MedTech Digital Platform: Adjusting the e-procurement process in Romanian healthcare

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Executive Summary

Background

Public healthcare is regarded as one of the critical infrastructure sectors, accounting for a large share of the population's welfare. The healthcare system is evaluated as a multi-trillion-dollar sector, with important parts of national and international budgets being allocated to it, with a significant part of this money is spent on the large market of medical devices, representing approximately 5 % to 10 % of total health expenditures. Bringing the right technologies into public healthcare facilities can assure the correct spending of public money, enhancement of healthcare services and even improvements in public health.

Medical technology introduction within public hospitals is heavily influenced by the procurement process. Having good procurement practices can lead to 'safe, equitable and quality health care'. Even though procurement has a high impact on public health, WHO found that as of July 2014 approximately 53 % of the member states do not have national policies, guidelines or recommendations on the procurement of medical devices. This holds true for Romania, as well. Romania is a member state of the European Union since 2007, still facing battles between reminisces of the Communist era (before 1989) and the transitioning period towards democracy. Being affected by unpredictable political situations, with budget cuts and only 0.6 % of the GDP allocated to capital investments in healthcare, the Romanian healthcare system finds itself in a precarious state.

The acquisition system in Romania is governed by the Law of Public Acquisitions which has been adapted after the Directive 2014/24/EU introduced by the European Commission in 2014. This directive aimed at harmonising the public acquisition systems across member states. Under this law, one can identify all regulations and values to be followed when making acquisitions in the public sector. Moreover, the legislation defines the utilisation of a digital platform termed The Electronic System for Public Acquisitions (SEAP) whose purpose is to allow the parties involved (i.e., public healthcare facilities and private entities) to conduct businesses online, what is termed e-procurement. However, even though digitalization has been proposed as a solution towards improving the acquisition system by removing several barriers (e.g., human factor, subjectivity, lack of transparency etc.) research together with first hand observations have shown that great inefficiencies are present in the system.

Research Objectives and Research Methods

Therefore, having identified a significant gap in the literature, with lacking studies conducted in Romania or about Romania, the present research sets to *understand and analyse the current barriers and problems in Romanian healthcare procurement and determine what is needed to update e-procurement of capital medical equipment.* In meeting the objective of the thesis, the following main research questions is proposed: *How can e-procurement of CME be adjusted to the current context in the Romanian healthcare system?*

The research methods used for answering the above-stated research questions, are two-fold. Initially, the thesis will present a literature review. This has the purpose of identifying the current state of research regarding e-procurement of medical devices, with a focus on Romania. Moreover, it will help identify relevant themes and hypothesis. The second stage of the research involves qualitative research methods. This is achieved through semi-structured interviews with relevant stakeholders in the procurement of medical devices from public healthcare facilities, followed by qualitative analysis. The scope of the interviews is to gather insights directly from the individuals interacting with the public acquisition system. Thus, a number of 11 interviews were carried, with four key groups of actors: acquisition personnel, medical staff, suppliers and individuals formerly involved in public acquisitions.

Results

The research results were achieved through combining the data following from the literature review, together with the data analysed from the interviews. Several key insights are worth noting.

First of all, the literature identified that research in Romania is highly missing. The literature review surfaced studies which are only tangentially touching upon the topic of e-procurement of medical devices in Romanian healthcare. This signalled the need of conducting exploratory interviews in order to capture the extent dimensions of the public acquisition system. Nonetheless, through the literature review, it was possible to give partial answers to the research question of the study. Thus, the results indicate that the procurement of medical

devices is perceived as a complex and tedious process, with significant effects on patient outcomes, medical practices and budgets. The acquisition system is also guided by subjective factors and, while e-commerce is present in some countries, including Romania, it has the basic role of connecting parties involved. Moreover, several (theoretical) success factors which must be met by e-procurement platforms to offer improvements to the acquisition process of medical devices are: advanced search and retrieval of information, having a dynamic system, reduce opportunistic behaviour, increase integration, motivation and involvement of users.

By conducting interviews, the research focused on the particular case of Romania, offering more accurate results. It is important to note that, even though the research set to propose improvements from a digital perspective, due to the lack of existent research, it was found through the interviews that the stakeholders perceive barriers and have needs other than initially thought. Therefore, the results of the research identified the following perceived issues within the current system: long tender times, delayed budgets, lack of professionals, demotivation, incorrect decision-making factors (e.g., price-guided only) and a lack of standardization (i.e., inconsistent technical specifications). In addition to this, results show that an updated acquisition system, meeting stakeholders' needs, is seen as: being dynamic, bringing accountability of stakeholders involved, improvement of human factors, as well as more reliable digital resources.

To conclude, the research provides a comprehensive overview of the blockers, disadvantages and needed improvements towards the acquisition of medical devices in Romania. The research shows that a digital platform which is functional and adapted to the Romanian context could have the potential to facilitate access to resources and information and could eliminate intermediaries, nonetheless, this would not guarantee that these objectives will be met before solving the other negative aspects identified throughout the research. However, this study has the important benefit of bringing together both theoretical and practical findings in order to offer the basis for future analysis into what technological solutions should be implemented so that technologies are brought into hospitals in an efficient, effective and timely manner.

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List of Key Terms and Definitions

Term	Definition
Technology Adoption	The introduction of new technologies in public hospitals, once the respective technology is available on the market
Procurement	The process of going through the necessary steps to bring a medical technology into public hospitals. Synonym with acquisition and purchase
E-procurement	Digital platform where two or more parties can interact and exchange value. Synonym with e-commerce, digital platform
Acquisition process	The steps and stages through which a medical technology has to pass in order to reach the hospital
Medical Equipment	Devices used in conducting medical activities
Capital Medical Equipment	Medical devices with a price over 139,000 Euro

Table 1: List of Key Terms and Definitions

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1 Introduction

1.1 Background

Healthcare is one the most innovative industries in the world, with $ 83 billion worth of investments for various technologies made in the US alone (McKinsey, 2020). The healthcare domain is evaluated as being a multi-trillion dollars industry worldwide, within which, in 2015, approximately 5 - 6% (Burns et al., 2018), with numbers as high as 7.5% in Europe (Klein, 2015), of the total health expenditures were represented by medical devices . Moreover, there is compelling research showing that new technologies account for approximately 50% of the growth in healthcare spending in the US and other high-income industries (Sorenson et al., 2013). Even though all of the above might indicate that new innovative technologies are brought in hospitals and, ultimately, improve patient outcomes, researchers have shown that the industry is late and slow in adopting innovation (e.g., Sorenson & Kanavos (2011) present the case of the National Health System in U.K. and other European countries).

The reasons for the slow rate of adoption are vast and complex, but one of the main reasons for this could be precisely the sheer number of technologies available to doctors and the way in which these medical devices reach hospitals. In healthcare, especially the public system, buying decisions should be reached through a public procurement process. This process is complex and laborious and can differ substantially from other industries (Radulescu et al., 2021). The healthcare system faces a wide range of people involved in the procurement process. There are stakeholders such as the acquisition department, as well as practitioners. This then leads to conflicting values and requirements. The procurement team's role is seen as authoritative and expansive, while doctors become detached from the formalized process (L. M. Miller, 2014). On the other hand, doctor's needs are not fully and correctly met (Burns et al., 2018). Therefore, various solutions were sought to improve the procurement process, amongst which, ever since the development of digital ways of conducting business, there have been sustained efforts into adapting the healthcare system to these changes.

1.2 Digitalization of Healthcare

Digitizing a business or industry leads to what is termed electronic commerce (e-commerce). E-commerce refers to the usage of electronic information technologies to aid in the information flow and to conduct business. It uses the Web as an infrastructure and offers the advantages of a universal software and providing information anywhere, anytime (Aggarwal & Travers, 2001). Thus, e-commerce can bring diverse advantages to the healthcare. This has been shown through research, as well as through some of the initiatives that have already been implemented. It is important to note that the activities carried out so far towards e-commerce have mainly taken place in the pharmaceuticals market (e.g., online pharmacies such as Amazon), but with almost no advances for medical devices used within hospitals.

As discussed previously, in the last twenty years, there have been sustained efforts into digitizing the healthcare

so far as to defining a new term: eHealth. But, as already mentioned, healthcare is slow to adapt to these changes, ranging from electronic health records (EHR) all the way to digitalization of the supply chain. This also holds true for the procurement process. Acquisition of a medical device is extremely complex, involving a wide group of decision makers. For example, purchasing an infusion device involves diverse groups of people: end users, power users, trainers, pharmacy staff, as well as those responsible for management and maintenance of the device (Vincent & Blandford, 2017). In an attempt to improve the process, e-procurement has been suggested as a solution.

