessments made on health technologies, the results can differ due to the context were the assessment takes place. This is a rich body of knowledge which it is important to use as experiences that everyone can learn from. Thus, sharing such activities is crucial. However, although this international evidence of best practices can be useful, it can only make sense if local contexts and settings are considered, so that policies can be developed, while ensuring that they can be implemented. This implies that in order for HTA be used as input to decision-making processes of strategic purchasing, it is necessary to uncover how decisions are actually performed and who is conducting them. Empirical research on this topic is however scarce in Portugal.

It is therefore important to shed light on the characterization of the decision-making processes in Portugal. To understand the context where the decision takes place is important since the influence of the individual as well as the organization will impact on the way decisions are made. Here, the purchase of MRI technology was taken as a case study.

A literature review was undertaken to identify the underlying topics of this research, namely Technology Assessment, decision-making, technology purchase and magnetic resonance imaging.

Forty decision-makers participated in the study by answering a questionnaire. From these, 27 also participated in a complementary semi-structured interview. These decision-makers were all involved in the process for the acquisition of an MRI scanner. Taking a mixed methods approach to achieve the aim of the research proved to be beneficial. Face-to-face interviews promoted the creation of a relaxed and trusting environment which allowed participants to develop their input and provide valuable additional information, especially regarding the rationalizations and arguments behind their understanding of the acquisition process. Thus, the interviews complemented results obtained from the questionnaires.

The first aim of the study was to identify the decision-makers actively involved in the technology purchase decision process (RQ 1). It was possible to identify two groups of decision-makers: one group composed by Radiology Coordinators (Radiographers) and Radiology Directors (Radiologists), and another group composed by the Administration, identified has the last decision-maker. This means that decisions take place at two different levels: on the one side, a technical and clinical level, made by "on the field" decision-makers; on the other side on an economic and political level, made by top managers. This means that the decision is conducted at the medium hierarchical level and communicated to the superior level to be formalized.

The second aim was to characterize the decision-making process (RQ 3) by identifying the use of evidence, steps, goals and competences as perceived by the decision-makers. In relation to the context in which it was analysed, the decision to purchase an MRI device seems to be a strategic, under uncertainty conditions and non-programmed, since it is not a recurrent decision, and in most of the cases it was a new decision (for this type of technology), with a high level of novelty and high importance due to its potential impact on the health care service.

Drivers and aims (RQ 4) that motivated the purchase were related to:

- Technology developments, due to the unique technological characteristics of the device and it's trends.
- The desire to provide quality health care (also associated with the possibilities and potentialities of MRI).
- The need to satisfy clinicians' preferences (Radiologists).

The steps of the process are well-defined and summarized as follows:

- The process starts with the identification of needs, mainly by radiologists and radiographers, who are usually the initiators and supporters of the new technology purchase, and are most actively involved in such initiatives.
- A committee is established, primarily composed of the Directors and Coordinators of the Department, the SIE responsible persons, and by a representative of the finance department.

They are responsible for writing a report, where all desired aspects of the technology are described. A set of criteria is established, and for each criterion a ponderation factor is attributed, to facilitate the assessment of the potential device to be purchased.

- The report is submitted to a call for tender formally published in the Official Journal (Diário da República), after being assessed for compliance with legal requirements (in the public sector).
- Applicants submit their sealed proposals, which are then assessed by the committee, according to the pre-established criteria and respective ponderations.
- Proposals are ranked, and the company located first is the one that the purchase is allocated to.

Since in the private sector a call for tender is not mandatory, in general companies are directly contacted by the decision-maker, who shares the report with them, and directly negotiates the purchase of the device:

- The final decision is taken, and the technology purchased.

Decision-makers consider indicators to be an important instrument to support their decisions (RQ 6), namely:

- **Costs associated with the technology acquisition and its maintenance**, mainly due to financial constraints, and in some cases pressures from top management level to reduce costs.
- **The characteristics of the suppliers** was seen as an equally important indicator, mainly referring to trust, which is reflected in terms of technical assistance quality and fast reactions from the suppliers when problems emerge.
- **Characteristics of the technology** is also used as an indicator, where not only software is considered, but also hardware characteristics such as dimension and length of the bore.

These indicators are mainly used before the decision takes place, and occasionally afterwards, to legitimise it. Few studies are performed to support the decision. These are mostly related to the characterization of the workload of the Radiology Department and to the technology acquisition costs and its maintenance. No national or international HTA study was used to support any of the decisions.

The decision process is subject to the influence of external and internal factors (RQ 5). Political pressures such as those implied by the health system’s request to keep costs as low as possible (in the public sector), or just the economic situation of the country which leads to cost constraints (private sector), are identified as external influences on the process. The opinions of others is also considered to be an external influence, exerted mainly via peers consultation, namely radiographers and radiologists at national or international level, who already have experience in working with the technology.

Internal influences are derived from the decision-maker themselves and their competence. Decision-makers are subject to several constraints, due to limits related to cognitive capacities of the decision-maker to search for and interpret evidence, and biases created by their own expectations and/ or distortion by external interests, which leads to non-evidence-based decisions. Emotion or feelings are not used to guide decisions, however intuition plays an important role, as decision-makers tend to be selective in terms of sources of information, often deciding based on impressions and opinions collected from others rather than facts or evidence.

In terms of competencies (RQ 2), 4 influencing factors are identified as most significant:

- Complementary knowledge refers to how to interact and work effectively in different situations in Radiology context, and to have knowledge of the principles relating to the operation of computers and associated technology, which is particularly important in the search for information.
- Personal skills of the decision-maker, mainly the initiative to resolve problems, to be able to establish open communication and to have good listening capacities, to be self-confident and determined to decide, even when it comes to hard choices.
- To be open and flexible to innovation and technologies with significant value for improving performance in radiology, and be available for research with added value and potential impact in the field.
- Technical Knowledge such as knowledge of physics, radiation protection and safety, medical sciences (anatomy, pathology, physiology, etc.), and knowledge of the principles and manipulation of electronic medical devices used in radiology.

In summary, the decision process is characterized by a bounded rationality, influenced by intuition and a consultant decision-maker. The decision is a bottom-up process, where information-gathering and consensus-building is in general undertaken within a committee, although external consultancy is also used. In most cases the process is not transparent, and although a committee is established, the reasoning and justification for selection of its members is unclear. The process is considered to be bureaucratic, time-consuming and long. Patients are negatively perceived as stakeholders in the process. Their experiences, needs and expectations are not considered.

The third and last aim of the research was to understand the role of Health Technology Assessment studies in the decision-making process. Results showed that HTA did not played a role in the decision-process, as no recommendations from HTA studies (at national or international level) were acknowledged or considered by the decision-makers to support their decisions. In Portugal, HTA practices in the medical devices sector are recent, and related studies are still scarce.

Considering the research question established, it is concluded that there was no influence of HTA in the decision process, due to the missing link between HTA studies and the decision-making process. Such missing link allowed however the identification of several barriers to the inclusion of HTA in the decision-making process. These barriers were identified at three levels, which will be further developed in the next sub-section:

- **Organizational:** barriers related to behaviour, structure, and organization of working environments in Radiology
- **Scientific**: limitations due to decision-makers level of scientific literacy
- **Material:** limitations related to the lack of material, financial, and human resources.

This study provides important insights into the decision-making process and the considerations used in MRI acquisition in Portugal. Some recommendations can therefore be outlined.

7.1. Recommendations

In each country, the adoption and use of health technologies is influenced by many factors, influenced by cultural aspects such as the relation to technology, and perceptions and experiences of health and disease, but also with regulatory aspects of the health system, such as financial aspects related to rising expenditures, relations with industry, aging populations, etc. These problems and issues are common and affect all countries, making the management of health technologies a global challenge. The results of this study provide empirical evidence that can shed light on how the decision process is characterized, and by doing so, understand how decision-makers legitimize their decisions regarding the purchase of MRI equipment. Such an exercise is of relevance since it identifies which sources of information and other relevant considerations are used by decision-makers in their argumentation. Similar exercises should be conducted in other countries, in order to unveil comparable decision-making processes and practices. Only with this knowledge can health systems identify gaps and improve decision-making processes.

Considering the development of HTA

Several barriers were identified to the inclusion of HTA in the decision-making process. In order to overcome them, recommendation can be made firstly in relation to the present research:

> **It is necessary to deepen the present study, in particular regarding the elements that influence the strategies and tactics adopted in the decision-making process for the acquisition of medical devices.**

At the organizational level, and as seen before, there are two levels of decisions: one level of decision is taken considering the technical and clinical aspects and another level were economic and political aspects are considered. This implies that there are two distinct ways of looking at the decision process, and therefore two ways of managing the acquisition process. The present thesis only provided for an overview or an identification of the decision-makers. It did not separate the analysis in terms of these two levels of decision-making:

> **It is therefore suggested a further research on this topic to understand in more depth, the values considered by the decision-makers in each of these levels.**

Although the steps of the process are well defined, it was not clear how the assessment of needs was conducted for MRI, by the Radiology Department. Although the acquisition of MRI seemed to be a strategic one, it was not clear if in all decisions, a concrete need assessment for MRI existed, considering a specific temporal frame to answer to specific needs and resolve specific problem(s). This absence could des-virtualize the decision process from the beginning since the decision would then be starting from a false permissive on the identification and prioritization of technology's needs. Thus, it was not clear if the decisions were taken considering a strategic purchase framework for the Radiology department, or even for the Hospital, since in most of the cases analysed, it seemed that the decision to purchase MRI was more based on a tendency to follow the market:

> **The topic of assessment of needs, should be studied and discussed in more depth.**

It is also important and urgent to clarify how the uptake of HTA by decision makers can be strengthened and supported by the Institution. Centralized organizational practices that foster the lack of a participative culture in the organization and therefore lack of involvement and relationships of sharing and dissemination in Radiology services are a cultural barrier to the share of information and knowledge. Therefore, there is a need to promote a more decentralized culture in Radiology Departments, where people can be involved to a greater degree in decision processes. In addition, the workload experienced in Radiology departments is a promoter of lack of time, as well as human, material and financial resources who also act as barriers for conducting and integrate research studies, such as HTA, into their routines. This was supported by empirical results that showed that few studies are performed after the installation of the technology, which leads to a poor or in some case non-existing monitoring of the decision, which is an essential step in order to gather data on performance, control current acquisitions and inform future ones:

> **The establishment of an in-house unit, able to carry out TA studies considering the hospital context and aiming to inform managerial local decisions on the uptake or disinvestment of medical devices is recommended.**

It is however important that those who produce and work in HTA understand the needs, values and processes of the decision-makers, in order to are able to translate scientific results into clinical practices:

Such unit should be comprised not only by TA multidisciplinary researchers but also by professionals from the health institution.

This multidisciplinary team needs to have knowledge in HTA in order to be able to organize HTA activity in-house and be able to provide for instance a technical or economic opinion with the organizational strategy as a background. Which leads to existing barriers at the scientific level due to the absence of skilled decision-makers having a good understanding of the science of HTA:

Contact between researchers and decision-makers should be promoted in order to foster common language and values.

Such contact between research and decision makers will allow a better understanding of decision process, and consequently a feasible understanding of HTA results by decision-makers.

The establishment of an in-house HTA unit can promote a more decentralized and participative culture in Radiology and in addition reduce scientific limitations and help increase organizational research uptake on HTA.

Considering MRI practices and future needs

In Portugal, the main driver behind the decision to purchase an MRI device was related to the technological characteristics of MRI, as this technique is considered to be, in some cases, superior to other imaging techniques. This has led to an increased demand for MRI exams in hospitals, and consequently intensive workloads and waiting lists. OECD (2020) data, confirms that the number of MRI exams in Portugal is increasing every year. This could be a potential indicator of over-utilization of MRI, which could potentially lead to a false need for such medical devices. It is therefore recommended that:

Portuguese guidelines for medical imaging should be revised frequently, considering clinical evidence of MRI in different indications.

It is recommended that these guidelines should be revised frequently (every two years). Taking advantage of existing HTA studies in this area (see for instance Agnes Kisser, Mayer, and Wild (2014), and Demaerel et al. (2006)) such an assessment can be conducted with consideration for the Portuguese context. The international share of such HTA reports can help to identify opportunities and challenges arising from health- related technologies by optimizing decision-making processes. In addition, the current MRI market is experiencing major technological advancements. It is recommended that this key research topic should be addressed in Portugal:

Determining the influence of MRI imaging on future healthcare trends and the viability for market expansion in a stringent reimbursement and regulatory environment.

For instance, the application of Machine Learning and Deep Learning requires skilled professionals to handle equipment and analyse data, meaning that new professional competences are emerging, and it is likely new related professions will be needed. This means that investment will also be needed in this area. Since HTA/TA studies on the impacts of ML and DL in Radiology in Portugal are lacking, this topic is considered to be an important need for action.

7.2. Limitations of the research

The importance of making decisions based on the best evidence possible, in order to enable informed choices about the purchase and implementation of health technologies is generally recognized. Evidence can be provided in different ways, such as by HTA studies. But the successful use of such evidence also depends on how decisions are made, and the competences of the decision-makers who take them.

In order to understand and characterize the process of decision-making, research was based only on what decision-makers had to say about the process. The decisions were already made, so using the questionnaire and conducting the interviews was the only feasible way to attempt to characterize the process retrospectively. This means that the research had to take into consideration decision-makers' recalled perceptions of what happed and how the process was conducted. According to Robbins, Judge, and Campbell (2010, 111), perception is a process by which individuals organize and interpret their sensory impressions in order to give meaning to their environment. One can argue that reality as perceived by the decision-makers regarding the purchase process may have differed from what really happened. In addition, given the use of descriptive statistical techniques, the results cannot be generalised to other contexts. Likewise, the content analysis carried out to systematize the perception of the interviewees only concerns these professionals and their opinions reported during the period that the interviews were carried out.

The different factors that may have influenced decision-makers' perceptions could also have been addressed. But this was not an aim of this research, although it could be an interesting topic to address in further research.

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APPENDIXES

Appendix 3-1 Questionnaire A "Technological Decision-making process"

INQUÉRITO AO PROCESSO DE TOMADA DE DECISÃO TECNOLÓGICA

Por favor, responda às seguintes questões sobre a aquisição de equipamento de Ressonância Magnética (RM).