Business-to-business e-commerce systems can help overcome several barriers currently present in the medical world. First of all, doctors, managers, department heads (i.e., key decision-makers) are highly limited in time. This translates into a need of delivering information efficiently. A digital platform that is accessible anytime, anywhere, can easily aid in this process. Also, it must not be forgotten that, in a digital world, when trying to decide to buy or not a product, research usually starts online. Moreover, given the complexity of the healthcare system, an e-commerce or e-marketing platform would allow for more transparency in the procurement process.

However, research, as well as first-hand observations, have shown that e-procurement solutions have not yet reached their full potential (Wang et al., 2015). One of the strongest arguments behind business-to-business (B2B) e-procurement in healthcare was that of more transparency and money being spent correctly. But, Mackey & Cuomo (2020) found that in developed countries, fraud and other forms of abuse in healthcare were estimated to cost individual governments around $ 12-13 billion every year. Moreover, in Sweden it was shown that medical equipment was bought at higher costs than estimated or that it was not possible to use due to insufficient functionality (Terio, 2010).

1.3 Romanian Healthcare Context

The above are problems that can be found in various countries deploying similar e-procurement solutions. However, issues are at a larger scale in developing countries, as is the case of Romania. Romania is an Eastern European country, impacted by the Balkan block. The 31 years of transition towards a liberal market have been marked by reminiscences of the communist period, both in the trust towards public institutions, as well as behavioural patterns. One of the most important challenges during this transition is found in the healthcare system. According to a report made by the EuropeanCommission (2019), health spending in Romania is the lowest in E.U., making the healthcare system the poorest in the E.U. (Lobont et al., 2019). Moreover, the system is heavily impacted by corruption, low level of technology adoption and old infrastructure. This has also led to irrational spending and critical financial resources being utilized inefficiently. Hurjui & Hurjui (2015) present, in a study carried on the Romanian healthcare system, how large sums of money budgeted for capital medical equipment was spent on devices that were not even used, or put in operation at a later point.

Last but not least, problems within the healthcare system can be deducted from the patient's satisfaction, with 49.08 % of patient being unsatisfied with the medical equipment available in the Romanian hospital (Cosma

et al., 2020). Research has shown that the Romanian system is still undergoing transformation, with hospitals trying to achieve a patient-orientated mentality, obtainable through transparency and effective communication (Coculescu et al., 2016, Vladescu et al., 2016).

1.3.1 The Current E-procurement Process in Romania

Romania provides a healthcare system where most of the hospitals are public. Thus, it is important to understand the current context and process through which public hospitals make their medical equipment purchases.

Considering that public hospitals receive their budgets from the government, their investments can only be done through public acquisitions (or tenders). As a result, they must abide by the law of public acquisitions (Romanian Parliament, 2016), and conduct most of their procurement through The Electronic System of Public Acquisitions (SEAP). According to this law, there are several requirements for the hospitals in order to purchase any product or service that may be needed.

Usually, the need for a service/product starts internally. Following, according to the Romanian Parliament, 2016, the hospital may initiate what is termed "Market Consultancy", which must be announced through SEAP. Through this step, the hospital can invite various experts and vendors to make offers. This stage generally ends with the hospital being able to construct a detailed technical specification and estimate their cost. With the previous information, the hospital can initiate a public acquisition procedure where vendors submit their offers and, even though multiple criteria for awarding a winner are possible, the general rule is that the lowest price wins.

Having presented very briefly how the system works, it may be argued that an e-procurement system is already in place. However, as various studies from other European countries have shown, as well as reviewing some tender documents, the system is still lagging on meeting the full benefits (Lingg et al., 2016). These inefficiencies and potential solutions are set to be analysed throughout this research.

1.3.2 Need of an Adjusted E-procurement in Healthcare

It can be noted that e-procurement within the healthcare industry was presented and argued for as bringing a whole range of advantages (A. Smith & Correa, 2005, Pasiopoulos et al., 2013), even in recent studies (Abas Azmi & Rahman, 2015). Nonetheless, B2B e-commerce has not yet reached its full potential. Problems such as transparency still exist in the procurement process, making incorrect decisions about what and when to buy is frequent (Hurjui & Hurjui, 2015, Mackey & Cuomo, 2020), leading to low or inappropriate adoption of technologies.

Digital platforms showcase multiple benefits for the healthcare industry. As already said, this is visible in the literature as well as in the pharmaceuticals industry, through different vendors who already provide such services. However, medical equipment designed for hospital use could benefit as well, leading to a much higher-quality

healthcare system. This stands the chances of enhancing healthcare systems in already developed countries, as well as in developing ones, such as Romania.

1.4 Research Objective Formulation

1.4.1 Research Focus: Public Hospitals & Capital Medical Equipment

The main unit of analysis of the research will be represented by Romanian public hospitals. This is because of multiple reasons. First of all, the number of public hospitals is much higher than that of private ones. For example, in 2016, there were almost three times more public hospitals (i.e., 367) than private hospitals (i.e., 187) across the territory of Romania. Moreover, only 4% of all hospitalized patients were in private centres. Also, private hospitals only have 6,600 available beds, while public hospitals have 125,000 (Tiron, 2016). A second reason for analysing public hospitals in more depth is the fact that, as mentioned previously, public hospitals must utilize a public procurement system. Thus, a wider group of stakeholders is involved and more complex implications, that all have a much deeper impact on the general population (i.e., patients).

Diving further, the research will focus on capital medical equipment (CME) purchases (e.g., advanced medical imaging devices, operating room equipment, ICU technologies). The reasons for focusing on the acquisition of this type of devices is especially because of their high cost comparing to other medical technologies - above 131,000 Euros, representing an important threshold under current legislations (*Directive 2014/24/EU*, n.d.). For example, an MRI can cost between $1 and $3 million (Abedini et al., 2018), thus also representing a strategic investment. The acquisition of a CME can have strategic importance from two perspectives. Firstly, it can be a marketing tool for patient retention or for the reputation. Secondly, it can represent a strategy into bringing healthcare to as many people as possible. Returning to the case of medical imaging, a study carried in 2012 has shown that two-thirds of the world's population has no access to diagnostic imaging (Paho, 2012). Therefore, it can be crucial for any healthcare system to understand how to bring new and efficient capital technologies (both economically and clinically) to their hospitals.

1.4.2 Research Objective

In the previous section, the practical problem was identified, showing that e-procurement in the healthcare sector has not achieved its best potential. Moreover, it can be argued that for the specific case of Romania, it is even lagging behind developed countries. It is important to note that research around this topic is slim in Romania, as it will be demonstrated throughout the remainder of this paper. In an attempt to fill the knowledge gap and to propose clearer directions of improvement, the following research objective is proposed for this research.

Research Objective: Investigate the current barriers and problems in healthcare procurement and determine what is needed to update e-procurement of capital medical equipment.

1.5 Research Questions

In order to be able to fulfil the objective of this research, the following main research question is being proposed. This main research question will then be divided into three sub-questions whose purpose will be described in more depth further. Separating the main research questions into sub-questions has the advantage of capturing a fuller and richer picture, with current, future and full-image perspectives being taken into account.

Research Question: How can e-procurement of CME be adjusted to the current context in the Romanian healthcare system?

Sub-question 1: How do the relevant stakeholders perceive the existing e-procurement process in relation to CME?

When attempting to improve a system, it is crucial that those directly involved or affected by the process bring forward their perspectives on the matter. Therefore, through the first sub-question, the current opinion of important stakeholders will be looked at. This will help the research into getting a detailed understanding of how individuals involved with the acquisition process of capital medical devices perceive the existing system and what barriers they face.

Sub-question 2: What is the general tendency of the relevant stakeholders towards a functional and adapted e-procurement system in Romania?

The improvements that are proposed to a system or process must be suitable and adapted to the users of those system. Thus, through the second sub-questions, the research will try to gain insights into what stakeholders believe an improved e-procurement system should look like. Moreover, this sub-question will help narrow down the research, whilst taking a different perspective from sub-question 1.

Sub-question 3: What are the improvements of e-procurement that provide a better fit with the needs and requirements of relevant stakeholders in Romanian healthcare?

Finally, the last sub-questions will offer the chance of developing and proposing potential changes that can lead to a more efficient and improved e-procurement process in the healthcare system. Through this question, the research will attempt to put all information together and completing the full picture where barriers identified, together with improvements from involved stakeholders following from the analysis will be combined into suitable propositions for the purchase of capital medical equipment.

1.6 Thesis Outline

The following research is organised as follows. In chapter 2, the methodology for the research will be presented. Chapter 3 provides an extensive overview of the relevant literature existing on the topic under investigation. In chapter 4, a thorough presentation of the interview results will be found. Chapter 5 will then present an in-depth analysis of the results, both from literature review and interviews. Following, chapter 6 will offer a discussion of the research, together with the answers to the research questions. Finally, chapter 7 provides the main conclusions of the research, together with the limitations and further recommendations.

2 Research Methods

2.1 Research Strategy

For the research under investigation, a strategy using a double method was selected, comprised of an extensive literature review which was then followed by interviews with experts in the field of public acquisitions in healthcare. First of all, the literature review allows for understanding the state of art of the existent research surrounding the topic of e-procurement as a process and more specifically, in the context of Romania. Through a thorough search amongst various scientific databases (e.g., Scopus, Web of Science or PubMed), the most relevant information can be identified. Moreover, a literature review has the advantage of bringing up themes and variables that can be included in the research and can aid in making a precise and clear problem statement (Sekaran & Bougie, 2010). On the other hand, the research will use interviews. These allow to capture the context surrounding the issue and to gain a more in-depth understanding of the topic. Through interviews, the dimension of reality can be captured, by finding the opinion of those relevant stakeholders having direct implications with the theme under research. Interviews represent an especially useful tool when an exploratory approach is targeted (Sekaran & Bougie, 2010).

Designing a research method also requires attention to be paid to meeting requirements of scientific research, such as validity and reliability. When looking at qualitative research, it can be noted that methods used rank high in internal validity, as natural situations are documented and details are gathered of what subjects describe during expressing their opinions and experiences. On the other hand, it is important to note that qualitative research methods might rank lower on reliability compared to quantitative research. Reliability depends on the particular context where research was carried, thus it may be difficult to replicate a qualitative research (Pope, 2002).

Throughout this section, the methods for data collection and analysis will be described. These methods used for the research are: literature review, semi-structured interviews, followed by qualitative analysis.

2.2 Literature Review

2.2.1 Search Description

As already mentioned in the previous section, one of the aims of this study is to identify the current state of research regarding e-commerce in healthcare, with a focus on the Romanian healthcare system. This is achieved through a literature review, in an attempt to identify relevant scientific gaps leading to further research.

The process was divided into approximately four stages, following a funnel approach. In the first stage, general searches were carried in an attempt to identify a slim number of relevant keywords, which would then aid in a more refined process. It should be noted that, having previous experience in the industry, some problems

were identified first-handed and vaguely researched previously. Thus, a sense of direction was already in place. The second stage involved searches within more scientific-orientated databases such as Google Scholar. This database has the advantage of offering a large number of results, but not sufficiently refined, as well as being biased towards previous searches. The third stage involved searching more advanced databases such as Scopus or World of Science (WoS). Lastly, the final stage involved refinement of the articles found, based on keywords, and selection of those highly relevant towards the topic of e-commerce in healthcare. The whole process, which must be noted, was an iterative process, will be discussed in more detail in the following sections.

Stage 1 – General Search: The first milestone was to generate a preliminary list of keywords which would aid in finding the relevant research topics. In doing so, Google was the main source of information. Google offers an extremely wide range of results; however, it permitted the identification of some keywords and phrases that are used in grey literature around the topic. Also, it offers a perspective into what are the current advancements and key people or companies working towards the topic in focus. With the help of Google, terms such as "business-to-business" or "B2B", "healthcare", together with "e-commerce" were identified.

Stage 2 – Structured Database Search: In the second step of the literature review, a more scientific-orientated database was required. Thus, Google Scholar presented this characteristic. But even though Google Scholar returns a wide range of results, it is biased by previous searches. Moreover, as the number of results is larger and larger, it was found that their relevance starts decreasing rapidly. For example, the first search was carried using the previously found keywords (e.g., as "business-to-business" or "B2B", "healthcare" and "e-commerce") and a staggering number of 13,200 results were returned, but starting with the fourth page results became increasingly irrelevant. Nonetheless, it has offered the advantage of finding more targeted results in the first returns, which can then enhance the search process. It is important to mention that Google Scholar was used in an iterative process, meaning that when new broad topics were identified, a search would be carried in Google Scholar to get a general sense of the direction.

Stage 3 – Funnelling the Search: During the third step, more advanced databases were used, such as Web of Science or Scopus, with an increased focus on the latter. After identifying some relevant keywords in the previous step, Scopus provided a scientific pool where resources could be identified. Even though the starting point was represented by "business-to-business" or "B2B", "healthcare" and "e-commerce", multiple other keywords have been used. Healthcare is a complex system, encompassing various words to describe approximately similar things. As a reason, synonyms were also used (e.g., medical technology and medical equipment). A more detailed overview of the keywords deployed in funnelling the search to those articles highly-relevant can be seen in Table 2.

Using the above keywords, Scopus returned varying numbers of results. For example, some initial searches returned around 275 results, while more refined searches returned 16 results. Thus, it was required that a process of scoping down the results is deployed. This was achieved through reading the title, together with skimming the abstract. In keeping track of the selected articles, Zotero was used as a reliable and efficient tool for reference management. Whilst trying to refine more and more the searches and to capture all of the relevant

Main Theme	Related Keywords
Healthcare	Doctors, Hospital
Medical Technology	Innovation, Medical Device, Medical Equipment, MedTech
Business	Acquisition, B2B, Consultancy, Go-to-Market, Marketing, Procurement, Promotion, Purchase, Sales, Strategy
Vendor	Distributor, Supplier
Digital	eHealth, E-acquisition, E-commerce, E-procurement, Online
Romania	n.a.

Table 2: Literature Review: Search Process Keywords

articles, at some point, it became apparent that the same results resurfaced over and over again, signalling the fact that searches started to become recurring. This was an indication of the fact that most of the literature available has been covered.

Having completed a search on a general level, from a geographical perspective, it was now important to identify relevant literature about the Romanian healthcare system. Therefore, similar keywords as presented in Table 2 were used, together with "Romania" as a recurrent keyword. This has allowed for an understanding of the current local context that the research is intended to apply to. A more detailed overview of the search strings used for the literature research can be observed in Appendix B.

Stage 4 – Article Selection: Once the databases were thoroughly analysed and it became apparent that the results were starting to be repetitive, the attention turned to the reference management software (i.e., Zotero), where roughly around 100 papers were saved into two categories: 1. Papers about Romania; 2. Papers focusing on the relevant topic, with cases from all over the world. Having such a high number of relevant scientific articles saved, more refinement was needed considering that not all articles are applicable to the topic or some researches may overlap. The criteria that were used will be discussed further.

2.2.2 Exclusion and Inclusion Criteria

As already mentioned, searches returned varying number of articles. Nonetheless, it was important to select the papers that will be included in the literature review based on relevant criteria. To achieve this, the criteria presented in Table 3 can provide a clear understanding of the selection process.

2.3 Interview Protocol

2.3.1 Semi-structured Interviews

For the presented research, following the literature review which enabled the identification of relevant themes and directions, as well as understanding what has been researched by others, several interviews were carried.

Criterion	Inclusion	Exclusion
Year	After 2000	Before 2000
Language	English, Romanian	All other languages
Geographical Boundaries	Any region	Only if unrelated to medical technology
Setting	Pre-Sale, Sales Process, Procurement Process	After-Sale, Follow-up
Type of Product	Medical Technology	Pharmaceuticals
Type of Business	Business-to-Business	Business-to-Consumer

Table 3: Literature Review: Inclusion and Exclusion Criteria

There were 11 interviews with key individuals considered experts in the domain of healthcare. This has allowed the exploration of the main themes under research, as well as finding new emerging themes, offering a much clearer picture.

The methods in qualitative research, as described above, can vary, however, offering the research the possibility to study phenomena in their natural settings. In answering the proposed research questions, a semi-structured interview was chosen, including open-ended questions. This has permitted to reach the research goals by framing the interviews, as well as testing for new themes or generating new hypothesis on the topic of decision-making processes for e-procurement. Moreover, a semi-structured interview is based on a flexible topic guide which can offer a loose structure in order to explore experiences and attitudes of the participants (Pope, 2002).