1. Caracterização do equipamento de RM:

Fabricante: ☐ Philips ☐ Siemens ☐ Toshiba ☐ G.E. ☐ Hitachi

Modelo: ____

Ano de Aquisição: ______________________

1. Qual dos seguintes, foi o motivo mais forte para a aquisição do equipamento de RM?

☐ Capacidade de expansão
☐ Acção competitiva
☐ Vencimento do contracto
☐ Mudança de liderança
☐ Desenvolvimento da tecnologia

2. Do ponto de vista do Serviço de Radiologia, quais os objectivos mais importantes tidos em consideração, no momento da aquisição do equipamento de RM:

		1	2	3	4	5	6	7	
Maximizar a receita	De forma alguma	☐	☐	☐	☐	☐	☐	☐	Muito importante
Minimizar custos de operação	De forma alguma	☐	☐	☐	☐	☐	☐	☐	Muito importante
Satisfazer a preferência dos clínicos	De forma alguma	☐	☐	☐	☐	☐	☐	☐	Muito importante
Satisfazer a preferência dos utentes/pacientes	De forma alguma	☐	☐	☐	☐	☐	☐	☐	Muito importante
Fornecer cuidados de saúde de alta qualidade	De forma alguma	☐	☐	☐	☐	☐	☐	☐	Muito importante
Realizar novas investigações	De forma alguma	☐	☐	☐	☐	☐	☐	☐	Muito importante

3. Que tipo de estudos foram feitos, e por quem, antes e depois da aquisição do equipamento de RM?

Antes	Depois
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

4. Aquando da aquisição de equipamentos de RM, utilizou algum tipo de indicador na sua decisão?
Por exemplo, indicadores financeiros, técnicos, organizacionais, etc.

☐ Sim
☐ Não (como consequência de pressão política, imposição superior, pressão da empresa fornecedora, por exemplo)
Se respondeu **Não** salte para a pergunta 9, por favor)

1

5. Indique os três indicadores mais relevantes para a sua decisão tecnológica:

- ☐ Utilização da tecnologia por parceiros
- ☐ Utilização da tecnologia pela concorrência
- ☐ Fornecedores (facilidade de relacionamento, suas características, sua tipologia, etc.)
- ☐ Características técnicas da tecnologia, recolhida através da internet, folhetos, feiras, eventos públicos, etc
- ☐ Características técnicas da tecnologia, recolhida através de intermediários (centros de I&D, centros tecnológicos, serviços de consultoria, associações industriais, etc)
- ☐ Disponibilidade de informação (estudos, pareceres, informação sectorial, etc)
- ☐ Qualificação de recursos humanos (internos)
- ☐ Factores ligados à organização do trabalho
- ☐ Custos (aquisição, manutenção, etc.)
- ☐ Indicadores de quota de mercado, de benchmarking, etc
- ☐ Outros indicadores financeiros (contabilísticos, TIR, VLA, Payback, etc)
- ☐ Outros. Por favor indique quais: ____

6. Quando é que utilizou indicadores na sua decisão?

	Nunca	Algumas vezes	Muitas vezes
Antes da decisão	☐	☐	☐
Após a decisão	☐	☐	☐

7. Qual é a sua opinião relativamente à seguinte frase: "Durante o processo de tomada de decisão tecnológica, os indicadores serviram para: "

	Discordo plenamente	Discordo	Concordo	Concordo plenamente
• Perspectivar o futuro (aumento da capacidade competitiva, avanços científicos, desenvolvimento de tecnologia, tendências do mercado, desenvolvimento da concorrência, etc.)	☐	☐	☐	☐
• Compreender melhor a situação actual em relação ao grau de actualização tecnológica	☐	☐	☐	☐
• Confirmar a minha decisão de aquisição / desenvolvimento	☐	☐	☐	☐
• Justificar a decisão de aquisição (à entidade de financiamento, a responsáveis políticos, à direcção, aos colegas, aos sócios, etc.)	☐	☐	☐	☐
• Caracterizar a aquisição / desenvolvimento	☐	☐	☐	☐
• Cumprir formalidades (com entidades financiadoras de projectos nacionais ou europeus, a entidades fiscalizadoras, legislação, certificações, etc.)	☐	☐	☐	☐
• Não foram úteis	☐	☐	☐	☐

8. Se a sua decisão tecnológica se baseou noutros factores não referidos neste questionário, por favor indique quais:
____

9. Sumariamente, indique as <u>etapas do processo</u> de tomada de decisão, referente à aquisição de equipamento de RM:

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______

10. Qual a <u>importância das seguintes pessoas</u> durante o processo de decisão?

	Irrelevante	Pouco importante	Importante	Muito importante
Director Clinico	☐	☐	☐	☐
Técnico Coordenador	☐	☐	☐	☐
Gestor da área	☐	☐	☐	☐
Director do Serviço de Saúde (Hospital / Clínica)	☐	☐	☐	☐
Responsáveis financeiros e contabilísticos	☐	☐	☐	☐
Peritos	☐	☐	☐	☐
Colegas	☐	☐	☐	☐
Relações pessoais (conhecidos, amigos, etc)	☐	☐	☐	☐
Utilizadores da tecnologia (Técnicos de Radiologia)	☐	☐	☐	☐
Gestores de conta / Consultores comerciais /vendedores	☐	☐	☐	☐
Meio empresarial / industrial	☐	☐	☐	☐
Investigadores / Académicos	☐	☐	☐	☐
Decisores políticos	☐	☐	☐	☐
Consumidores (utentes)	☐	☐	☐	☐
Grupo de cidadãos (Associações, grupos de pressão, etc)	☐	☐	☐	☐
Sociedade em geral	☐	☐	☐	☐
Comunicação social	☐	☐	☐	☐

11. Os <u>Indicadores (financeiros, técnicos, organizacionais, etc.) foram mais importantes do que as Pessoas</u> referidas na pergunta anterior? (Responda apenas se a sua resposta foi **SIM** na questão 4)

☐ Sim
☐ Não

12. Como <u>percepcionou a sua tomada de decisão</u>?

	Nunca	Algumas vezes	Muitas vezes
Hierárquica	☐	☐	☐
Solitária	☐	☐	☐
Competitiva	☐	☐	☐
Em colaboração	☐	☐	☐
Com participação de outros intervenientes	☐	☐	☐

13. Foi o último decisor ao longo de todo o processo?

☐ Sim
☐ Não. Se Não, quem foi? ____

14. Relativamente à decisão tomada para a aquisição de equipamento RM, como percepciona a satisfação, sob a perspectiva dos seguintes grupos?

		1	2	3	4	5	6	7	
Direcção do Hospital	Insatisfatória	☐	☐	☐	☐	☐	☐	☐	Muito satisfatória
Chefias do Serviço de Radiologia (área clínica)	Insatisfatória	☐	☐	☐	☐	☐	☐	☐	Muito satisfatória
Chefias do Serviço de Radiologia (área técnica)	Insatisfatória	☐	☐	☐	☐	☐	☐	☐	Muito satisfatória
Pessoal do Serviço de Radiologia (Médicos)	Insatisfatória	☐	☐	☐	☐	☐	☐	☐	Muito satisfatória
Pessoal do Serviço de Radiologia (Técnicos)	Insatisfatória	☐	☐	☐	☐	☐	☐	☐	Muito satisfatória

Posso esclarecer consigo algumas das questões abordadas neste inquérito?
Se Sim, indique por favor o seu email:____

Muito obrigado pela sua colaboração.

Para qualquer questão/sugestão contacte-me, por favor, através do *e-mail*
mj.maia@campus.fct.unl.pt

Appendix 3-2 Overview of the decision-makers that participated in the research

Code	Position	Sector	Localization	Questionnaire	Interview
DM 1	Radiology Department Coordinator	Private	Lisbon	x	x
DM 2	Radiology Department Coordinator	Public	Lisbon	x	x
DM 3	Engineer at Installation and Equipment Service (SIE's)	Public	Lisbon	x	x
DM 4	Radiology Department Director	Public	Lisbon	x	x
DM 5	Radiology Department Director	Public	Lisbon	x	x
DM 6	Clinic Owner / Administrator	Private	Lisbon	x	x
DM 7	Clinic Owner / Administrator	Private	Lisbon	x	x
DM 8	Radiology Department Coordinator	Private	Lisbon	x	x
DM 9	Radiology Department Coordinator	Private	Lisbon	x	x
DM 10	Radiology Department Coordinator	Private	Lisbon	x	x
DM 11	Clinic Owner / Administrator	Private	Lisbon	x	x
DM 12	Radiology Department Coordinator	Private	Lisbon	x	x
DM 13	Radiology Department Coordinator	Private	Lisbon	x	x
DM 14	Radiology Department Coordinator	Public	Lisbon	x	x
DM 15	Radiology Department Coordinator	Private	Lisbon	x	x
DM 16	Radiology Department Coordinator	Private	Lisbon	x	x
DM 17	Radiology Department Coordinator	Private	Lisbon	x	x
DM 18	Radiology Department Coordinator	Private	Lisbon	x	x
DM 19	Radiology Department Coordinator	Private	Lisbon	x	x
DM 20	Clinic Owner / Administrator	Private	Lisbon	x	x
DM 21	Radiology Department Coordinator	Private	Lisbon	x	x
DM 22	Administrator	Private	Madeira	x	
DM 23	Radiology Department Coordinator	Private	Madeira	x	
DM 24	Board President	Private	Algarve	x	
DM 25	Radiology Department Coordinator	Private	Algarve	x	
DM 26	Clinic Director	Private	Algarve	x	
DM 27	Radiology Department Director	Public	North	x	
DM 28	Radiology Department Coordinator	Public	North	x	
DM 29	Hospital Physicist	Public	Lisbon	x	
DM 30	Radiology Department Coordinator	Public	Lisbon	x	
DM 31	Radiology Department Coordinator	Public	Lisbon	x	x
DM 32	Radiology Department Director	Public	Lisbon	x	x
DM 33	Radiology Department Director	Public	Lisbon	x	
DM 34	Clinic Director	Private	Azores	x	
DM 35	Radiology Department Director	Public	Centre	x	
DM 36	Radiologist	Private	Lisbon	x	
DM 37	Radiology Department Coordinator	Private	Centre	x	x
DM 38	Radiology Department Coordinator	Public	Lisbon	x	x
DM 39	Manager	Private	Lisbon	x	x
DM 40	Radiology Department Coordinator	Private	Lisbon	x	x

Appendix 3-3 Letter of invitation

FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE NOVA DE LISBOA

Exmo. Sr(a). ___________________

Monte de Caparica, Data

Assunto: **Pedido de autorização para aplicação de questionário, no âmbito de tese de doutoramento**

O meu nome é Maria João Ferreira Maia, sou investigadora e aluna do Programa Doutoral em Avaliação de Tecnologia, na Faculdade de Ciências e Tecnologia, da Universidade Nova de Lisboa. Venho por este meio, solicitar a V. Exª autorização para que, no âmbito da minha tese de doutoramento intitulada "O processo de tomada de decisão na Radiologia: o exemplo da Ressonância Magnética, num contexto de Avaliação de Tecnologia em Saúde", possa aplicar um pequeno questionário sobre "***Competências para a tomada de decisão***", a todas as classes profissionais do Serviço de Radiologia e Neurorradiologia. A informação recolhida irá permitir um melhor conhecimento sobre as competências necessárias à tomada de decisão através de um mapeamento das mesmas a nível dos diferentes profissionais num Serviço de Radiologia.

Verifiquei que Serviço de Radiologia, existe um equipamento de Ressonância Magnética. Por esta razão, para complementar o meu estudo, possuo outro questionário que gostaria de, sob a forma de uma conversa/entrevista, caso seja possível, realizar aos tomadores da decisão aquando da aquisição deste equipamento. Caso estes decisores, por motivos de agenda, não se possam encontrar comigo, gostaria de solicitar a sua colaboração com o preenchimento do questionário "**Processo de tomada de decisão tecnológica**".

Saliento que serão garantidos o anonimato e a confidencialidade dos dados, em relação aos profissionais e à instituição, respectivamente. A participação é de carácter voluntário.

A metodologia proposta neste protocolo salvaguarda que a recolha de dados não envolve qualquer tipo de informação relacionada com os doentes/utentes, pelo que não existe necessidade de consentimentos informados da parte dos mesmos.

Os dados recolhidos serão usados apenas no âmbito da tese de doutoramento, nomeadamente na elaboração da tese e dos trabalhos que lhe estão associados.

Os questionários em papel serão fornecidos pelo investigador não sendo por isso requeridos qualquer tipo de recursos por parte da vossa Instituiçaõ para a realização do estudo.

Junto anexo pedido de autorização formal, bem como o protocolo de investigação, onde constam os questionários em questão.

Grata pela atenção que possa dispensar.

Com os melhores cumprimentos,

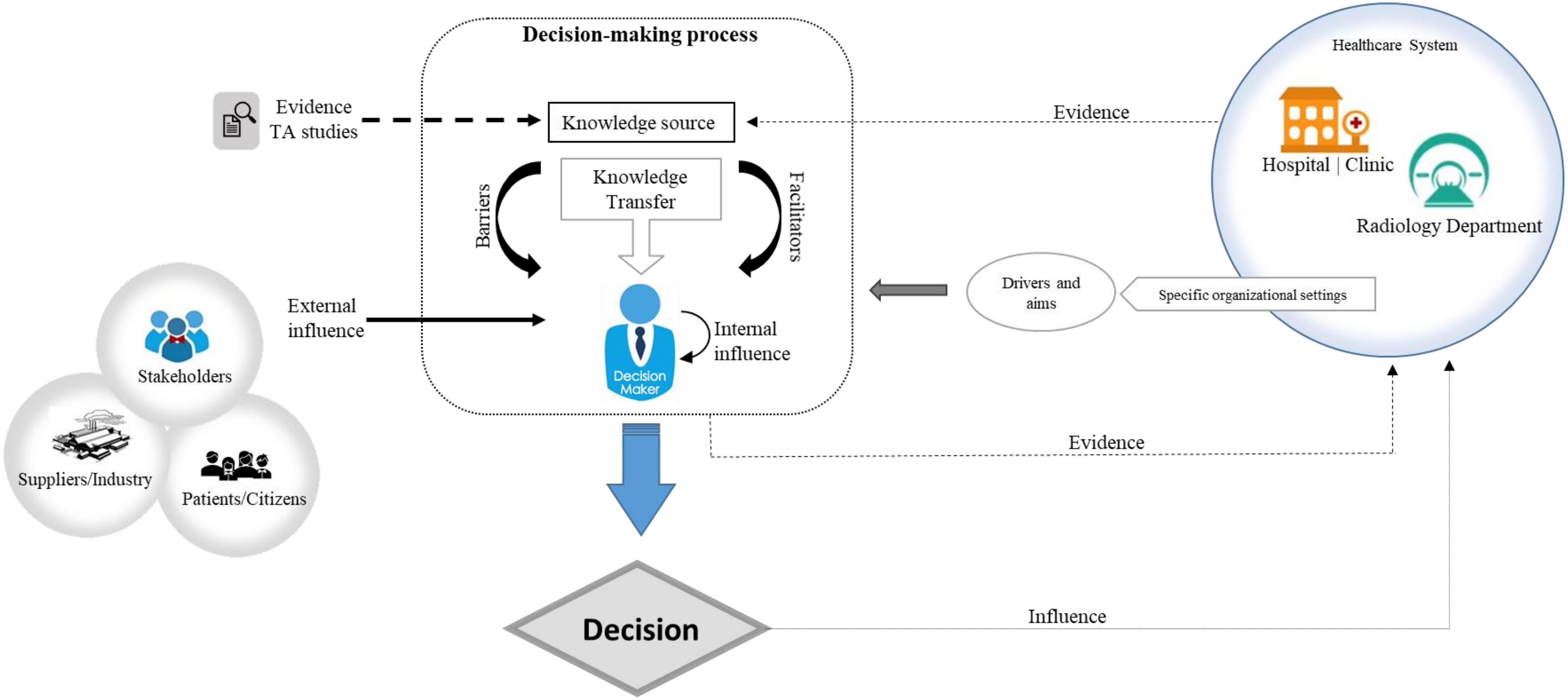
Maria João Ferreira Maia

Appendix 3-4 Interview guideline

	Topics	Questions	Objectives (required information)
Open questions	Characteristics of the interviewee and the Radiology department	- Gender - Position - Sector - Location	Brief characterization of the interviewees and the Radiology department
Introductory questions	**Drivers for the technology purchase**	- From the point of view of the Radiology Department, what was the motivation behind the decision to purchase an MRI scanner? - From the Department perspective, what were the main objectives with the purchase?	To establish the starting point of the decision process and the drivers that led to it.
Transition questions	**Characterization of the decision-making process** Use of evidence (in general) - before the decision - after the decision	- Were there any kind of studies performed before or after the purchase of the device? - Who conducted the studies?	To establish the use of evidence in the process. To identify specific indicators.
	Use of indicators and its importance	- Were there any indicators used to support the decision? If yes, which ones? (a set of options are presented for complement) - Please prioritize the 3 most important indicators, used in the decision. - When and how often did the indicators were used? (closed question with options) - Was there any other indicator used?	
	Role of the indicators	- To what extended do you agree with the following sentences? (a Likert scale is to be mentioned): The indicators were useful: • To understand future needs • To better understand the actual situation in relation to the technological development • To confirm the purchase decision • To justify the purchase decision • To characterize the acquisition • To fulfil formalities • They were not useful	

	Topics	Questions	Objectives (required information)
Key-questions	Steps of the decision-making process	- Please summarize the steps taken in the decision-making process (MRI scanner purchase)	To characterize the decision-making process. To understand the possibility of external influences.
	Role of people	- How important was the role of the following people during the decision process? (list of people is pre-defined. A Likert scale is presented) - Did someone else played a role that was not mentioned? - Were the indicators previously identified more important than the people mentioned?	To identify who were the decision-makers involved. To establish the importance and the role of the different decision-makers involved in the process. To characterize the influence that external factors, such as relationships can have in the process.
Final questions	Self-perception of the decision process	- How did you perceived your decision making? (some options are presented. A Likert scale is to be used) - How did you perceive the satisfaction of the following groups with the decision process? (a list of groups is presented. A Likert scale is to be used) Please elaborate	To characterize the influence of the personal characteristics of the decision-maker in the process. To establish the satisfaction of others with the process.
End of the interview	Review	If you were able to go back in time, would you have done something different? Was there any aspect that you considered to be important in relation to the decision-making processes that was not approach so far?	Make sure nothing goes unsaid Getting advice from respondents

Appendix 3-5 Categorical analysis



Appendix 4-1 Interviews synopses

		Code	Line	Segment
Drivers for technology purchase	Motivation and aim(s)	DM1	95	(…) provavelmente deve ter mais capacidade tecnológica para fornecer os clientes, mas também tem, muitas vezes, a ver com não pagarem tantos impostos.
		DM13	23	(…) a ressonância que nós tínhamos era bastante antiga, provavelmente já não teria a tecnologia com capacidade de responder àquilo que eles (Radiologistas) precisavam.
		DM4	25	(...) essa competitividade é um bocado complicada no nosso modelo hospitalar e de gestão, porque no fundo não há propriamente uma competição entre os hospitais. Os hospitais têm uma área geográfica de implantação, servem uma determinada população e essa população é praticamente obrigada a ir a esse hospital, não é?
		DM9	299	A defesa disto é que, é uma questão de maior oferta, e pode gerar maior procura e, a questão de instalarem (...) para captar aqueles clientes do centro de Lisboa para ali. Agora, se devemos ter ali duas ressonâncias? Acho que não.
		DM10	333	(...) o universo global da medicina começou-se a fazer muito mais ressonância do que antes… aos poucos começou-se a substituir um bocadinho doutras técnicas pela ressonância.
		DM10	337	(..) as coisas evoluíram brutalmente e, portanto, apesar das ressonâncias terem hipótese de evoluir em termos de software, hardware, bobines; se ter conseguido algumas actualizações, os próprios clínicos do serviço já sentiam algum défice de qualidade e de capacidade de fazer exames diferentes naquela máquina e, portanto, começou-se a pensar em adquirir um novo equipamento
		DM11	64	Na altura parecia que a ressonância ia explodir, como deveria ter explodido, de certa forma, antes de aparecerem os condicionalismos financeiros que todos conhecemos, e portanto, achávamos que tínhamos que ter aquilo, senão ficávamos um pouco amputados tecnicamente.
		DM11	122	Alguns tinham experiência, outros tinham vindo de óptimos estágios, por exemplo nos Estados Unidos, com ideias muito claras do que gostariam de fazer. Isso foi o nosso impulso. Portanto, nós não estávamos preocupados se havia ali à esquina, se queríamos ser melhor que aquele.
		DM11	124	Tínhamos gente que achávamos que tecnologicamente estava muito bem preparada para avançar com uma técnica, e que porque não aproveitar esse know-how (…)
		DM11	146	(…) a vontade de crescer e de termos os recursos humanos foi a base.
		DM42	2	Existem aqui dois… basicamente dois grandes níveis de reflexão sobre a decisão de investir. Uma delas é clinica…. Desde já e logo deve ser a prioritária…. Se há ou não a necessidade do equipamento… então há uma decisão clinica a tomar, que normalmente é feita pelo Director de Serviço ou com quem for pertinente na altura. E depois tem uma decisão económica, que tem a ver com os gestores. Portanto existem estas duas grandes vertentes!
		DM12	206	(…) também não quero fugir, porque acho que se o fizer não estou a ser correcto, ao marketing. Porque também faz parte de uma entidade privada poder dizer que faz. Houve aqui algum interesse…
		DM8	7	Nós também nós queríamos diferenciar pelos equipamentos que havia em termos de state-of-the-arte, o que há de melhor no momento.
		DM7	44	Eu sou um técnico de saúde, sou um operário especializado e, a ferramenta com que eu trabalho é um doente. Portanto, é muito importante que… mas não é ele que eu tenho de satisfazer. O meu verdadeiro cliente é o médico que o manda
		DM7	44	É muito mais importante satisfazer o médico porque, sendo assim, de uma via indirecta eu estou a satisfazer um doente.
		DM12	52	Satisfazer… não isto não teve, não teve de forma alguma. Não. Os pacientes também não, nem eles sabem o que é.
		DM4	41	Satisfazer os clínicos, isso, acho que não. Isto, os utentes, não, fornecer, eu penso que isto aqui… os doentes acho que não têm noção, e em Portugal ainda menos, não é?
		DM11	66	A parte do desenvolvimento tecnológico, a competição aqui nem existia, porque não havia mais na zona.
		DM11	80	Toda a gente sabia que a ressonância não ia ser rentável.
		DM12	93	Seja na pública, seja na privada, e você deve perceber, se calhar melhor que eu, que é um investimento brutal e esses investimento tem que ter objectivos. E esses objectivos são com certeza, e a ideia é, quando se investe, seja numa ressonância ou noutro, é melhorar a prestação, portanto, podermos fazer novas ideias clínicas.
		DM5	125	Não é a preferência dele, é a preferência nossa, o desgraçado não tem preferência nenhuma.
		DM8	11	Continua a não ser o factor mais importante, porque se fornecessmos cuidados de saúde de alta qualidade e eles não forem rentáveis… não faz sentido… infelizmente… pode chocar algumas pessoas, mas é verdade!
		DM14	245	Realizar novas investigações, nós nunca fomos um serviço virado para a investigação. Satisfazer a preferência dos utentes, os utentes pouco sabiam na altura sobre isto, mas sim, pronto, ok. Satisfazer a preferência dos clínicos, muito. Minimizar custos de operação, maximizar a receita, esta é a menos porque isto é um serviço público, um serviço público tem muito pouco de maximização de receita.
		DM16	19	A escolha dos equipamentos foi muito racional: o que é que precisamos? É bom que seja uma coisa boa, testada e de topo, mas não pode ser o topo de gama porquê? Porque isto vai durar 10 anos e o topo de gama no inicio a gestão é caótica, porque a ampola não estava preparada (...) Queríamos comprar uma coisa que de certa maneira fosse fiável, que desse segurança as pessoas e aos profissionais e que se pudesse fazer todos os exames que pretendíamos"
		DM7	54	Realizar novas investigações, num consultório privado, acho que tem muito pouca importância. Não é aqui que vou fazer estudos científicos.
		DM5	65	agora cá qual tempo para investigação? Não há! Em relação aos clínicos, exactamente a mesma coisa, fomos assaltados «Ah e tal, uns protocolos de investigação, e não sei quê, no domínio disto e daqueloutro» … águas de bacalhau.

		Code	Line	Segment
Characterization of the decision- making process	Use of evidence	DM9	341	Só que, também é verdade que esta história de troca de equipamentos tem custos elevadíssimos, sobretudo na ressonância. Por exemplo, as gaiolas não são compatíveis, tem de se desinstalar tudo e montar tudo de novo. Só uma instalação e desinstalação custa, para aí, sei lá: 50 000 Euros; ou, coisa assim parecida. É muito dinheiro e, portanto, se calhar, com esses 50 000 Euros fazemos um upgrade a este equipamento e ficamos satisfeitos e, temos outro lá em baixo. Deve ter sido o caso mas, primeiro que decidissem… (a clínica já tinha 1 RM)
		DM1	150	Não foi a que apresentou o preço mais baixo. Escolheu-se o aparelho que na altura a marca ainda não tinha em Portugal.
		DM2	68	(…) foi visto que tínhamos uma lista de espera brutal e que só com um equipamento não dava resposta.
		DM10	61	E foram feitos estudos da quantidade de exames que não se faziam – e, tinha a ver com as listas de espera de exames e etc. – para se perceber que, depois, com a vinda do novo equipamento se seria, ou não, de valorizar.
		DM5	155	na privada tem de se fazer, é obrigatório.
		DM5	165	no serviço nacional de saúde (…) seria uma perda, eu até percebo, não há necessidade de fazer um estudo de mercado, o mercado está cá dentro, não é?
		DM15	49	(...) todos os anos, fazemos um estudo de viabilidade, para ver se é necessário alguma coisa ou se na realidade há gastos a mais.
		DM14	249	Não, estávamos em 1998.
		DM4	51	(...) todos nós, subjectivamente e objectivamente, todos nós sabíamos que com o aparelho de 0,5 Tesla isto estava esgotado, quer em qualidade, quer em quantidade de exames, não havia hipótese. Toda a gente sabia que o hospital estava a mandar para o exterior um grande, grande número de exames, outros diagnósticos eram de má qualidade, porque o equipamento já não era satisfatório. Agora, isso era um dado evidente, eram dados evidentes, não houve nenhum estudo a dizer «Olhe o hospital faz tantas ressonâncias, tem tantos pedidos é obrigado a mandar tantas para fora (...)». (...) está previsto haver indicações de acordo com a população servida por cada unidade hospitalar, e o nível do hospital, se é um hospital A4, se é um A1, se é um A2, consoante o nível do hospital então pode ter TAC de 64 planos, TAC de não sei quê. Ressonância de 3 Tesla, ressonância de 1,5. Tantas angiografias. E tantos técnicos a trabalhar nesse serviço. Isso está previsto.
		DM3	113	(...) querendo ou não, um fornecedor que nos, em quem nós tenhamos confiança, que nos dê garantias em termos de assistência técnica, de rapidez de assistência técnica, de qualidade de assistência técnica, não sendo um ponto avaliado directamente é sempre um ponto tido em consideração.
		DM3	137	Por uma questão de legislação, nós temos de fazer isto desta forma, por isso temos de utilizar os indicadores
		DM3	141	Avaliámos a garantia proposta por cada um deles.
		DM3	143	Talvez a uniformização de fornecedores da imagiologia.
		DM3	147	Para facilitar mais em termos de assistência técnica e termos de contrato de assistência técnica, tentar haver uma uniformização da marca. Como a ressonância anterior já era desta marca, se calhar já estariam habituados…
		DM3	151	(…) nós tínhamos, há uma série de equipamentos na imagiologia que já são da firma X, a ideia de ter uma firma a prestar assistência técnica a tudo, facilita bastante, em termos de custos de contrato também facilita.
		DM5	341	Cumprir formalidades da legislação. A gente teve de obedecer à legislação ali ao, por isso é que tivemos de ter o apoio de uma firma de advogados.
		DM6	12	(…) o que nós íamos procurar, era dentro daqueles todos que tinham as características que nós queríamos, aquele que fosse mais barato.
		DM6	62	Fundamentalmente os custos, as características e, o facto de realmente com os fornecedores W. Tínhamos TAC, ECO, tudo. E, portanto, foi isso.
		DM6	86	Havia um senão que a ADSE queria um 1,5T para termos ADSE e, a partir daí…
		DM6	155	(…) dentro dessa tecnologia toda que é de ponta, uma pessoa tem de ver softwares; é fundamental saber o que é que – em termos de vanguarda – se poderia fazer.
		DM6	171	(...) por exemplo, aquela coisa da claustrofobia; os equipamentos quanto mais curtos, menos barulhentos, etc.; isso, foi uma coisa que também se pesou um bocadinho. (...) isto tudo a pensar nos doentes. Portanto, os utentes são importantes. Não propriamente a opinião deles…
		DM6	178	(…) se o doente ficava com a cabeça de fora; se conseguia ficar com a cabeça de fora; se ouvia menos do que nos outros aparelhos, etc. Isto a pensar no consumidor. É importante.
		DM7	46	Fui forçado a pensar numa maneira relativamente diferente e, dar muita importância ao doente por uma razão que já lhe vou contar, e que eu desconhecia que isso pudesse ter tanta importância, sobretudo em termos de ressonância magnética.
		DM7	46	Aqui, chego à conclusão que a AA é a única marca que tinha umas coisas que, depois, percebi que são muito importantes: maior diâmetro do túnel, túnel mais curto e isolamento do som. Esta máquina produz menos 80% do ruído que as outras.
		DM7	72	A minha preocupação foi a escolha do melhor equipamento ao melhor preço e, parou practicamente aí.
		DM7	77	Há sites americanos que falam da satisfação do cliente e, de facto, no ano em que comprámos a AA – por ter menos avarias –, os proprietários da AA estavam mais satisfeitos consigo próprios e com que tinham, do que os da YY ou VV ou BB.
		DM7	116	Claro que têm de ser avaliados. Então agora… que as coisas são todas medidas ao micro-segundo, ao milímetro, ao cêntimo… as coisas têm de ter uma rentabilidade…
		DM7	173	É fundamental haver indicadores para informar as pessoas, e as pessoas tomaram a decisão tendo como base esses indicadores!
		DM7	173	(…) tinha sido utilizado um indicador que era mais subjectivo, que foi o da avaliação da qualidade de imagem a olho nu dos radiologistas.
		DM11	128	Acabámos por comprar do fornecedor a quem nunca tínhamos comprado nada. Isso não foi importante.