2.3.2 Participants Selection

One of the most difficult tasks in participant selection is that of how many participants are sufficient. As opposed to quantitative research methods where sampling is representative or probability based, in qualitative research, respondents are chosen depending on criteria dependent on the research objective (Pope, 2002). For the research under investigation, this meant selection of individuals who are involved in the acquisition of capital medical equipment within public healthcare contexts (e.g., clinical department heads, hospital managers, acquisition department heads). Sampling the participants started through social network and a list of possible interviewees was generated, followed by contacting the individuals. This resulted in carrying a number of 11 interviews, with data saturation being considered to have reached when themes became repetitive or no new insights were generated (Morse, 2000). An anonymised list of professionals interviewed during the research can be seen below, in Table 4, where RAP - Respondent Acquisition Personnel; RMS - Respondent Medical Staff; RS - Respondent Supplier; RFIS - Respondent Formerly Involved Staff.

Interviews were carried face-to-face in order to bring the dimension of contextuality in the research. In addition, it was important for interviews to be carried in person because participants tend to be more open to discussion, as opposed to talking over the phone. This has allowed the interviewer to also see the reactions of participants and to better understand their attitudes. Another advantage of face-to-face interviews is that the questions can be adapted and doubts can be clarified (Sekaran & Bougie, 2010). However, having face-to-face interviews

also imposed limitations. The most relevant one is that it has proven difficult to grasp the full picture across different regions in the country of research - Romania. Nonetheless, due to network benefits, it was possible to interview participants from two main important regions in Romania: Bucharest - the capital city and Timisoara - a western city, with well-developed healthcare facilities.

The duration of the interviews was on average 30 minutes, with 2 interviews lasting approximately one hour. During the interviews, by using the below-described interview guide, the participants were asked open-ended questions which permitted them to describe their own opinions and attitudes towards the theme being analysed.

Interviewee	Description	Region
RAP1	Head of Acquisition Department - Hospital	Bucharest
RAP2	Head of Medical Devices Department - Hospital	Bucharest
RAP3	SEAP Operator - Hospital	Bucharest
RAP4	Head of Acquisition Department - Hospital	Timisoara
RMS1	Imaging Department	Timisoara
RMS2	Cardiovascular Medical Doctor	Timisoara
RMS3	Radiology Department	Bucharest
RS1	Head of Tender Department - Private Company	Bucharest
RS2	General Manager - Private Company	Bucharest
RFIS1	Former Acquisition Personnel (Top Management Position)	Bucharest
RFIS2	Former Hospital Manager	Bucharest

Table 4: Interview Participants

2.3.3 Interview Guide

In order to frame the interviews and offer consistency to the research, an interview guide was thoroughly developed. In developing the guide, the first step consisted of introducing all themes arising from the literature review and developing as many questions as possible. This was then followed by a detailed analysis in an attempt to make the interview guide as highly relevant as possible. Therefore, various questions were either deleted (i.e., redundant), combined or developed further. Then, four major themes have emerged and the questions were divided depending on the category it belonged to. The four themes that were discussed through the interviews, together with its scope are presented further. A thorough overview of the questions used as a guide during the interview can be observed in Appendix A.

As the interview guide was taking shape, it was discussed and analysed further together with the research supervisors which allowed for valuable input into constructing a consistent and well-based interview questions. In parallel, the interview guide was tested with two individuals considered experts in capital medical equipment (i.e., a 20 plus years of professional experience as a medical equipment vendor and a public acquisition department head).

Internal Validity

In addition, while constructing the interviews, it was important to account for the internal validity of the

research. It is important to note that the interviews were carried in Romanian, in the native language of the respondents. Considering that the interviewees were not experts in English, it was decided that Romanian offered a framework for avoiding biased responses due to the utilization of inadequate terms which did not fully reflect the experiences and attitudes of the respondents. Moreover, special care was taken for the translation from English to Romanian and vice-versa. As such, during the interviews, the most important concepts and terms were explained in order to ensure the internal validity of the research (e.g., when discussing capital equipment, the interviewees received a definition of what this represents, as described in the research). Lastly, in order to offer internal validity to the research, the quotations used throughout the research were carefully translated into English, respecting all norms necessary for understanding the context and ideas expressed by the participants.

A. The Current Procurement System

Through this theme, the existing process was discussed from the perspective of participants. As above-mentioned, this includes a wide range of involved stakeholders, each indicating various barriers (or not) of the acquisition process of CME.

B. Committee & Evaluation Criteria

When analysing a procurement system it is not sufficient to understand the actions required, but also who are the decision-makers conducting these actions or having the capabilities of changing their directions. In addition to this, it is crucial to understand what criteria are being set and followed when reaching decisions.

C. Technology in Romanian Hospitals

The third part of the interview contains discussions relating to the medical technologies in the Romanian healthcare system. This is especially important as it can give indications relating to how the key stakeholders perceive new technologies, as well as the current state of technology adoption in Romania. Results from this section can show decision-makers' attitudes towards the importance of bringing innovative technologies into public hospitals.

D. Ideal World

The final part of the interview aimed at discussing how an efficient system should be designed from the perspective of relevant actors. Through this section, data could be gathered relating to what those affected would see as a requirement of the system. Moreover, even though the participants were asked about the best case scenario, the responses could further surface barriers not previously mentioned or unprompted.

2.4 Analysis Protocol

To facilitate the analysis of the data collected through the interviews, in those cases where the participants agreed, audio recordings were made. Two exceptions existed, where the participants did not consent to audiotaping, thus extensive notes were taken that could facilitate the analysis. As previously mentioned, there were 15 interviews, resulting in 7.5 hours of recordings. Following, the interviews were transcribed. This stage resulted in 73 pages of written data that could be inserted into the qualitative analysis software for analysis purposes.

The software chosen for data analysis was ATLAS.ti. Analysis software have notable advantages over manual or paper-based techniques, especially in coding and retrieval of data, creating and differentiating data based on determined criteria and to view and investigate theoretical relationships (Woods et al., 2016). Through this qualitative analysis software, an iterative process can be deployed. The process involved careful reading of all transcripts and coding all relevant information. Through this step, relevant themes were identified. The process was then repeated to narrow down the themes and offer greater insights. Using ATLAS.ti has ensured that the analysis process is systematic and rigorous, as well as internal consistency (Woods et al., 2016).

2.5 Chapter Closing Remarks

Throughout this chapter, a detailed overview of the research methods and their purpose has been presented. It was shown that deploying literature review as the initial stage in the research has multiple advantages in understanding the current state-of-art of research and what variable are required to be introduced in the research. Following, exploratory semi-structured interviews offer the benefits of capturing relevant stakeholders' opinions and experiences. Lastly, the data gathered during the interviews is analysed through qualitative software which assures rigour and a systematic approach. In the following chapters, the findings from both strategies will be presented, followed by compiling the full picture.

3 Literature Review

3.1 Procurement of Capital Medical Equipment

Healthcare is one of the most rapidly growing industry in terms of technology development. This can have two major implications. First of all, it must be acknowledged the fact that costs are rising at a never-before-seen rate, with medical technologies representing one of the most important contributing factor, accounting for approximately 50 % of the growth in healthcare spending in the US and other high-income industries (Sorenson et al., 2013). The second implication of rapid and intense technology development in the healthcare sector is that important attention must be paid to which equipment is introduced in hospitals. The choice of technology deployment does not only have an economic impact, but also a strategic one, as medical devices can help hospitals in diversifying or improving the medical services available, aiding them to establish a position on the healthcare market (e.g., patient retention, medical staff retention). In addition to this, and what could be argued as the most important aspect, the selection of the right medical technology has a tremendous impact on patients' outcome (Lingg et al., 2016), as well as on the innovative performance of hospitals and their ability to improve their performance (Moreira et al., 2017).

Given the wide spectrum of technologies that can be labelled as medical devices (i.e., from at home monitoring devices, surgical wires, orthopaedic implants and all the way to operating room devices or imaging devices), as well as for the purpose of this research, medical technologies will be differentiated into low-cost medical equipment and capital medical equipment (i.e., high-cost medical equipment). Capital medical equipment (CME) represent those technologies that have both an economic and strategic impact. These technologies are those which represent the highest share of hospitals' expenditures in terms of medical device acquisitions. Moreover, CME can have an important effect on both hospital positioning, as well as patients' outcomes. For example, MRIs (or imaging devices in general), which can have costs ranging from $ 1 to $ 3 million are one of the most needed medical technologies at a world-wide scale.A study carried in 2012 has shown that two-thirds of the world's population has no access to diagnostic imaging (Paho, 2012). Therefore, it can be crucial for any healthcare system to understand how to bring new and efficient capital technologies (both economically and clinically) to their hospitals. Apart from imaging devices, other examples of capital medical equipment include: hybrid operating rooms, digital robotic microscopes, neuronagivation systems or high-performance orthopaedic surgical tables.

Introduction of new CME in hospitals is heavily influenced by the procurement process. The literature views the procurement process as a tedious and complex process, while, at the same time, it is being stressed the importance of correctly selecting the medical technologies. This is crucial because the way in which medical technologies are bought does not only affect budgets, but also the improvements in patient outcomes, which technologies are made available to the doctors and, ultimately, what business and suppliers become successful (F. A. Miller et al., 2019). Nonetheless, the procurement process is criticized as being too technical, rigid and price focused, without accurately assessing the benefits or economic value (F. A. Miller et al., 2019).

Other authors have focused on understanding the actors involved in the procurement process. The same complexities characterising the public acquisition of medical equipment can be found. A whole range of stakeholders are usually involved such as: end users, power users, trainers or those managing the devices. In addition, depending on the context, regulatory bodies or purchasing groups may be involved (Vincent & Blandford, 2017). The paper provides a deep-analysis of the actors having an impact on the purchasing process which can be seen in Fig. 1.

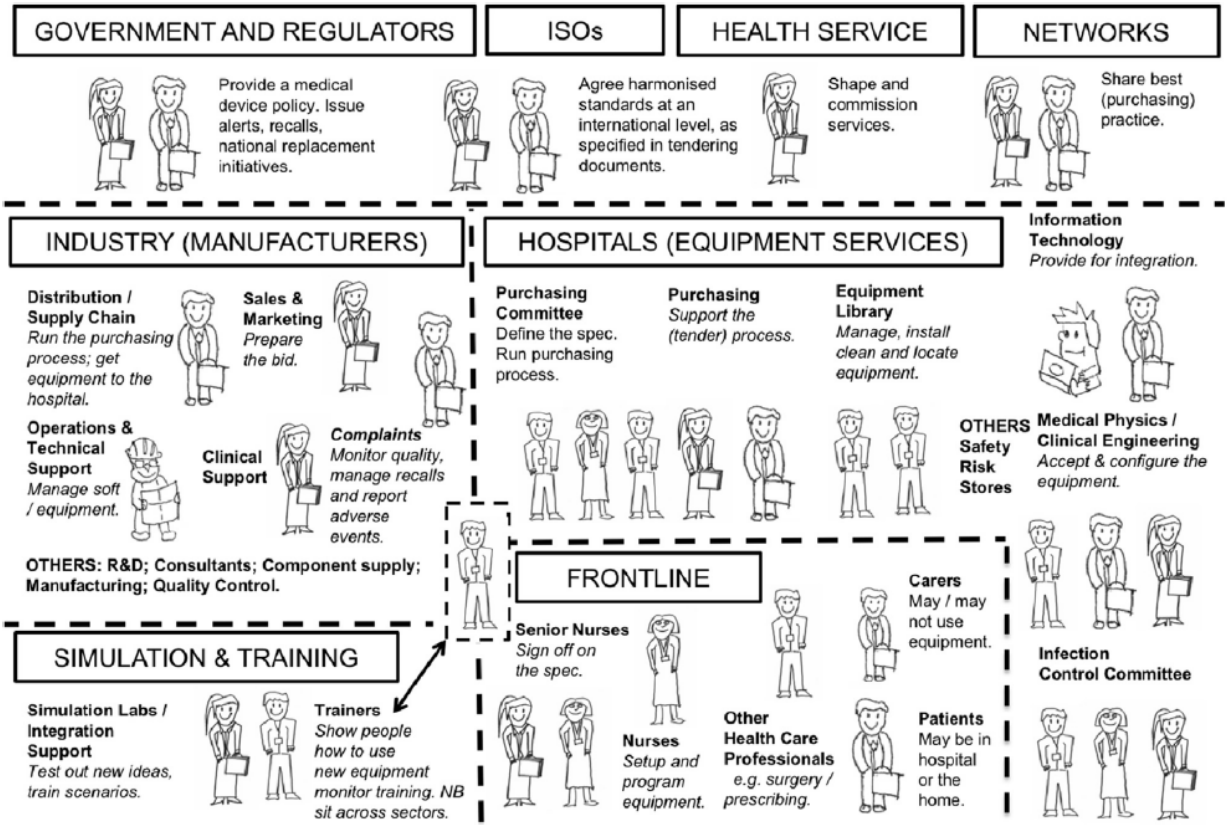

Figure 1: Actors in the Public Procurement System (Vincent & Blandford, 2017)

In a study carried by reviewing over 220 tender documents in the Canadian healthcare system - the procurement process is similar to the one used in public hospitals across Europe, F. A. Miller et al. (2019), found that the procurement is usually aimed at soliciting specific products, thus reducing the potential for innovative solutions. Moreover, it found that the procurement's role is usually authoritative and expansive, having to purchase supplies and equipment needed by the healthcare facility to run. An interesting statement by F. A. Miller et al. (2019) is that, as opposed to historical data, clinicians have become too detached from the formalized process. The process is usually conducted by the manager or a group who assess the acquisition on diverse criteria (equipment, brand, quality, cost (Radulescu et al., 2021)). As a result, the needs of the practitioners are not fully and accurately addressed.

Nonetheless, during the acquisition of medical equipment, others see the doctor as having a significant role, as he/she can be regarded as the one of the key persons initiating this process, as well as, in some cases, direct

the purchase towards a certain vendor (Burns et al., 2018). For this reason, several researchers have tried to understand how practitioners select their needed medical technologies. Burns et al. (2007) has conducted a comparative technology evaluation of sutures and endomechanical products, which account for $ 2.5 billion in the U.S. of total device spending. They have compared the products of 8 vendors in a laboratory setting within a hospital from the U.S. (one limitation of their study). The reason for the study has been the lack of clinical-based evidence, with doctors selecting products based on testimonials, habit or tradition. The findings of the study suggest that doctors choose their products following rather subjective criteria than objective ones, with vendors who are already trusted by the practitioners at the top of the list. However, having a comparative evaluation can aid in supporting (or not) vendors' claims and information asymmetry in the seller-buyer relationship can be overcame.

The above findings are further supported by a questionnaire administered to 201 surgeons in trying to understand what are preference items of surgeons (Burns et al., 2018). Even though the study was carried on almost different medical specialities (i.e., orthopaedics), the results are very similar. The first considerations surgeons look at are the technical ones such as patient outcomes, scientific evidence and ease of the implant and its instrumentation. Then, on the second place in terms of surgeons' preferences came the sales/service considerations. These include sales representatives' follow-up, knowledge, availability and thoroughness. Lastly, Burns et al. (2018), conclude that even though technological differences can appear, these are not s significant and doctors' select vendor based on habit, familiarity and accumulation of user efficiencies over time.

Looking at the process, taking a general perspective, one can identify both similarities and differences between various systems. It is important to note that each country presents its particularities, even though, for example in the European Union, the wide approach is similar, in accordance with (*Directive 2014/24/EU*, n.d.). Nonetheless, in order to have a better grasp of the procurement process for CME, various systems will be further briefly analysed.

Various authors have attempted to understand the public procurement process in different contexts. However, given the scope of this research, analysis of healthcare systems will be looked at. Terio (2010) offer an in-depth analysis of medical devices procurement in Sweden, focusing on one of Scandinavia's premier health facilities. As already mentioned, European public system must align their regulations with those brought forward by the European Union Act on Public Procurement, according to which procurement must be carried out in a professional manner and with competition. Moreover, there is great emphasis on equal treatment of all vendors, no discrimination and transparency. As a result, the usual procedure, and especially for CME (i.e., devices with costs over 131,000 euro) is that of tenders. Tenders are the preferred procedure in most other European countries as well. Sorenson & Kanavos (2011) documented a comparison between five countries where the most used procurement procedure is that of "competitive bidding or open public tenders".

Nonetheless, the process is usually more complex and involves a whole range of stages before and after the tender. For the particular case of Sweden (which, as it will be seen, is relatively similar to other systems), the process involves the following steps. Firstly, the procedure is initiated when the hospital begins working

on the investment plan for the following year. This is then followed by a "purchasing project plan and team", completing the tender documents, tender announcement, review evaluation, selection of supplier and the final steps of contracting, delivery and follow-up (Terio, 2010). A schematic of the entire process applicable to Sweden can be seen in Fig. 2.