		DM12	454	Há uma pressão financeira brutal em cima das pessoas e a decisão neste momento é tomada só, posso-lhe dizer que ainda há bem pouco tempo, ainda agora há duas ou três horas, estive a falar com uma colega, da nossa área, esteve a dizer que as decisões, que a decisão lá no hospital dela. A decisão do equipamento e dos materiais, não levaram em conta nada, nada! Eles disseram «Nós gostávamos que fosse preto, que fosse assim e que fosse assado.», E depois apareceu outro a dizer que era assim e assado, «Quanto é que custa? É mais barato, compro!» Está a perceber? Pronto, tudo o que perguntou aí, o que é que interessa? Custo! E isso é…
		DM13	158	O facto de termos o PACS da XX.
		DM5	177	Se o concelho de administração não tem instrumentos, e agora cada vez mais, não tem instrumentos analíticos informáticos para isso, está tramado!
		DM5	275	Entrou o contrato de manutenção, que é fundamental, como sabe. E o preço desse contrato de manutenção também tinha uma bitola de, de, para a escolha do equipamento. Portanto, havia várias bitolas, há o preço, e há o contrato de manutenção, os prazos de entrega também (...)
		DM5	311	Há vinte anos atrás, faziam-se agora estudos de mercado, quer dizer, era a sensibilidade, naquela altura era a sensibilidade.
		DM5	395	(…) os financeiros são importantes. Mas eles também só tinham que tomar uma decisão, limite inferior, limite superior, ponto final, acabou. Mas, não há duvida que é fulcral, essa baliza é fulcral.
		DM10	496	Decidiu-se comprar uma ressonância, era necessária para toda a gente, a escolha da ressonância teve mais a ver com a parte técnica.
		DM15	115	O aspecto financeiro sobrepõe-se a isso. Ou seja, todos nós tivemos uma palavra, assim como temos em qualquer reunião, todos nós temos uma palavra. Mas depois vamos fazer contas.
		DM5	59	Nós sabemos à partida, que, não vamos conseguir dar resposta a tudo. Quer dizer, vamos actualizar o serviço, fazer com que o serviço seja um serviço moderno, com equipamento actualizado. Com ressonância magnética imprescindível e já com um atraso brutal, em relação àquilo que devia ser, mas que não vamos conseguir dar resposta a tudo. Porque ao longo destes vinte anos, o que é que aconteceu? É que as ressonâncias magnéticas pulverizaram-se por todo o lado, as indicações clínicas aumentaram brutalmente, de modo que quando nós instalamos o equipamento, sabemos à partida que vamos satisfazer uma pequena parcela das necessidades do hospital ou do centro hospitalar onde a gente está instalado. Não podemos dar resposta, vamos criar um outro problema, é que vamos criar um outro problema.
		DM14	361	A facilidade de relacionamento e características e tipologia dos fornecedores também era importante para nós. Porquê? Eu explico, porque por exemplo, quando nós punhamos um equipamento a concurso, não só as características técnicas eram importantes, mas tudo o resto, os contratos de manutenção, o relacionamento já existente.
		DM17	2	A firma X é uma parceiro importante do grupo, por isso se adquirissemos a outra marca....
		DM18	2	A opção pela aberta prendeu-se pelo custo. A aberta é mt mais barata.
		DM8	2	Em termos de equipamentos esta a ter-se alguma reserve em termos de aquisição de novos equipamentos, a preservar-se muitos bem os que se têm e em novas aquisições… o critério eu diria que é 80% (e acho que estou a ser simpático) é económico.
		DM8	9	Depois há um processo de negociação com as empresas e como sempre aquilo aqui o factor principal foi sempre o factor custo…
		DM8	10	Na altura já tínhamos um historial com a ZZ e na altura compramos os equipamentos à ZZ… e isso pesou na altura!
		DM37	5	Fez-se uma opção pela Y e eu penso que a opção que se fez pela Y, naquela altura… enfim, estou a arriscar-me um bocadinho a dizer isto, mas… eu acho que foi uma opção politica. Nós anteriormente tínhamos comprado um pacote de equipamentos há Y… onde se gastou muito dinheiro… havia uma grande ligação com Y nessa altura e houve ali alguma relação. por acaso a adjudicação do equipamento até foi um bocadinho estranha (…). Houve uma série de negociação com a Y na altura que já havia de outros equipamentos. Por tanto esse foi mais uma questão de gerir alguns custos (vários) que tínhamos e uma questão de manter o bom relacionamento que tínhamos com a Y.”
		DM19	6	Havia necessidade de colocar uma ressonância e que custasse o menos possivel
		DM1	166	Um outro aspecto importante é que havia um bom relacionamento com a equipa técnica e de gestão da marca.
		DM1	170	Já se tinha feito aquisição àquela firma de vários equipamentos e, sempre tiveram um bom relacionamento, tanto com os engenheiros que trabalham lá, tanto com a direcção da própria empresa em Portugal.

Characterization of the decision- making process — Stakeholders involved in the process and their importance

Code	Line	Segment
DM12	252	De maneira que tem de haver argumentos é evidente que na ressonância também o há. Eles começam por dizer, e nós vamos percebendo, nós vamos palpando, falando clinicamente, nós vamos palpando o que é que eles têm para nos oferecer. Oferecer de tecnologia, mais-valias dos equipamentos e no fundo onde é que eles são fortes. Depois eu vou percebendo, não sou nenhum velho, mas já não sou nenhum novo, de maneira que a relação com comerciais tenho eu diariamente. Se nós formos, se nos orientarmos só pelos trunfos que eles têm, quase de certeza que fazemos asneira. Porque todos nós, eu se lhe quiser vender estes óculos, podem não valer nada, mas arranjo qualquer coisa de bom neles, não é? Se nós só valorizarmos o que é bom e não valorizarmos o que é mau com certeza que depois…
DM12	258	Eu sou administrador de um hospital não sei onde e digo «Eu não compro à XX, compro à WW!», eu tenho de dizer porque é que não comprei. Nós aqui não! Nós aqui, «Olhe, comprei à XX porque gosto de amarelo!», ponto final. Não temos de dar cavaco a ninguém. Portanto, é esse o sistema. Ou seja, e a decisão, como diz, é uma decisão conjunta, não há patamar. Há, não sei se devo chamar patamar. Existe uma motivação clinica, ou seja, que é a área técnica a dizer o que queria, «Eu quero ter um mamógrafo, com tomossíntese digital directo, estereotaxia, com mesa de biópsia e com..., fantástico. Isto é a ideia que eu tenho, como director de serviço. E que eu tenho das ideias que os clínicos nos transmitem, «É pá, isto realmente é o que nós precisávamos, eu quero bom para o serviço.» Mas essa decisão nós transmitimos, nós quer dizer, eu enquanto orientador transmito. Mas esta decisão, depois é fundida com a área comercial, com a área de pagamentos, com as áreas… tudo, portanto há aqui uma… não existe… no público isto não existe, no público há uma diferença, há um caderno de encargos, não é?
DM1	217	Nós temos uma parceria com o instituto superior técnico na área da física, portanto, acho que sim. Foi importante também.
DM2	202	Do gestor da área, eh pá, é pouco importante porque ele não tem conhecimento (…) ... a gente é que lhe diz o que é que importante.
DM2	210	É irrelevante, ele desde que eles autorizem, depois todo o processo de decisão já não…já nem chega lá.
DM2	216	Os peritos, não tivemos perito nenhuns no assunto.
DM4	59	No guião é obrigado a participar.
DM6	132	Muito importante. Porque, neste caso concreto, não eram os colegas do próprio consultório; eram outros colegas que tinham equipamentos que nos foram dando feedback das coisas.
DM9	214	Importante, porque queremos prestar qualidade no serviço, a importância vem daí.
DM11	118	Não fomos propriamente contratar ninguém. Economistas que nos ajudaram, os amigos, familiares.
DM11	212	Peritos porquê? Porque, foram, obviamente que foi importante, porque como sabe a implantação de uma ressonância não é fácil, em termos estruturais, em termos de ruido, etc., etc., etc. Portanto, tivemos que ouvir peritos para saber onde é que poderíamos pôr, se pudéssemos comprar, se comprássemos a ressonância, como é que ela podia estar instalada, onde, para depois não haver problemas não é? (...) Portanto, foram ouvidos peritos.
DM12	321	Atenção, não quer dizer que não tomemos em consideração, mas não perguntámos aos utentes.
DM12	442	«O que é que achas?», não é? Podemos até nem ter grande peso, mas gostamos de botar a palavra. E acho que isso é importante pois motiva as pessoas.
DM13	34	A escolha do equipamento foi toda do Dr. Xpto
DM5	9	Há a administradora da área, mas que não está, que indirectamente, quer dizer, não tinha que tomar conta, mas…
DM5	11	Não ela nem sequer se sentou connosco.
DM5	27	Não era ela não tomava directamente, ela não tinha que tomar decisões.
DM5	59	Não, nem pensar. Qual consulta, está-me a ver no serviço nacional de saúde... e íamos... quem? Íamos perguntar a um desgraçado com um tumor cerebral se queria uma ressonância? Ele dizia «Mandem-ma fazer em qualquer sitio, se eu preciso dela.» Não, as pessoas tinham, os seus problemas estavam resolvidos.
DM5	125	Não é a preferência dele, é a preferência nossa, o desgraçado não tem preferência nenhuma.
DM5	345	O director clínico do hospital, não interferiu…
DM5	367	Perguntei a algumas pessoas: «Olha tu trabalhas, tu lidas…» a opinião. Às vezes a gente costuma fazer… até para o estrangeiro a gente telefona.
DM15	101	Este é economista, ele é economista e este é gestor de marketing, ...depois não percebem nada de saúde.
DM14	379	Os colegas também, houve alguns colegas que foram importantes, sobretudo os que já tinham experiência nesta área lá fora. Não havia muitos.
DM19	24	Os equipamentos duram pouco... 12, 14 anos... e alguns arrantam-se até ao fim...e depois são comprados em pacotes e os Técnicos não opinam nada... são negócios...
DM3	236	Sim, desvios. Por isso, foram mais importantes, sim, apesar de tudo os indicadores são mais importantes.
DM4	91	Isso é um não, não foram mais importantes do que as pessoas. Não foi porquê? Porque aqui, como você sabe, não há uma discussão financeira de custos a sério.
DM10	218	Teoricamente, deviam ser os indicadores mas, aqui não. Portanto é um «nim».
DM12	424	Eu tenho de comprar uma ressonância para o Hospital X, por exemplo, uma coisa pesada. Comissão de escolha, venham os senhores doutores, venham os senhores técnicos, venham os financeiros, venham os directores da área, vem aquela malta toda. Cada um com a sua ideia, não é? Debatemos, debatemos, debatemos. Gastamos, isto tem um custo, todo este processo tem um custo, que se nós fossemos contabilizar é brutal. E depois, normalmente, a decisão vai motivada para podermos negociar o melhor, porquê isto tudo? Para podermos negociar o melhor possível.