Figure 2: Representation of the Public Procurement System in Sweden (Terio, 2010)

A similar approach to procurement is also found in Canada where F. A. Miller et al. (2019) stated that the Northern American and European systems share multiple characteristics, deploying a tendering system in purchasing medical equipment. By reviewing over 220 public tender documents, the researches have found that the majority of buyers are Group Purchasing Organizations (GPO) – 55.7 percent, with individual healthcare facilities being most frequent buyers – 44.3 percent. Diving deeper, in running the tenders, two different major types of documents are needed. The first category includes information relating to product being sold and the vendor selling the product. Under this category, various aspects are mentioned such as technical or clinical details about the product and criteria relating to vendor's experience and qualifications. Under the second type of documents, financial criteria are found. These generally include the "total cost", however, the authors stress the fact that the term is incorrectly used, as these costs did not extend further, for example across the product's life-cycle.

3.1.1 Key Points about Procurement of Capital Medical Equipment

As shown, procurement within public healthcare systems is usually complex (from the process itself, to the multitude of stakeholders involved) and decision-making can be difficult. Research has shown that in most

countries, one of the main aims of implementing an open tendering system (F. A. Miller et al., 2019, Lingg et al., 2016, Sorenson & Kanavos, 2011). Findings have shown that usually decisions are guided by price-comparison, with quality falling to second places, in order to achieve the goals of cost containment. In order to do so, countries such as the U.K. or Germany (Lingg et al., 2016), have purchasing groups whose purpose is to buy large quantities of products aiming for cost reduction, whilst in other countries (e.g., Switzerland) buying groups are usually rare, with healthcare professionals usually enjoying the independent system (Lingg et al., 2016). However, a large purchasing group usually leads to 'a one size-fits all' solution which may not be an accurate approach, overlooking other relevant aspects or have a negative impact on the diverse range of patients' needs, providing either unsuitable or unnecessary devices to physicians (Lingg et al., 2016). It is important that a more flexible approach towards public procurement in order to ensure quality of products, physician acceptance or improve level of innovation. Moreover, the tender system is also heavily negatively impacted by the lack of experienced procurement personnel (Sorenson & Kanavos, 2011).

3.2 E-procurement and Medical Equipment

One of the propositions which has been brought forward since the beginning of the 21st century, as the internet was starting to grow, is that of digitization of healthcare, more specifically e-markets. These represent firms that operate in the online business-to-business (B2B) marketspace within private or public sectors. E-markets can be operated by a major buyer or supplier, by a consortium or an independent party (Johnson, 2013). E-markets can be referred to in various ways: digital markets, B2B exchanges, e-commerce or digital platforms. In another paper, digital platforms are defined as exchange platforms where two or more parties can interact and exchange value (Hermes et al., 2020). E-commerce platforms are viewed as efficiently matching buyers and sellers having as a result the reduction of search costs and information asymmetry and improving efficiencies (Aggarwal & Travers, 2001, Hermes et al., 2020). However, e-procurement is a complex environment where various sectors (e.g., private-public, public-public) are connected in an online interface, with a range of challenges and barriers (e.g., harmonisation between E.U. legislation and all national contexts) that must be understood and addressed (Bof & Previtali, 2007).

3.2.1 General look at e-procurement

Various efforts have been made in order to understand what e-markets require to be successful and bring about the changes they promise. Johnson (2013) presents a study in which critical success factors of B2B e-markets in various industries (e.g., aerospace, healthcare, higher education) are assessed. The methodology deployed in the study was through a thorough literature review, followed by a pilot study and then 58 semi-structured interviews. In the study, e-markets are viewed as an important part of the economy which can diverge into every area of the economic activity. One differentiating factor is the concept of strategic fit, stating that e-markets must have capabilities that offer benefits to the entire supply chain, at the same time possessing dynamic capabilities to adapt to changes in needs. According to Johnson (2013), there are several factors that can bring the success of

e-markets amongst which deep integration of suppliers and buyers, participation of industry leaders, branding and reputation or existence of a rich content. These findings are sustained by other researches, who argue for the need of stakeholder involvement and motivation (Lin et al., 2010, Visconti & Morea, 2020).

Turning towards e-markets for the healthcare sector, the literature identifies more barriers that require to be crossed. Palamas et al. (2001) completed a list of requirements from the buyers and suppliers. On the one hand, buyers (i.e., the hospital) require advanced search and retrieval of information for multiple manufacturers; friendly and informative presentation of products; presentations using virtual reality (VR) and efficient sales support. Looking at the supplier, other needs are found, such as a secure communication channel, cost effectiveness and access to user profiling and statistics. In addition to these barriers, there are bottlenecks on the supply chain. Some of these are health providers data shortage and data recorded on paper, as well as governance and accountability drawbacks (Visconti & Morea, 2020).

With healthcare being a particular case where multiple stakeholders, perspectives and sought-after results are converging together, implementing e-procurement can be a difficult task. One critical aspect towards having an efficient digital platform is that systems should go beyond the technological benefits. Establishing trust and confidence amongst users is often cited in the research as an important characteristic (Mackey & Cuomo, 2020, Wang et al., 2015). This is further supported by Abdulsalam & Schneller (2020) who, based on semi-structured interviews with relevant key people from the healthcare industry, have mentioned the importance of strong relationships between supplier and buyer. However, they have identified some barriers that should be crossed in order to develop such networks. Thus, in healthcare some of the issues stifling the development of e-procurement are lack of information sharing, opportunistic behaviour, often changing regulations and alliances between buyers and certain suppliers (Abdulsalam & Schneller, 2020). Furthermore, Wang et al. (2015) have brought up issues such as security on the network, bringing a positive contribution towards the corporate strategy, availability of renowned brands and recognition of the added value of digital platforms by relevant staff. Not integrating these concerns into the design of e-procurement can have tremendous effects as it has been shown that in developed countries alone, fraud and other forms of abuse in the healthcare have been estimated to cost individual governments as much as $ 12 – 13 billion per year (WHO, 2010b).

It can be observed that implementing digital markets present a whole range of barriers and bottlenecks that require solutions. However, it is important to also look at the benefits of e-commerce in healthcare considering that a generational change amongst decision makers is taking place, with reports showing that, in 2019, the median age of the purchasing professional was 45 (Rupp, 2020), as well as research proving the importance of IT capabilities into hospitals' financial performance (Leidner et al., 2010). In addition, reports estimate that almost 94 % of healthcare equipment is first researched online (Rupp, 2020) and a study carried on 366 doctors reported that 36.64 % of them spend two hours every day to research for medical equipment (Saminadan, 2017)

3.2.2 Advantages of E-procurement for Public Hospitals

Attempts towards e-commerce in healthcare, as previously mentioned, have been made as soon as the beginning of the 21st century. Despite this, results are showing that adoption is low and moving at a slow pace (Bof & Previtali, 2007, Bravar et al., 2001, Lin et al., 2010) and that improvements are required. Nonetheless, it is important to understand what are the true benefits of e-commerce in healthcare and why proper implementation is required.

One of the most important advantages of B2B e-commerce in healthcare is the increased rate at which information can flow between stakeholders (Bof & Previtali, 2007, Ketikidis et al., 2010). This, in turn can lead to improved efficiencies, which will then result in reduced costs (Aggarwal & Travers, 2001). In their study of trying to understand the barriers experienced by an organization in implementing e-commerce, Bof & Previtali (2007) have mentioned the real advantages of this system. These include reduced paperwork and administrative hours, leading to more time for other tasks; improved accuracy, as transaction errors are reduced; improving auditing and security controls, leading to much better traceability and transparency. In addition, due to access to a wide base of manufacturers, healthcare providers have the advantage of doing well-documented research and purchase more qualitative products, which better fulfil their needs (A. D. Smith & Flanegin, 2004). Going further, in a recent study, Abas Azmi & Rahman (2015) see the utilization of a digital procurement for procurement in hospitals as a "gatekeeper", ensuring the application of all rules implemented, without being biased and choosing the best value for the money. Moreover, e-procurement is viewed as safeguarding public officials through its transparency, as well as obliging suppliers to give proof of their capabilities so that fraudulent transactions are being avoided.

B2B e-commerce does not only provide benefits to healthcare providers, but also to firms across the supply chain (i.e., manufacturers, vendors, distributors). Businesses can decrease their operational costs as transaction costs are diminished and development speeds increase (Holmes & Miller, 2003). Moreover, manufacturers would have the ability to circumvent distributors and communicate directly with the customer. This would translate into the manufacturer's ability to precisely understand the needs and desires of the client. Another feature of direct client-manufacturer communication is that innovative and new devices can be presented to the doctor, without the need to find a distributor or convincing a distributor of the benefits in order to sell further (Ketikidis et al., 2010).