		Code	Line	Segment
Characterization of the decision- making process	Perception of the process	DM5	391	Porque estas pessoas todas, são pessoas como eu, que estiveram envolvidas no processo. Portanto todas são importantes, mas são tão importantes as pessoas que estiveram na discussão do processo como o que o processo contém do ponto de vista técnico.
		DM12	444	Chegar ali, até posso não lhes ligar nenhum, mas chegar ali ao pé de um colega e dizer assim: «Oh pá, o que é que acha, temos de comprar uma antena, assim ou assado?», e ele diz «Assado!» — e eu até posso não concordar, mas perguntei.
		DM11	242	Se os indicadores financeiros nos tivessem dado, sem qualquer espécie de dúvida que o negócio não era viável, as pessoas podiam querer muito que não fazíamos. Daí, isto há sempre muitas vertentes. Como é lógico. Estar a responder preto ou branco nestas coisas é muito difícil porque há vários tons de cinzento no meio. Se não fosse economicamente viável, ponto final, por muito que quiséssemos.
		DM5	391	Porque estas pessoas todas, são pessoas como eu, que estiveram envolvidas no processo. Portanto todas são importantes, mas são tão importantes as pessoas que estiveram na discussão do processo como o que o processo contém do ponto de vista técnico.
		DM16	17	(…) e uma relação estranha...porque os indicadores foram construídos pelas pessoas, por estas pessoas. Por isso... uma coisa não podia existir sem a outra.
		DM1	282	Sim, consultivo. (...) Sempre me deixaram, sempre e quando iamos negociar, muitas vezes até diziam: «Olhe esta bobine que nós… o standard é isto; mas, se nós comprarmos esta bobine, esta e esta, o custo acresce "n" Euros» – na altura, Escudos – «achas que vale a pena comprar, ou não?», «Há muitos exames para isto, ou não?»…
		DM1	303	E acho que eles levavam em linha de conta aquilo que eu lhes dizia. Claro, que um gestor financeiro só vê números.
		DM2	259	Não tinha ninguém com quem competir, só se fosse com o director de serviço.
		DM11	274	Por isso é que eu estou a dizer que estas coisas nunca são geralmente um mar de rosas, mesmo quando nós pensamos que fomos ao máximo, que conseguimos o máximo, em tudo (...) Depois vimos a saber que se calhar aquele excelente negócio, não foi assim tão bom quanto isso, porque as margens com que estas companhias lidavam (não sei se ainda lidam) são gigantescas e portanto é tudo muito relativo. Daí que se me perguntar «Está completamente satisfeito com aquilo que fez?», estou, fiz o melhor que podia. Era impossível fazer melhor? Do que eu sei agora, passados não sei quantos anos, não. Era possível ter feito melhor.
		DM12	238	Numa decisão destas onde estamos aqui a jogar com vertentes tecnológicas raras, estamos a falar de tecnologia de ponta, ou estamos a falar de necessidade de reestruturação, digamos assim, de infra-estrutura, onde há sempre uma necessidade de obras ou coisas completamente fora. Posso-lhe dizer que até tive de levantar o tecto do piso por causa da gaiola. Há o custo também que é brutal, não é? Tudo isso, é evidente que tem de ser pesado, e a decisão tem de ser bem medida. Podemos estar a falhar redondamente e depois então é que é uma chatice.
		DM12	408	Eu acho que é importantíssima, e o decidir em grupo é cada vez mais importante. Eu falo por mim, que sou da área e sei o que sei, e sei que sou limitado noutras áreas, que não sei. E o financeiro sabe fazer contas muito bem-feitas, mas não sabe sequer o que é a RM.
		DM12	418	Eu próprio tenho dificuldade em decidir ou tenho, quer dizer, posso ter a minha ideia, mas vamos lá tentar falar com as pessoas. Mas depois começo a ouvir, e ouvir meia dúzia é o suficiente. Ouvir demais às vezes baralha o sistema. Porque cada macaco no seu galho. E às vezes é difícil nós…
		DM12	420	Eu posso decidir, vamos por a hipótese que era eu que decidia a compra da ressonância, «Olhe, eu quero uma ressonância cor-de-rosa!», e depois vimos a ver que afinal a cor-de-rosa foi uma má opção, que devia ser amarela. Temos pena, que é como se costuma dizer, ninguém … quer dizer haverá depois é um director, um… «Eh pá, fizeste asneira!», «Fiz!» continua, quer dizer, no estado já não é bem assim, não é?
		DM12	430	Que se arrasta, um processo, uma coisa complicadíssima, que tem um custo de processo que depois é mais caro que o esforço financeiro.
		DM12	432	Aliás, os próprios vendedores são eles os primeiros a dizer, «Eh pá, pedem-me descontos de 20 mil euros naquele mamógrafo ou naquele TAC, mas depois perdem anos de discussão para decidir.» E nós a pagar.
		DM12	434	No privado é assim «Pá é preto ou amarelo?», «Amarelo!», «Quantos é que são?», «São meia dúzia.», Resolve-se rapidamente. E às vezes, nós aqui não é esse o caso, mas posso-lhe dizer que há locais privados onde nem se consulta.
		DM12	474	(…) as decisões são tomadas do topo o resto é peanuts.
		DM12	293	Nós resolvemos mandar vir a ressonância, não tínhamos doentes marcados, não havia nem sequer convenções para a ressonância, foi uma situação muito calma e serena. Foi assim. Fez-se as obras calmamente, o equipamento foi montado, foi tudo muito pacato.
		DM5	47	(…) adoptar a tecnologia moderna, isto já devia ter acontecido há quinze anos atrás.
		DM5	65	Finalmente, temos ressonância magnética, e depois quebram-se as expectativas. Não só, não damos resposta a tudo, como não damos resposta àquilo que, ao fim e ao cabo, quando um individuo trabalha a nível hospitalar e não na privada pensa, «No hospital a gente faz outro tipo de coisas e tal, e não sei quê e conseguimos fazer, explorar…» Não há capacidade. Um aparelho destes, um só, não tem capacidade para isso.
		DM5	339	Eu quando adquiro, tenho que dar justificação com certeza. Aliás, se tudo corresse mal, posso ir parar a tribunal, não é verdade? Imagine-se que havia uma burla naquilo, não é? E distorcíamos o processo todo.
		DM5	403	Não havia hierarquia nenhuma, as pessoas que ali estavam, digamos, há uma escolha de um grupo, e esse grupo funciona homogeneamente. (...) cada um de nós, procurar no outro, nos seus parceiros, aquele que é mais competente numa área. Sei lá, por exemplo, na escolha da bobine cardíaca, obviamente eu não me pronunciava.
		DM10	496	Sim até porque todos colaborámos mas, era uma decisão que era pacífica. Decidiu-se comprar uma ressonância, era necessária para toda a gente, a escolha da ressonância teve mais a ver com a parte técnica.

		DM16	21	Simplificava a estrutura das informações tecnicas dos equipamentos
		DM17	13	Teria aumentado a intensidade de campo na proposta consultava outras marcas
		DM18	13	Eu digo-lhe com muita honestidade: se fosse hoje eu não tinha posto a ressonância. Nós estamos a ter prejuízo...pronto, ela está paga, tudo bem, mas… (…) Nós temos de fazer contas. Independentemente de sermos profissionais de saúde... isto é um comércio! E isto funciona como funciona um restaurante! Se não vierem cá utentes, com certeza que estamos tramados. Não há volta a dar!
		DM18	18	A ressonância é um investimento muito caro. A clínica nunca tinha tido ressonância, e para nós era muito importante… e na altura consideramos isto um risco mas foi um sucesso absoluto.
		DM37	5	Fez-se uma opção pela XX e eu penso que a opção que se fez pela XX, naquela altura… enfim, estou a arriscar-me um bocadinho a dizer isto, mas… eu acho que foi uma opção politica.
		DM42	5	A minha participação nesse processo é claramente técnica. Com certeza que troco opinião sobre a possibilidade de investir ou não, mas a decisão e a reflexão é feita sempre pêlos médicos radiologistas. Nesse aspecto não me cabe a responsabilidade de decisão. A minha participação é sempre complementar no sentido de preparar os aspectos mais técnicos… o caderno de encargos, saber quais são as características pertinentes para a escolha e digamos controlar o processo, efectivamente. digamos tenho uma participação no controlo do processo nos aspectos técnicos e faço parte da decisão final, portanto a decisão final do presidente da comissão de escolha que normalmente é do médico radiologista, faço parte da decisão final nessa perspectiva dos aspectos técnicos.
		DM42	6	Não tive um papel de decisor de primeira linha, digamos assim, mas tive um papel de consultor nessa decisão
		DM43	8	Para podermos negociar preços para ganhar uns milhares… adjudicamos tudo a mesma empresa… e o foi… aquele que apresentar o valor mais baixo nos equipamentos topo de gama e obras. Por isso como deve calcular, ganhamos nums, perdemos noutros… mas era o pacote… e uma vez que é pacote.. a aquisição fica um pouco deturpada daquilo que nós queremos…
		DM43	10	Foi um processo longo que durou 2 anos
		DM43	11	Foi politica … (a decisão) Houve aqui uns processos de escolha q não seguiram verdadeiramente… os tramites normais por politicas paralelas…
		DM43	13	(...) as coisas nem sempre são compradas pela utilidade do equipamento… por aquilo que o equipamento pode servir melhor… de determinado perfil de necessidade hospitalar… (...) porque houve interesses de outros negócios (...) e os equipamentos de RM soa a pedras nos sapatos de algumas pessoas… A RM tem lacunas, porque não consegui adquirir todo o software, porque depois há actualizações… o preço dispara… mas n há dinheiro… [a decisão] não tem a ver… com a qualidade que se pretende… ou o perfil para aquilo que se pretende predominantemente…
		DM19	25	... uma coisa é o que está em concurso... depois quando ganham entregam outra...
		DM 38	26	Basta ver quem são as pessoas e onde é que elas estão... e que equipamentos estão nos outros sitios...e aqui em Portugal é mais complicado...e não é so aqi em Portugal... e até porque muitas das firmas nem se quer se preocupam quem são os decisores dos serviços... com a Radiologia...(...) isso é um mundo muito complexo... (...) Esta a ver negocios de 6 e 8 milhoes...por isso é que depois os Técnicos... muitos dos Técnicos... técnicos e médicos... não é so os técnicos...andam a passear... vão para aqui, vão para ali, vão para todo o lado... não há almoços grátis!
		DM4	99	A direcção do hospital, nunca está completamente satisfeita, quer sempre mais.
		DM11	266	Até porque alguns aprenderam a fazer ressonância, portanto foi mais uma possibilidade de evoluírem profissionalmente.
		DM11	268	Abre outras perspectivas de trabalho.
		DM14	401	A direcção nunca fica muito satisfeita.
		DM3	244	O último decisor, acaba sempre por ser o serviço, que acaba por assinar. Porque nós fazemos o parecer técnico e eles acabam por ser os últimos a assinar o parecer técnico, apesar de depois passar ainda pelo concelho de administração e passar pelo serviço de compras, mas basicamente a decisão que o concelho de administração ou o serviço de compras, ou serviços financeiros tomam é se se compra ou não se compra. Nunca se coloca a hipótese de «Não, esta decisão está errada é melhor outro equipamento!»
		DM15	431	É o concelho de administração que tem de dar, mas eu não sei se foi a directora do Serviço de Gestão de Compras, que comunicou a decisão lá para cima. Não é a decisão, o resultado.
		DM15	83	Mas o último decisor é a administração. (…) Pelo aspecto financeiro, apenas.
		DM8	8	Foi uma decisão feita com a minha ajuda, mas principalmente da administração. Não é a administração que diz: “É isto!”. Mas é a administração que diz, é isto, baseado na informação que foi transmitida, em grande parte por mim e pelo director clinico.

		Code	Line	Segment
Characterization of the decision- making process	Steps of the process	DM3	63	Fazemos sempre uma ponderação com o preço, neste o caso valia 30%, a qualidade técnica valia 40%, com as várias características que solicitamos às empresas que respondessem. Depois percentagens, assistência técnica pós garantia, principalmente em termos de valor, também avaliamos, neste caso avaliamos só o valor, mas nalguns casos também avaliamos componentes de qualidade da assistência técnica e garantia. E depois a valoração destes factores todos dá uma pontuação final que nos vai levar a escolher este equipamento em detrimento do outro.
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		DM3	81	(...) porque a partir de 195 mil euros, se não estou enganado, mas pronto, mais coisa menos coisa, todos os concursos são obrigatórios ser concursos públicos. Abaixo desse valor, nós podemos decidir se é concurso público ou se apenas contactamos as firmas que decidirmos.
		DM3	173	Para garantir que está tudo dentro das regras para não haver, queixas ou erros na legislação é que vai ao departamento jurídico.
		DM3	295	É a parte da negociação, muitas vezes os privados acabam por ter muito mais poder de negociação com as firmas, ou seja, têm duas propostas e acabam por poder negociar com este e com outro, e tentarem baixar preço, ter melhores condições, ter outras características de oferta dos equipamentos. Nós acabamos por estar muito mais restritos àquilo que pedimos inicialmente, aquilo que as firmas respondem e depois disso há muito pouco poder negocial.
		DM3	297	Os privados têm muito mais capacidade negocial do que nós.
		DM4	59	No guião é obrigado a participar.
		DM4	61	O caderno de encargos resulta da opinião de vários elementos da parte técnica, da direcção clínica, do serviço de instalações e equipamentos.
		DM6	49	Só vimos as características dos aparelhos quando fomos ver os aparelhos in loco não fizemos nenhum tipo de estudo específico.
		DM6	102	(…) no nosso caso concreto, foi a negociação das condições de manutenção; quer desse equipamento, quer do restante parque tecnológico que nós tínhamos.
		DM7	106	A XX não dava nenhuma TAC na compra da ressonância; e outras coisas assim. Enquanto que a WW e a AA estavam desejosas disso. A TT permitia-me pagar o aparelho a sete anos e ainda metia cá os computadores e não sei o quê! E eu a dizer-lhes «Mas, eu não quero computadores nem quero pagar em sete anos! Eu quero o melhor aparelho de ressonância magnética!» Está a perceber? Se eu tivesse a comprar para um hospital, provavelmente, tinha sido flexível a estas coisas todas. Com as dificuldades de equipar o serviço, eventualmente até com um Mercedes por fora, teria resolvido o problema de maneira diferente, compreende?! Não tem nada que ver, comprar para um privado ou, comprar para… Aqui, sou eu a poupar no meu próprio bolso. Sou eu que estou a pagar portanto tenho de ter muito juízo: se eu quero comprar uma ressonância, não quero comprar uma ressonância e uma TAC; como não há almoços grátis eu não posso acreditar que a XX me dá uma TAC se eu comprar uma ressonância grátis – não me dá nada! Estou a pagar as duas obviamente! É, ou não é?! Portanto, tenho de pensar. Provavelmente, o que eles queriam era que eu substituísse a TAC por um Porsche. Está a compreender a minha ideia?
		DM9	162	Não. Fomos chamados e foi dito: «O que está em cima da mesa é isto, isto e isto. Esta firma oferece isto, a outra aquilo e, esta aquilo. É essencial para o serviço que seja feita esta escolha como vocês diziam ou, se nós escolhermos este equipamento, coloca em causa o funcionamento do serviço? É algo que vai ter implicações em termos de funcionalidade do serviço, ou não? Ou pode ser adquirido?» Perante o quadro que nos mostraram, é assim, uma coisa era nós acharmos que era mais vantajoso para o serviço e, que seria uma opção mais segura por «n» razões. Outra coisa, é nós sermos lógicos e dizer. Não queremos ser teimosos. Digamos, de facto, em termos de características do equipamento, eles são, mais ou menos, idênticos mas, em algumas particularidades, podem ser melhores do que aquele. Mas, se é essencial? Se já não posso funcionar com este? Se pode funcionar tão bem como com aquele? Se calhar, não. Mas, tendo em conta que estes oferecem ou, que este equipamento custa metade deste, se isso é suficiente para justificar, ou não… Houve aqui, ou seja, nós perante as circunstancias, conscientemente, não podíamos dizer «Não, queremos aquele. Porque é aquele e, só aquele, que queremos.» Não podíamos, não era lógico. Dissemos: «Nós preferimos aquele mas, se por circunstâncias de negócio, ou financeiras, etc., se tiver de se ir por este, tudo bem.
		DM9	167	Estava a ser negociado ao mesmo tempo os equipamentos para a medicina nuclear, para o hospital de cascais e, portanto, era um bolo em que aquilo que foi vendido é que esta ressonância sairia quase de borla. O que é mentira. Completamente mentira e, nós sabíamos disso: que era mentira. Provavelmente, nem ficou mais barata do que se fosse a outra. Mas, isto é para a administração… Foi aquilo que nos disseram taxativamente. Perante este cenário…
		DM10	193	Na práctica a decisão foi de acordo os nossos indicadores porque falou-se num equipamento aberto e de 3 tesla e que, nós dissemos que não havia necessidade. Porque se não, se calhar, teria sido adquirido.
		DM10	199	Sim, eles mandam sempre. Desde que tenham os indicadores daquilo que se pretende, têm várias abordagens: ou mandam um relatório; ou em vez de mandar um equipamento mandam três ou quatro ali á volta para uma pessoa poder ver um bocadinho mais do que aquilo que… «Olha, este não conhecia. Se calhar…» e em vez de uma opção dão várias; às vezes têm uma abordagem directa com o serviço, vêm cá e falam connosco: «Então, o que é que querem mesmo?», «Então, e não querem isto e mais aquilo?» e pronto, para apresentarem as coisas mais de acordo com aquilo que se pretende.

		DM11	102	Primeiro há uma fase que é, a nossa capacidade financeira permite que budget. Depois dentro desse budget, quais são as opções possíveis, dentro dessas opções possíveis, quais são as variáveis de custo. E nessas variáveis de custo, nós vamos entrar com o preço do equipamento, vamos entrar com o preço da manutenção e vamos entrar também em linha de conta com aquilo que são as cerejas do bolo, que nós dizemos a brincar, que é aquilo que em termos de negociação podemos tirar para potencializar aquele espaço, sem gastar mais dinheiro, ok? No caso, o que nós queríamos para lá, que conseguimos foi um ecógrafo, entre aspas, à borla, que ninguém dá nada à borla. Quer dizer, quando a ressonância dá um ecógrafo à borla, está a metê-lo no preço da ressonância. Essas coisas são sempre assim, quem não acreditar nisto é ingénuo. Tenta-se maximizar isso, porque se não forçar isso eles não dão.
		DM11	108	As empresas no mercado que vale a pena, especialmente em equipamentos pesados, são quatro. São as quatro com que falámos. Depois a partir daí, eles perante um determinado plano de negócios, fizeram as suas apresentações. Fizemos uma short list, destas quatro duas, para não complicar muito as coisas.
		DM11	322	É obrigatório. Tem de haver o licenciamento.
		DM11	324	Não faz a mínima ideia do conseguir-se legalizar as coisas. Neste país é kafkiano, legalizar uma coisa, quer uma coisa, quer fazer tudo direitinho, vai às entidades e pergunta, isto é um processo kafkiano, que pode demorar anos.
		DM11	326	Pode ficar com a instalação parada, aqui há uns tempos atrás ele facilitaram, e portanto a pessoa pode de imediato começar a trabalhar e a qualquer altura ser inspecionada, mas fácil do que existia antes. O que vale é eu neste país, apesar de tudo, como é uma aldeia, o A conhece sempre o B, que é primo do C, que já jantou com o H, certo? E assim as coisas, vão-se encurtando etapas, porque se for de peito aberto…
		DM12	344	As legalizações são Kafkianas. Mas não, a única, melhorou só porque o processo burocrático foi facilitado, agora comunica-se e ponto final, mas eles é que tomam a iniciativa de vir quando entenderem, até aqui não era bem assim.
		DM13	226	Só o público é que precisa de abrir concurso. A privada não precisa de publicar absolutamente nada.
		DM5	29	E depois havia a participação dos assessores jurídicos, que são exteriores ao hospital. Que foram contratados pelo hospital, portanto, não fazem parte do hospital.
		DM5	427	Depois a seguir, são os contratos do leasing, do isto, daquilo, daqueloutro. Mais coisas que têm a ver com uma área, com que a gente não tem nada a ver e nem queremos.
		DM5	429	Portanto, uma coisa é a decisão da compra, outra coisa é a realização, a decisão da compra, digamos, o último passo, ao fim e ao cabo é, depois da conta e somar ver o que é que a grelha deu.
		DM5	433	Melhor assim, «O resultado do concurso foi isto!», e pronto, e aquilo seguiu lá os trâmites legais, tudo vem escrito em Diário da República. Aquilo há um, neste momento ninguém pode brincar em serviço, para a aquisição, há legislação apertada, para se seguir. Portanto, a gente não anda a inventar. Aquilo está tudo escrito, você tem de ter conhecimento disso.
		DM15	87	Foram os três elementos da administração, portanto, foi o presidente do conselho da administração (...). Portanto, delegou nos outros activos, que são o financeiro e o gerente. Depois foi o director clinico e fui eu.
		DM15	192	Porque já faz parte dos cadernos de encargos dos concursos, se está certificado ou não.
		DM14	203	(…) pertencia o director do serviço, pertencia eu, pertencia o administrador… M: Da área? T: Da área, e pertencia o engenheiro. M: O engenheiro que é, dos SIE's? T: Dos SIE's.
		DM14	209	Era feito um levantamento sobre as necessidades que eram necessárias para os equipamentos e todos os critérios que tinham de fazer parte do processo concursal, ok? Portanto, quer do ponto de vista da qualidade, quer do ponto de vista do financiamento, quer do ponto de vista das características técnicas dos equipamento, portanto, isto era algo que nós tivemos sempre muito cuidado e faziam parte dos requisitos para a aquisição do equipamento.
		DM14	223	(…) uma das coisas que nós fizemos, quando fizemos a aquisição dos equipamentos, sempre, foi, muitas vezes discutia-se. Qual é que era a verba que tínhamos para financiamento e depois o que é que conseguíamos pôr naquele pacote de financiamento, e como é que conseguíamos gerir isto com os indivíduos da empresa. E muitas vezes era nestas discussões do concelho, mais da área do concelho, com uma discussão mais estratégica que eles conseguiam pacotes… e que se conseguia que eles nos pusessem lá mais algumas coisitas. Software, ou mais algum… M: Ou outros equipamentos. T: Ou outros equipamentos, era assim que a gente conseguia.
		DM14	229	(...) como é que era feita a avaliação? A avaliação era feita, tendo por base uma série, portanto uma percentagem que era atribuída a cada uma dos campos, ok? Não me lembro já, já não me consigo lembrar disto, precisamente, como é que é que foi. Provavelmente foi 40% para os requisitos do equipamento, 20% para os requisitos da qualidade, 10% para o financiamento, deve ter havido aqui alguma coisa deste tipo assim.
		DM14	231	Teve que ser aberto em Diário da República.
		DM14	233	Depois, as candidaturas são seladas, portanto, são abertas perante os elementos do júri, não é? Portanto, depois são avaliadas
		DM14	235	Quem ficou melhor classificado em ranking foi quem ganhou.
		DM16	3	Direccao central de diagnistico por imagem (DCDI). Uniformiza as practicas e compras das unidades para lisboa e papel consultivo nas áreas do norte e sul. Quando uma unidade quer comprar um equipamento fala com a direcção central

		DM16	6	(…) DCDI: - reuniao de todas as caracteristica do equipamento - contacto com firma a requisitar propostas tendo como base a info anterior - firmas enviam propostas - comparaçao das propostas – caracteristicas técnicas - analise das sinergias do grupo – quais as vantagens de determinado equipamento dentro do grupo - contrapropostas – ex. Valores contrato de manutenção - escolha – decisão
		DM16	15	Durante 10 anos o equipamento é do XP ao fim desse anos acaba a parceria e o eqp passa para a ARS
		DM17	7	- Constataçao da procura e dificuldade em assegurar a demanda - Contacto directo com Siemens para fornecimento de tecnologia (nao houve contacto com mais nenhuma empresa) - Envio de sugestão por parte da siemens da tecnologia - Comparação do proposto pela firma com caracteristicas tecnologicas identificadas como sendo as desejadas Escolha da tecnologia
		DM18	5	- Administração e o director clinico e o TR coordenador (3 socios) - Escolha da tecnologia aberta (0,35T) pela diferença de custo de aquisição e manutenção. - Pesquisa de mercado com visita em congresso da tecnologia - tr coordenador - Contactadas 3 firmas: AA, BB e CC - Negociação entre firmas Escolha da firma que oferecia as melhores condições"
		DM18	11	A XX propôs um equipamento por cerca de 500.000... e eu disse... se eu tenho uma coisa que posso comprar por menos 120 mil... e ele disse-me "epá mas eu ofereço-te um ecógrafo e não sei quê e tal... e eu... "só um bocadinho"... liguei para os fulanos da WW e disse: meus amigos, a XX oferece-me um ecógrafo... e eles dissera, "a gente também te pode oferecer".. e eu.... pronto... é só uma questão de negociar!
		DM8	3	A questão técnica dos equipamentos… na ressonância… é… "eu quero ter uma ressonância" ... e quero fazer mama? E quero fazer cardíacos? E quero fazer difusão espectroscopia? Isso é que … quero ou não… a partir dai todos têm…são comparáveis! E depois vamos discutir preço, condições de financiamento… porque há empresas que têm facilidade e nos dizem que já negociaram com um banco … porque agora também está muito difícil dos bancos financiarem ... chegas a um banco e é uma guerra… "porque não…" …. Porque os bancos também não têm dinheiro… e as condições dos bancos são horríveis… as vezes há empresas que ao fornecerem o equipamento dizem: "nós já trabalhamos com este banco e nós já garantimos o financiamento, portanto se vocês quiserem dentro destas condições, o financiamento está garantido!" Isto só por si pode ser uma razão suficiente para que se achàramos que aquele equipamento tem condições…
		DM8	5	Foi adquirido um pacote de equipamentos … e na altura negociou-se com 3 firmas a aquisição do parque tecnológico.
		DM8	6	Foi dito as características técnicas gerais dos equipamentos. (clínicos centralizados na direcção clinica
		DM7	7	Havia diferenças enormes entre o preço dos equipamentos e, depois, quando se percebeu que havia concorrência, que havia ofertas paralelas… Uma das empresas, chegou a oferecer-me uma TAC se eu comprasse uma ressonância. De qualquer modo eu entendi sempre que aquilo que estava a comprar era uma ressonância e, queria a melhor ressonância que eu podia comprar, ao preço mais barato possível.

Appendix 5-1 Items (composite indicators) and respective statements, per group of knowledge

Group	Question	Item	Statement
Group: Knowledge	Q1	Medical Sciences	I have knowledges about the structure, function and standard diseases of the human body. It includes anatomy, physiology, pathology, biochemist, etc., knowledges.
	Q2	Physics	I have general knowledge on the physics of radiation, necessaries to the application of the different image technologies.
	Q3	Radiobiology and Radiological Protection	I have knowledges towards the comprehension of the effects caused by radiations on the human body, as well as protection and radiological safety.
	Q4	Electronics and Clinical Instrumentation	I have knowledge of the principles and manipulation of electronic medical devices used in Radiology.
	Q5	Management and Administration	I have knowledge on different technical areas of management and administration (knowledge of principles, techniques and management tools in planning, organizing, leading, quality control assurance, etc.)
	Q6	Communication and Behavioural Sciences	I have knowledges that allow to interact / work effectively in different situations as well as knowledge about the understanding of development and human behaviour either at the sociological or psychological level.
	Q7	Informatics	I have knowledge of the principles relating to the operation of computers and associated technology.
Group: How to do	Q8	Exams protocols	I review and adjust protocols of the exams made, keeping them up to date and adapted to changes and unforeseen circumstances.
	Q9	Internal quality assessment measures	I implement internal quality assessment measures, namely satisfaction monitoring and active management of claims, encouraging the participation of patients in the improvement of services.
	Q10	Projects and activities execution	I follow, control and assess the execution of projects and activities making sure and their development and goals are according to defined deadlines and costs.
	Q11	Rationalization measures	I implement measures for rationalization, simplification and automation of work processes and procedures, aiming to improve the productivity of services and costs reduction.
	Q12	Take measures in useful time	I take measures or make options in useful time, having in mind the Department priorities and the urgency of situations.
	Q13	Innovative solutions proposal	I propose innovative solutions in the systems of internal planning, methods and work processes. I establish consensus and agreements through negotiation, being persistent and flexible.
	Q14	Information critical analysis	I analyse in a critical and logical way, the information necessary to the performance of my tasks and activities.
Group: How to be	Q15	Principles of Ethical Conduct	In daily practice, I apply the principles of legality and ethical conduct.
	Q16	Auto confidence and determination	I am self-confident and determined to decide, even when it comes to hard choices.
	Q17	Open communication	I use a form of open communication and I create a climate conducive to the expression of others, by listening the other carefully.
	Q18	Initiative for problem resolution	I take the initiative to solve problems that arise in the scope of my activity.
	Q19	Resolution of problems with creativity	I can resolve unanticipated problems creatively.
	Q20	Organization task ahead	I organize the tasks in advance, in order to ensure a good performance of the Department.
Group: How to learn	Q21	To be listened to and taken into account	I am listened and considered by my co-workers.
	Q22	Potential implication of problem resolution	I consider alternatives for solving the problems and their potential implications for the Department and decide, in a reasoned manner, the appropriate options.
	Q23	Responsibility for decision	I assume the results of the decisions I make, being responsible.
	Q24	Availability for research projects	I reveal interest and availability for the development of research projects with added value to the Department and external impact.
	Q25	Adherence to innovations and technology	I am open to innovations and technologies with significant value for improving the operation of my Department and for individual performance.
	Q26	Integration in team works	I am integrated into work teams, inside and outside their usual context.
	Q27	Share information and knowledge	I share information and knowledge with colleagues, and I am available to support them, when requested.
	Q28	Knowledge on medical device characteristics	I have knowledge concerning the technical characteristics of the equipment.

Appendix 5-2 Identification and characterization of variable for analysis

Dimension	Variable Name	Variable Label	Scale and values
1	ANATOMY	Medical Sciences	Ordinal (1-5) 1- Don't agree/Not applied 2- Slightly agree 3- Agree 4- Strongly agree 5- Fully agree
2	PHYSICS	Physics	Ordinal (1-5)
3	PROTECTION	Radiobiology and Radiation Protection	Ordinal (1-5)
4	PRINCIPLES	Electronics and Clinical Instrumentation	Ordinal (1-5)
5	MANAGEMENT	Management and Administration	Ordinal (1-5)
6	BEHAVIUOR	Communication and Behavioural Sciences	Ordinal (1-5)
7	INFORMATICS	Informatics	Ordinal (1-5)
8	PROTOCOL	Exams protocols	Ordinal (1-5)
9	QUALITYASS	Internal quality assessment measures	Ordinal (1-5)
10	PROJECTS	Projects and activities execution	Ordinal (1-5)
11	RACMEASUR	Rationalization measures	Ordinal (1-5)
12	TAKEMEASUR	Take measures in useful time	Ordinal (1-5)
13	SOLUTIONS	Innovative solutions proposal	Ordinal (1-5)
14	CRITICANAL	Information critical analysis	Ordinal (1-5)
15	ETHICS	Principles of Ethical Conduct	Ordinal (1-5)
16	AUTOCONF	Auto confident and determine	Ordinal (1-5)
17	OPENCOMMUN	Open communication	Ordinal (1-5)
18	AUTOACTIV	Conducting activities autonomously	Ordinal (1-5)
18	PROBRESOL	Initiative for problem resolution	Ordinal (1-5)
19	CREATIVITY	Resolution of problems with creativity	Ordinal (1-5)
20	TASKS	Organization task ahead	Ordinal (1-5)
21	LISTEN	To be listened to and taken into account	Ordinal (1-5)
22	PROBIMPLIC	Potential implication of problem resolution	Ordinal (1-5)
23	RESPONSAB	Responsibility for decision	Ordinal (1-5)
24	INVESTPROJ	Availability for research projects	Ordinal (1-5)
25	INNOVATION	Adherence to innovations and technology	Ordinal (1-5)
26	TEAMWORK	Integration in team works	Ordinal (1-5)
27	SHAREINF	Share information and knowledge	Ordinal (1-5)
28	EQUIPUSE	Use of equipment with knowledge	Ordinal (1-5)
29	INSTITUTION	Institution Typology	Nominal: 1- Public; 2-Private
30	GENDER	Gender	Nominal: 1- Male; 2-Female
31	AGE	Age in years	Ratio
32	ACADEMQUAL	Academic Qualification	Ordinal 1- 6th Degree 2- 9th Degree 3- 11th Degree 4- 12nd Degree 5- Bachelor 6- Graduation 7- Master 8- PhD 9- Postdoctoral
33	PROFCAT	Professional Category	Ordinal 1- Radiographer 2- Radiologist 3- Clerk 4- Operational Assistant
34	EXPRAD	Experience in Radiology in years	Ratio
35	EXPMRI	Experience with MRI equipment in years	Ratio

Appendix 5-3 Questionnaire B "Competences in Decision-Making"

FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE NOVA DE LISBOA

Doutoramento em Avaliação de Tecnologia
"Decision-making process in Radiology"

Inquérito

Competências ao nível dos Saberes

Este questionário é uma ferramenta de recolha de dados, utilizada exclusivamente no âmbito do doutoramento em Avaliação de Tecnologia (FCT/UNL), pela doutoranda Maria João Maia na elaboração da sua tese "O processo de tomada de decisão na Radiologia: o exemplo da Ressonância Magnética, num contexto de Avaliação de Tecnologia em Saúde". A informação recolhida irá permitir um melhor conhecimento sobre a auto-avaliação que os diferentes profissionais do Serviço de Radiologia fazem às competências, através de um mapeamento das mesmas. Serão garantidos o anonimato e a confidencialidade dos dados, em relação aos profissionais e à instituição, respectivamente. A participação é de carácter voluntário.