Vendors can also take advantage of the scalability potential of e-markets. Considering that internet runs across borders and that the need of sales representatives can be decreased, companies can expand and reach new customers with more ease (Chadha et al., 2020, Holmes & Miller, 2003, Lin et al., 2010). On top of these advantages, companies can gain visibility and increase effectiveness of their marketing efforts, thus creating opportunities for revenue growth (A. D. Smith & Flanegin, 2004). Lastly, it is important to put things into current context. As the pandemic caused by Covid-19 has showed, having personal, face-to-face meetings is a challenge and people are forced to communicate through online mediums. Thus, digital marketplaces will allow

for continued relationships with existing or new customers as access to healthcare professionals is and will be (in the short-term perspective) restricted (Chadha et al., 2020).

Efforts into developing a digital platform can be traced back to as soon as 2001 (MEDICOM, (Palamas et al., 2001)), with researchers identifying and validating a potential portal where all information are available, connecting end-users and manufacturers/suppliers Design and implementation. The findings have shown great potential for e-commerce and acceptance of both buyers and suppliers, however, there has been no clear development of an efficient medical devices' platform. These issues shall be presented in next sections, discussing the (unrealized) potential of e-procurement platforms for the healthcare sector.

3.3 Procurement of Capital Medical Equipment in Romanian Public Hospitals

The healthcare in Romania is mostly a public one, with the largest population having access to free care. Thus, it is of multiple reasons that it is important to understand what is the structure of this sytem. First of all, the number of public hospitals is much higher than that of private ones. For example, in 2016, there were almost three times more public hospitals (i.e., 367) than private hospitals (i.e., 187) across the territory of Romania. Moreover, only 4% of all hospitalized patients were in private centres. Also, private hospitals only have 6600 available beds, while public hospitals have 125000 (Tiron, 2016). A second reason for understanding the public healthcare system, against private clinics, is the fact that, as mentioned previously, public hospitals must utilize a public procurement system. For this reason, there is a wider group of stakeholders involved and more complex implications, that all have a much deeper impact on the general population (i.e., patients).

3.3.1 History of the Romanian Healthcare System

Romania has been part of the European Union since the year 2007, a point in time when it had to begin aligning itself with the legislation of the E.U. This included the healthcare system, as well. However, the changes required by the E.U. came as the Romanian healthcare system was already going to reforms following the change of regime in 1989, when the country changed from socialism to capitalism with several reminiscences, such as bribery within the healthcare system, still remaining (Stan, 2012). This resulted in entangled outcomes, bringing forward the important aspect of accurately understanding the current context and state of Romanian healthcare.

The first documented law relating to health in Romania dates back to 1874, when, according to this law, all health services were provided by the state, with the Health Directorate within the Ministry of Internal Affairs being the central authority for the health sector. This was then followed by small changes following the unification of Romania, when laws were harmonized across the entire territory. The following changes occurred during the instauration of the communist system when all private health institutions were nationalized. After the fall of the communist regime, in 1990, the Romanian government made the decision of fundamentally

changing the healthcare system, attempting to implement a more decentralized system. Multiple health laws were introduced in 1995, 2002 and lastly in 2006 when the still standing law of health (i.e., Law 95/2006) was introduced (Vladescu et al., 2016)

The Romanian healthcare system is organized at two levels: national level and county level. At the national level, varying ministries (e.g., Ministry of Health or Ministry of National Defence) or national agencies (e.g., National Health Insurance House) have a diverse range of regulatory, financial, as well as other roles and responsibilities, but which are outside the scope of this research. At the second level other institutions can be found: District public health authorities, District health insurance houses, District council and District branches of professional associations. Public hospitals are usually owned by the District Councils; however, exceptions can be found (e.g., Ministry of Health, Ministry of National Defence).

3.3.2 Procurement of CME in Romania

In Romania, in contrast to examples given in section 3.1., most of the procurement activities of medical devices are carried at the level of the healthcare facilities for both private and public sectors. However, for the public hospitals, procurement must abide by the administrative regulations on public procurement which is overlooked by Law of Public Procurement (Law 98/2016), enforced by the National Agency for Public Procurement (NAPP).

Investments in the healthcare system can come from multiple sources. One of the most important resources are represented by the Ministry of Health and the budgets of local authorities (e.g., investments of 81 million euros in 2012, decreasing to 21 million euros in 2013). According to current legislation, budgets are approved and transferred on a yearly basis, in accordance with the investment plans and documented proposals made by the healthcare facilities in the previous years. The second major source of financial resources can be accessed through the World Bank and EU structural funds (e.g., support in development of feasibility studies, technical analysis and architectural designs). Lastly, public hospitals can access financing from National Health Insurance House or public-private partnerships, though in a relatively low percentage of total investments (Vladescu et al., 2016).

Regardless of the multiple sources of financing that public hospitals can have access to, various inefficiencies are found in the system. For example, Romania allocates only 0.6 % of the GDP to capital investments in healthcare sector (EuropeanCommission, 2020). This is then seen in the lack of capital investments. According to OECD, Romania ranks the lowest in terms of imaging capabilities (e.g., CT, MR, PET scans), with only 38 total scans per 1000 patients, representing a 50 % lower rate than the EU average - Fig. 3 (EuropeanCommission, 2020). Another critical aspect that is found in the procurement process of medical devices is that of costly equipment being procured and not used afterwards because of lack of staff or lack of funds for consumables and maintenance (Vladescu et al., 2016).

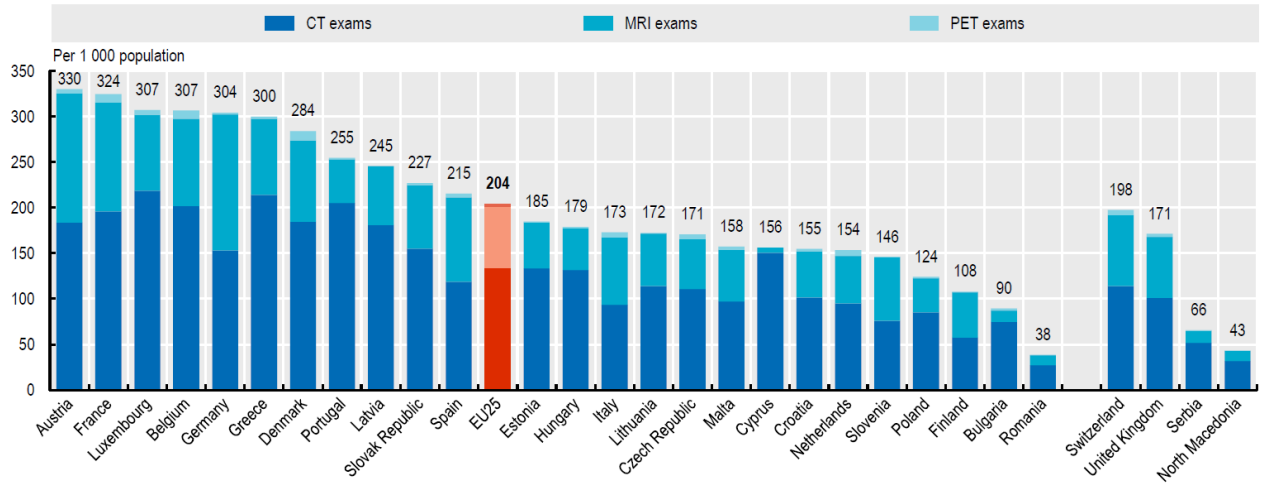

Figure 3: Imaging Exams per 1,000 population in 2018 (EuropeanCommission, 2020)

3.3.3 Legislation Overview

Given the scope of the research (i.e., public hospitals in Romania), it is crucial to also analyse the relevant legal aspects that govern the procurement process for introducing technologies in hospitals. As mentioned in section 1.4, acquisitions being carried in the public healthcare sector are governed by Law 98/2016, the Law of Public Procurement (Romanian Parliament, 2016) and conduct their procurement through SEAP (The Electronic System of Public Acquisitions). Law 98/2016 is currently further supported by the Governmental Decision number 392/2020 (HG-395-2020) which acts as a methodological guide in applying the Law of Public Acquisitions (Romanian Government, 2016). It is should be noted that public hospitals must acquire almost everything through a national public acquisition system, all the way from office stationery, food to construction services and capital medical equipment.