Código: ______________________ Data:____/____/____

Tipologia da Instituição: ☐ Pública ☐ Privada

Idade: ________ Sexo: ☐ Masculino ☐ Feminino

Habilitações Académica: ______________________

Grau Académico: ______________________

Categoria Profissional: ______________________

Anos de Experiência na Radiologia: ______________________

Anos de Experiência com RM: ______________________

Como classifica, em termos de concordância, as seguintes afirmações, tendo em consideração a seguinte escala:

1. Não concordo / Não se aplica
2. Concordo pouco
3. Concordo
4. Concordo muito
5. Concordo plenamente

Possuo:	1	2	3	4	5
Conhecimentos sobre ciências médicas, nomeadamente a estrutura, função e doenças padrão do corpo humano (Inclui conhecimentos de anatomia, fisiologia, patologia e bioquímica, etc.)	☐	☐	☐	☐	☐
Conhecimento geral sobre física das radiações, necessária à aplicação das várias formas das tecnologias de imagem.	☐	☐	☐	☐	☐
Conhecimentos para a compreensão dos efeitos das radiações no corpo humano, bem como protecção e segurança radiológica.	☐	☐	☐	☐	☐
Conhecimentos sobre os princípios e o funcionamento dos dispositivos electrónicos e compreensão dos equipamentos utilizados em Radiologia, de modo a que estes possam ser utilizados.	☐	☐	☐	☐	☐
Conhecimentos sobre diferentes áreas técnicas de gestão e administração (conhecimentos em princípios, técnicas e ferramentas administrativas, em planear, organizar, liderar, garantia do controlo de qualidade, etc.).	☐	☐	☐	☐	☐
Conhecimentos sobre a compreensão do desenvolvimento e do comportamento humano quer a nível sociológico ou psicológico, bem como conhecimentos que permitam interagir/actuar efectivamente em situações diversas (comunicação).	☐	☐	☐	☐	☐
Conhecimentos dos princípios referentes ao funcionamento dos computadores e da tecnologia associada.	☐	☐	☐	☐	☐

v.s.f.f.

Eu:	1	2	3	4	5
Revejo e ajusto o protocolo dos exames efectuados, mantendo-os actualizados e adaptando-os a alterações e circunstâncias imprevistas.	☐	☐	☐	☐	☐
Implemento medidas internas de avaliação da qualidade, designadamente a monitorização da satisfação e gestão activa das reclamações, fomentando a participação dos utentes na melhoria dos serviços.	☐	☐	☐	☐	☐
Acompanho, controlo e avalio a execução dos projectos e actividades assegurando o seu desenvolvimento e a sua realização de acordo com os prazos e custos definidos.	☐	☐	☐	☐	☐
Implemento medidas de racionalização, simplificação e automatização de processos de trabalho e procedimentos, com vista a melhorar a produtividade do serviço e a reduzir custos.	☐	☐	☐	☐	☐
Tomo medidas ou tomo opções em tempo útil, tendo presente as prioridades do serviço e a urgência das situações.	☐	☐	☐	☐	☐
Proponho soluções inovadoras ao nível dos sistemas de planeamento interno, métodos e processos de trabalho. Estabeleço consensos e acordos através da negociação, sendo persistente e flexível.	☐	☐	☐	☐	☐
Analiso de forma crítica e lógica a informação necessária à realização das minhas tarefas e actividades.	☐	☐	☐	☐	☐

Eu:	1	2	3	4	5
Aplico os princípios da legalidade e de conduta ética, na práctica quotidiana.	☐	☐	☐	☐	☐
Sou auto-confiante e determinado a decidir, mesmo quando se trata de opções difíceis.	☐	☐	☐	☐	☐
Utilizo uma forma de comunicação aberta e crio um clima propício à expressão dos outros, ouvindo-os com atenção.	☐	☐	☐	☐	☐
Tomo a iniciativa para a resolução de problemas que surgem no âmbito da minha actividade.	☐	☐	☐	☐	☐
Resolvo com criatividade problemas não previstos.	☐	☐	☐	☐	☐
Organizo as tarefas com antecedência de forma a garantir o bom funcionamento do serviço.	☐	☐	☐	☐	☐

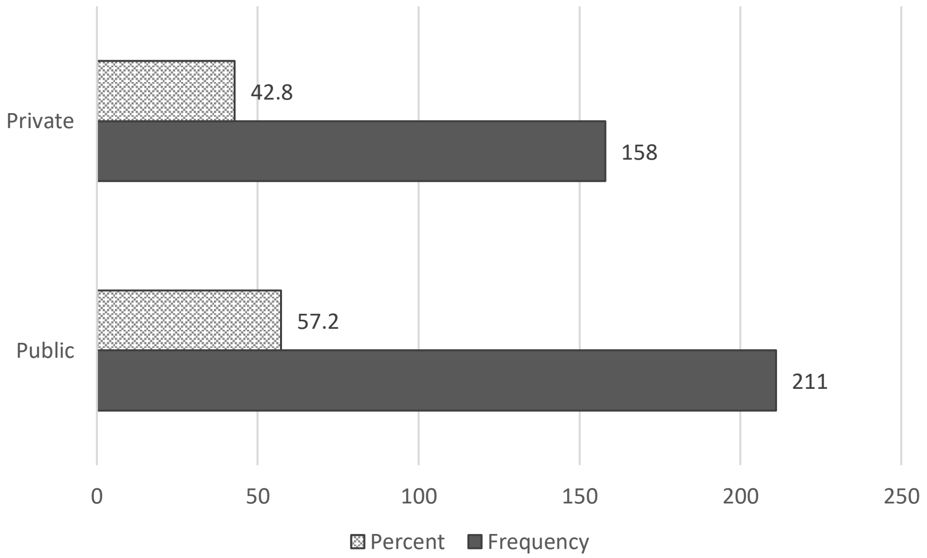
Eu:	1	2	3	4	5
Sou ouvido e considerado pelos colegas de trabalho.	☐	☐	☐	☐	☐
Considero as alternativas de resolução dos problemas e as suas potenciais implicações para o serviço e escolho de forma fundamentada as opções adequadas.	☐	☐	☐	☐	☐
Assumo os resultados das decisões que tomo, com sentido de responsabilidade.	☐	☐	☐	☐	☐
Revelo interesse e disponibilidade para o desenvolvimento de projectos de investigação com valor para o serviço e impacto a nível externo.	☐	☐	☐	☐	☐
Adiro às inovações e tecnologias com valor significativo para a melhoria do funcionamento do serviço e para o desempenho individual.	☐	☐	☐	☐	☐
Integro-me em equipas de trabalho, dentro e fora do meu contexto habitual.	☐	☐	☐	☐	☐
Partilho informações e conhecimento com os colegas e disponibilizo-me para os apoiar, aquando solicitado.	☐	☐	☐	☐	☐
Tenho conhecimento sobre as características técnicas dos equipamentos	☐	☐	☐	☐	☐

Muito obrigado pela sua colaboração.

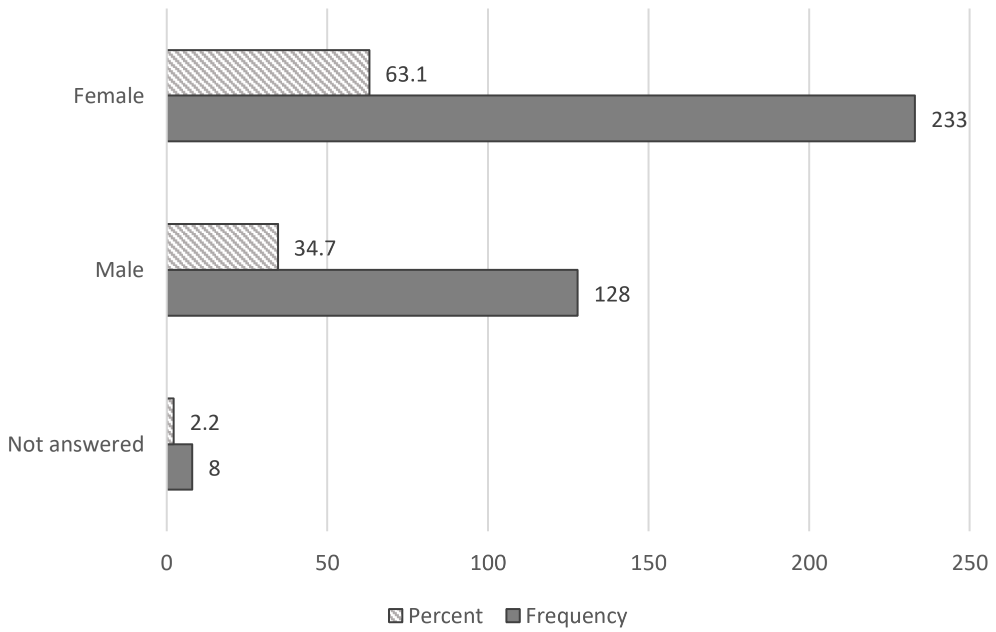
Para qualquer questão/sugestão contacte-me, por favor, através do *e-mail* mj.maia@campus.fct.unl.pt

Appendix 5-4 Socio-demographic characterization of the respondents

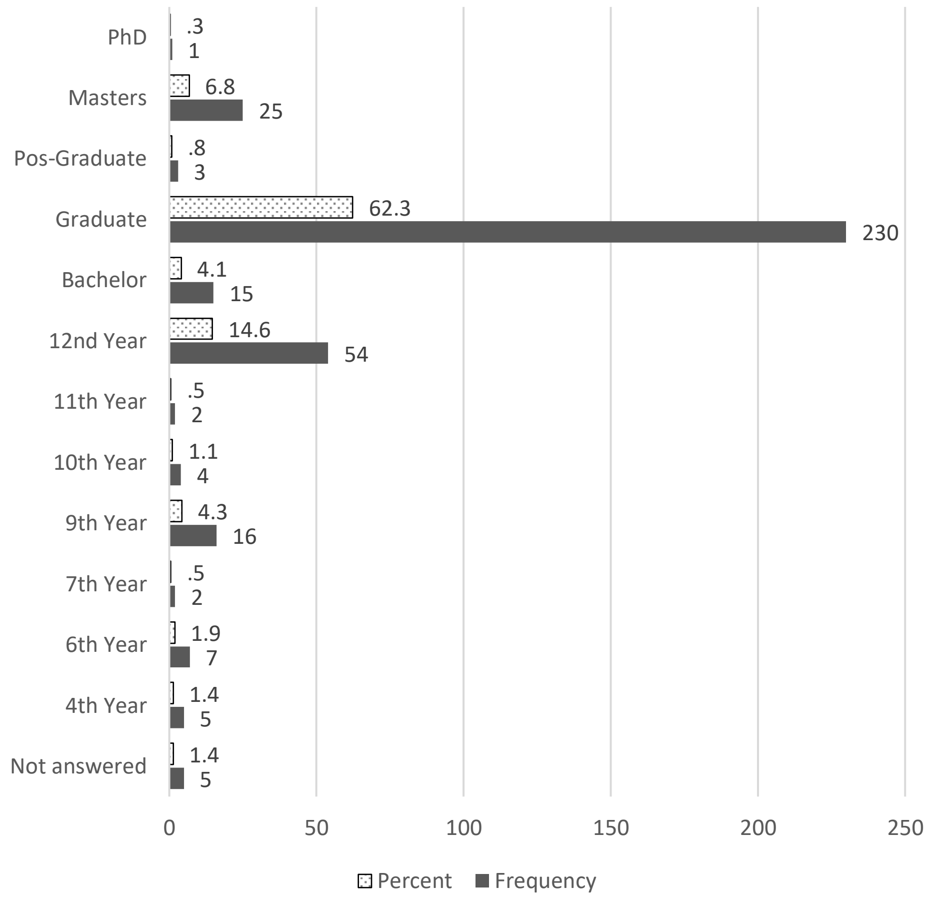
By Institution type



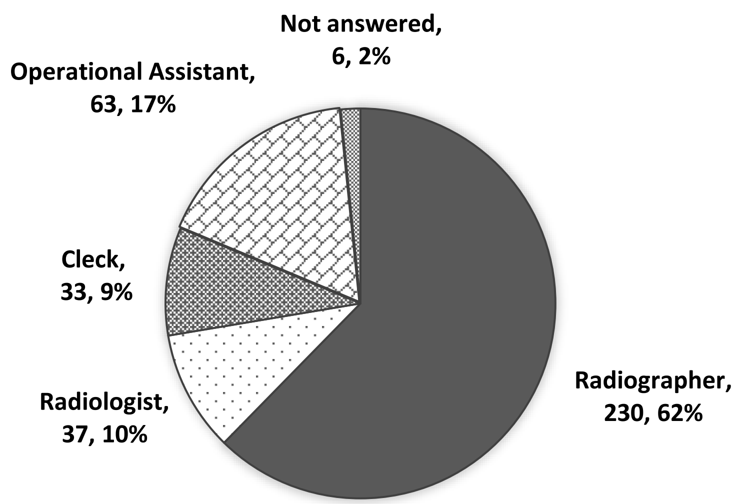
By Gender



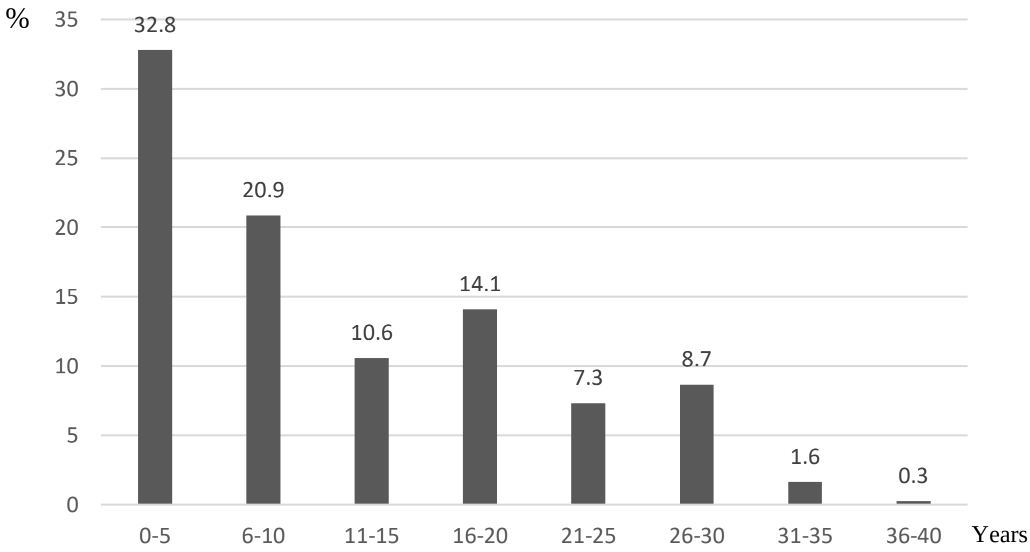
By Academic Qualification



By Professional Category



By Experience in Radiology



Appendix 5-5 Model testing

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Medical Science	.200	369	.000	.892	369	.000
Physics	.226	369	.000	.869	369	.000
Radiobiology and Radiation Protection	.269	369	.000	.832	369	.000
Electronics and Clinical Instrumentation	.232	369	.000	.874	369	.000
Management and Administration	.220	369	.000	.907	369	.000
Communication and Behavioural Sciences	.211	369	.000	.877	369	.000
Informatics	.218	369	.000	.873	369	.000
Exams protocols	.257	369	.000	.847	369	.000
Internal quality assessment measures	.176	369	.000	.907	369	.000
Projects and activities execution	.193	369	.000	.901	369	.000
Rationalization measures	.197	369	.000	.899	369	.000
Take measures in useful time	.250	369	.000	.847	369	.000
Innovative solutions proposal	.219	369	.000	.900	369	.000
Information critical analysis	.267	369	.000	.843	369	.000
Principles of Ethical Conduct	.304	369	.000	.740	369	.000
Auto confidence and determination	.255	369	.000	.842	369	.000
Open communication	.249	369	.000	.824	369	.000
Initiative for problem resolution	.263	369	.000	.823	369	.000
Resolution of problems with creativity	.256	369	.000	.849	369	.000
Organization task ahead	.235	369	.000	.842	369	.000
To be listened to and taken into account	.259	369	.000	.853	369	.000
Potential implication of problem resolution	.258	369	.000	.841	369	.000
Responsibility for decision	.291	369	.000	.759	369	.000
Availability for research projects	.228	369	.000	.872	369	.000
Adherence to innovations and technology	.258	369	.000	.820	369	.000
Integration in team works	.261	369	.000	.816	369	.000
Share information and knowledge	.292	369	.000	.758	369	.000
Use of equipment with knowledge	.252	369	.000	.782	369	.000

a. Lilliefors Significance Correction

Linearity Test - ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	279.681	28	9.989	15.066	.000[b]
1	Residual	221.432	334	.663		
	Total	501.113	362			

a. Dependent Variable: Professional Category
b. Predictors: (Constant), Use of equipment with knowledge, Projects and activities execution, Physics, To be listened to an taken into account, Communication and Behavioural Sciences, Organization task ahead, Availability for research projects, Auto confidence and determination, Integration in team works, Informatics, Take measures in useful time, Open communication, Management and Administration, Resolution of problems with creativity, Potential implication of problem resolution , Information critical analysis , Innovative solutions proposal, Principles of Ethical Conduct, Adherence to innovations and technology, Electronics and Clinical Instrumentation, Responsibility for decision, Rationalization measures, Exams protocols, Initiative for problem resolution, Internal quality assessment measures, Medical Science, Share information and knowledge, Radiobiology and Radiation Protection

Test of Homogeneity of Variances				
	Levene Statistic	df1	df2	Sig.
Medical Science	16.455	3	359	.000
Physics	13.601	3	359	.000
Radiobiology and Radiation Protection	22.300	3	359	.000
Electronics and Clinical Instrumentation	8.781	3	359	.000
Management and Administration	14.901	3	359	.000
Communication and Behavioural Sciences	8.915	3	359	.000
Informatics	2.751	3	359	.043
Exams protocols	22.940	3	359	.000
Internal quality assessment measures	7.098	3	359	.000
Projects and activities execution	4.888	3	359	.002
Rationalization measures	1.712	3	359	.164
Take measures in useful time	9.564	3	359	.000
Innovative solutions proposal	8.103	3	359	.000
Information critical analysis	9.225	3	359	.000
Principles of Ethical Conduct	7.371	3	359	.000
Auto confidence and determination	7.896	3	359	.000
Open communication	1.826	3	359	.142
Initiative for problem resolution	4.438	3	359	.004
Resolution of problems with creativity	1.842	3	359	.139
Organization task ahead	.474	3	359	.700
To be listened to and taken into account	4.390	3	359	.005
Potential implication of problem resolution	5.654	3	359	.001
Responsibility for decision	4.385	3	359	.005
Availability for research projects	5.042	3	359	.002
Adherence to innovations and technology	12.540	3	359	.000
Integration in team works	2.180	3	359	.090
Share information and knowledge	6.457	3	359	.000
Use of equipment with knowledge	3.305	3	359	.020

Multicollinearity test

Coefficients[a]

Model		Collinearity Statistics Tolerance	VIF
1	Institution Typology	.977	1.023
	Gender	1.000	1.000
	Age in years	.978	1.023
	Academic Habilitations	.974	1.026

a. Dependent Variable: Professional Category

Coefficients[a]

Model		Collinearity Statistics Tolerance	VIF
1	Gender	.999	1.001
	Age in years	.946	1.058
	Academic Habilitations	.797	1.255
	Professional Category	.794	1.260

a. Dependent Variable: Institution Typology

Coefficients[a]

Model		Collinearity Statistics Tolerance	VIF
1	Age in years	.938	1.066
	Academic Habilitations	.789	1.268
	Professional Category	.794	1.260
	Institution Typology	.977	1.024

a. Dependent Variable: Gender

Coefficients[a]

Model		Collinearity Statistics Tolerance	VIF
1	Professional Category	.827	1.210
	Institution Typology	.985	1.016
	Gender	.999	1.001
	Academic Habilitations	.815	1.227

a. Dependent Variable: Age in years

Coefficients[a]

Model		Collinearity Statistics Tolerance	VIF
1	Age in years	.970	1.031
	Professional Category	.981	1.020
	Institution Typology	.988	1.013
	Gender	1.000	1.000

a. Dependent Variable: Academic Habilitations

Bivariate correlation

Correlations

	Pearson Correlation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Medical Science	1																											
2	Physics	.749**	1																										
3	Radiobiology and Radiation Protection	.639**	.790**	1																									
4	Electronics and Clinical Instrumentation	.565**	.704**	.754**	1																								
5	Management and Administration	.373**	.414**	.397**	.493**	1																							
6	Communication and Behavioural Sciences	.438**	.373**	.445**	.456**	.538**	1																						
7	Informatics	.448**	.398**	.416**	.456**	.481**	.550**	1																					
8	Exams protocols	.649**	.669**	.568**	.532**	.362**	.363**	.423**	1																				
9	Internal quality assessment measures	.201**	.200**	.219**	.251**	.421**	.291**	.260**	.368**	1																			
10	Projects and activities execution	.256**	.252**	.216**	.264**	.406**	.292**	.263**	.426**	.748**	1																		
11	Rationalization measures	.257**	.242**	.272**	.310**	.374**	.359**	.208**	.363**	.651**	.651**	1																	
12	Take measures in useful time	.334**	.260**	.338**	.347**	.355**	.400**	.371**	.411**	.420**	.445**	.554**	1																
13	Innovative solutions proposal	.316**	.281**	.230**	.290**	.462**	.317**	.289**	.453**	.596**	.645**	.643**	.470**	1															
14	Information critical analysis	.337**	.288**	.409**	.376**	.266**	.372**	.380**	.389**	.285**	.246**	.416**	.557**	.310**	1														
15	Principles of Ethical Conduct	.324**	.341**	.373**	.323**	.217**	.246**	.328**	.396**	.126*	.128*	.197**	.374**	.114*	.487**	1													
16	Auto confidence and determination	.342**	.332**	.357**	.341**	.253**	.289**	.341**	.393**	.268**	.224**	.283**	.356**	.244**	.501**	.604**	1												
17	Open communication	.231**	.189**	.261**	.234**	.189**	.323**	.295**	.312**	.202**	.161**	.278**	.327**	.222**	.481**	.604**	.522**	1											
18	Initiative for problem resolution	.264**	.207**	.288**	.228**	.253**	.286**	.329**	.359**	.274**	.232**	.361**	.470**	.295**	.498**	.551**	.525**	.498**	1										
19	Resolution of problems with creativity	.261**	.210**	.225**	.268**	.268**	.291**	.345**	.290**	.265**	.235**	.302**	.329**	.341**	.396**	.355**	.522**	.396**	.627**	1									
20	Organization task ahead	.105*	.088	.154**	.151**	.183**	.252**	.207**	.177**	.233**	.179**	.307**	.334**	.314**	.411**	.308**	.293**	.378**	.525**	.457**	1								
21	To be listened to and taken into account	.226**	.232**	.251**	.250**	.178**	.205**	.214**	.292**	.192**	.198**	.261**	.230**	.195**	.324**	.289**	.347**	.364**	.390**	.390**	.331**	1							
22	Potential implication of problem resolution	.321**	.331**	.308**	.311**	.317**	.253**	.281**	.349**	.322**	.335**	.371**	.409**	.392**	.389**	.377**	.395**	.440**	.436**	.383**	.445**	.478**	1						
23	Responsibility for decision	.224**	.200**	.254**	.226**	.124*	.190**	.188**	.322**	.104*	.116*	.222**	.349**	.107*	.466**	.570**	.447**	.519**	.599**	.484**	.495**	.370**	.436**	1					
24	Availability for research projects	.225**	.248**	.263**	.293**	.326**	.178**	.287**	.288**	.282**	.372**	.267**	.328**	.283**	.367**	.303**	.303**	.248**	.327**	.349**	.264**	.318**	.359**	.348**	1				
25	Adherence to innovations and technology	.346**	.302**	.339**	.346**	.316**	.301**	.364**	.400**	.135**	.224**	.212**	.402**	.228**	.423**	.465**	.390**	.386**	.441**	.362**	.325**	.361**	.395**	.491**	.560**	1			
26	Integration in team works	.156**	.163**	.253**	.252**	.223**	.213**	.232**	.245**	.149**	.183**	.253**	.386**	.165**	.409**	.413**	.389**	.437**	.444**	.305**	.342**	.330**	.380**	.502**	.414**	.525**	1		
27	Share information and knowledge	.207**	.187**	.255**	.241**	.226**	.213**	.189**	.287**	.089	.075	.203**	.378**	.134*	.507**	.542**	.461**	.519**	.502**	.400**	.440**	.385**	.395**	.675**	.429**	.596**	.652**	1	
28	Use of equipment with knowledge	.286**	.258**	.328**	.324**	.207**	.210**	.271**	.352**	.096	.087	.217**	.373**	.164**	.487**	.475**	.422**	.421**	.501**	.407**	.385**	.333**	.372**	.594**	.365**	.623**	.477**	.663**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 5-6 Construct Validity test results

Communalities (1st round)

	Initial	Extraction
Medical Science	1.000	.715
Physics	1.000	.866
Radiobiology and Radiation Protection	1.000	.765
Electronics and Clinical Instrumentation	1.000	.697
Management and Administration	1.000	.647
Communication and Behavioral Sciences	1.000	.723
Informatics	1.000	.666
Exams protocols	1.000	.684
Internal quality assessment measures	1.000	.736
Projects and activities execution	1.000	.784
Rationalization measures	1.000	.707
Take measures in useful time	1.000	.524
Innovative solutions proposal	1.000	.699
Information critical analysis	1.000	.530
Principles of Ethical Conduct	1.000	.607
Auto confidence and determination	1.000	.571
Open communication	1.000	.576
Initiative for problem resolution	1.000	.674
Resolution of problems with creativity	1.000	.523
Organization task ahead	1.000	.486
To be listened to and taken into account	1.000	.367
Potential implication of problem resolution	1.000	.488
Responsibility for decision	1.000	.683
Availability for research projects	1.000	.626
Adherence to innovations and technology	1.000	.724
Integration in team works	1.000	.597
Share information and knowledge	1.000	.753
Use of equipment with knowledge	1.000	.623

Extraction Method: Principal Component Analysis.

Note:
In PCA the total variance is considered, and it is assumed that the communality for each variable is 1 (one).

Component Matrix[a]					
	Component				
	1	2	3	4	5
Exams protocols	.714				
Radiobiology and Radiation Protection	.670				
Electronics and Clinical Instrumentation	.668				
Initiative for problem resolution	.663				
Auto confidence and determination	.663				
Adherence to innovations and technology	.653				
Physics	.644				
Principles of Ethical Conduct	.644				
Medical Science	.643				
Informatics	.605				
Share information and knowledge	.603				
Resolution of problems with creativity	.601				
Management and Administration					
Open communication					
Responsibility for decision					
Communication and Behavioural Sciences					
Rationalization measures					
Integration in team works					
Innovative solutions proposal					
Internal quality assessment measures					
Projects and activities execution					
Availability for research projects					

Extraction Method: Principal Component Analysis.

a. 5 components extracted.

Rotated Component Matrix[a] 1st Round

	Component				
	1	2	3	4	5
Initiative for problem resolution	.742				
Open communication	.739				
Principles of Ethical Conduct	.721				
Auto confidence and determination	.713				
Responsibility for decision	.683				
Resolution of problems with creativity	.619				
Information critical analysis					
Physics		.909			
Radiobiology and Radiation Protection		.822			
Medical Science		.791			
Electronics and Clinical Instrumentation		.732			
Exams protocols		.700			
Projects and activities execution			.863		
Internal quality assessment measures			.843		
Rationalization measures			.803		
Innovative solutions proposal			.788		
Take measures in useful time					
Adherence to innovations and technology				.743	
Availability for research projects				.711	
Share information and knowledge				.666	
Integration in team works				.657	
Use of equipment with knowledge					
Communication and Behavioural Sciences					.750
Informatics					.723
Management and Administration					.648

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.903
Bartlett's Test of Sphericity	Approx. Chi-Square	4903.415
	df	231
	Sig.	0.000

Appendix 5-6 Initial Standardized estimates of the Structural Model in competences for decision-making