Usually, the need for a service/product starts internally. Following, according to the Romanian Parliament, 2016, the hospital may initiate what is termed "Market Consultancy", which must be announced through SEAP. Through this step, the hospital can invite various experts and vendors to make offers. This stage generally ends with the hospital being able to construct a detailed technical specification and estimate their cost. With the previous information, the hospital can initiate a public acquisition where vendors submit their offers and the general rule is that the lowest cost wins.

The existing Law entered in force beginning with 2016, when the whole acquisition legislation has been adapted so that it was in line with European directives (i.e., Directive 2014/24/EU). As a result, it can be stated that similarities can be found across the public acquisition systems in Europe, however every country has adapted to its local context. The Law differentiates between two main actors: 1) contracting authority: the organization initiating an acquisition procedure and 2) the economic operator: the organization having the choice of participating in a tender, becoming an offering authority. Moreover, the Romanian Law also defines the system acting as an intermediary between the two parties: SEAP, representing the information system

through which contracting and offering authority may interact while a tender is in process.

For a public acquisition to take place, the contracting authority has to go through three stages. The first one refers to the stage of planification/preparation initiated by necessity identification and composing a necessity report to be approved by the manager of the authority. The second stage, termed the stage of procedure organization and contract/framework agreement award, starts with uploading all documents in SEAP and finalizes with awarding the contract/framework agreement. The final step which is termed the stage of contract performance refers to monitoring and executing the contract/framework agreement.

There are various types of procedures available to the contracting authority: open procedure, restricted procedure, competitive procedure with negotiation, competitive dialogue, innovation partnership, use of negotiated procedure without prior publication, simplified procedure. The selection of this is dependent on three criteria: 1) estimated value of the acquisition; 2) complexity of the contract/framework agreement and 3) meeting specific conditions of applying certain procedures. In estimating the price for a particular procedure, the contracting authority has the possibility of running a market consultation. This also may aid the contracting authority in seeking or accepting advice from independent experts that can be used in planning and conducting the procurement. As stated, in deciding the type of procedure, price estimates are an important factor. Also, given the scope of this research is capital medical equipment, the most important threshold is 648,288 lei, corresponding to 139,000 Euro in 2016, or 131,674 Euro in 2021. All acquisitions equal or greater than this price must also be published in the Official Journal of European Union.

The Law does not only impose actions and stages that must be followed during public acquisitions, but also values that should be applied. According to Article 2 of Law 98/2016, the scope of the law is to assure the necessary legal framework for purchasing good, services or workings in conditions of economic and social efficiency. Moreover, the base principles underlying the given Law are: no discrimination, equal treatment, proportionality, transparency, mutual recognition and accountability. These values can be found in most European member states, as stated in Directive 2014/24/EU. According to Bof & Previtali (2007) the scope of these principles is for governmental bodies to create the best conditions on public markets, as well as stimulating competitiveness, innovation and quality and to allow public entities to increase the welfare of European citizens.

It can be noted that the Romanian system of public acquisitions is in line with other countries, especially European countries. In addition, public hospitals have access and must utilize a digital platform in order to conduct procurement of medical equipment. However, it can be argued that the implementation of digital platforms in the context of medical devices procurement has not yet reached its full potential.

3.4 (Unrealized) Potential of E-procurement for Public Hospitals

Ever since the benefits of digitization have started to be understood, during late 1990s and early 2000s, the healthcare industry has tried to achieve its goals (be it cost minimization, better health, interoperability, flexibility etc.), by developing and implementing eHealth. This term encapsulates a whole range of synonyms and variants such as e-commerce, digital markets, telemedicine, e-procurement and so on. Despite all of the advantages and extent research into identifying the barriers and conditions for efficient integration, the current state of eHealth, specifically in the area of B2B commerce, is not as bright as one might have expected.

There have been various attempts for applying B2B e-procurement within the healthcare system, but without the expected success. Ketikidis et al. (2010), describes a proposed technical solution but, the research finds issues in implementing the system across E.U. countries due to policies and regulations. An even earlier attempt has been made by Bravar et al. (2001), where an online auctioning system was proposed. Again, the system was not very well adapted to the market, though the industry seemed very interested in online researching.

Others, have frequently cited the issues of poor usability, availability, appropriateness, affordability and acceptability of medical devices which are bought by hospitals (Diaconu et al., 2017, Vincent & Blandford, 2017), as well as the need of medical staff's direct involvement in the process, as opposed to having solutions imposed to them (Vincent & Blandford, 2017). Even though the medical staff's role in the adoption is significant, their role in procurement of the devices is usually reactionary. Greater collaboration between the procurement and physician can have a positive effect towards a more informed and value-based technology procurement. These problems can be traced to e-procurement which, in its attempt to make the process more transparent and follow the rules, the decision-making process usually involves soliciting specific products, which can hinder the innovation or unexpected offerings (F. A. Miller et al., 2019), with decision makers favouring the familiar and the appropriate technical specification (Diaconu et al., 2017). Other problems with the current process of e-procurement relate to the criteria which guides the procurement decisions. As the system is currently focusing on lowering costs, and thus choosing the lowest cost, research has shown that more advanced methods are necessary so that adequate and added-value technologies are selected (Kiralyova et al., 2017). Furthermore, with the current system, buyers may find themselves in a lock-in with the supplier (especially for capital medical equipment). It has been found that due to the nature of the legislation, the hospital is usually bounded to the winner of the contract for the duration of the product's life (i.e., for maintenance, servicing etc.) (Consiliul-ConcurenteiRomania, n.d.).

Nonetheless, the literature review presented here has shown that there is a vast interest in and well-documented advantages of digital platforms for B2B transactions in the healthcare system. This comes in favour of current practices which are seen as too rigid and authoritative and as lacking doctors' valuable input. In addition to identifying the benefits, previous research has detailed the challenges for these systems. But, if we are to look at the inefficiencies that still exist or failures to apply digitalization, one might wonder if the barriers recognized so far are not the real ones.

Regardless, there is a clear need of digitalization of the healthcare system. This has existed for the last 20 years and outlooks of the healthcare system present the same trends. When looking at the medical technology transactions, which are expected to reach $ 800 billion worth of sales by 2030 (KPMG, 2019) and with innovation booming, benefits for proper medical equipment selection can be realised through digital means. Deloitte (Deloitte, 2019) and McKinsey Company (Chadha et al., 2020) place changing the business paradigm into a much more digital version, as one of the priorities for advancements in the way healthcare is delivered.

3.5 Chapter Closing Remarks

The presented chapter aimed at identifying and analysing relevant literature in relation with the scope of the research – e-procurement of capital medical equipment within public healthcare facilities, with a focus on Romania. Doing so allowed to understand the current state of the research available on the topic under investigation. The literature review has had as a main purpose understanding how changing the traditional B2B environment into a digital one (i.e., e-commerce) will impact healthcare. It was shown that there is a whole plethora of benefits. This also holds true for developing countries, such as Romania. It was identified that Romania is still transitioning a period of reform and that digitalization efforts are not carried fully. However, it might be the case that, given failed attempts, requirements and needs of the healthcare system are not well or completely understood, especially in Romania. The literature review discussed showed that acquisition of medical equipment is a complex process, presenting intrinsic particularities, such as a wide range of involved actors, a high number of available technologies and tedious process during decision making. The literature review has identified similarities between various systems (e.g., Sweden, Germany and even Canada). Narrowing down, for the particular case of Europe Union, this is happening because of the need to harmonize multiple acquisition systems, under the Directive 2014/24/EU, governing public acquisitions across all industries.

It was shown that, for the complex situation of the healthcare system, various initiatives have been taken towards digitalization. Apart from (digital) solutions such as e-health, electronic health records and many more, authors have argued for the necessity of e-procurement. The literature identified multiple advantages, as well as barriers and critical success criteria for the implementation of digital procurement platforms in healthcare.

Through the above literature review, the research also tried to analyse the specific context of the focus country: Romania. It was identified that, as expected, Romanian healthcare legislation is adapted from the European directives. Moreover, it was identified that Romanian public healthcare is using a digital platform for acquisitions – SEAP, but whose purposes have not been fully understood. It was found that a significant lack of research is present in Romania, with few authors trying to research topics only vaguely tangential with the procurement of medical devices in public hospitals. While there is literature arguing for the benefits of digitalization, it is for the reason of lacking research in Romania that it is necessary to bring the dimension of context into the research gain a more in-depth understanding of the acquisition process, roles of stakeholders and how e-procurement can bring positive changes in the healthcare domain.

Moreover, a thorough literature review can offer great insights into a topic under investigation, however, for the one presented here, it has only partly fulfilled this prerequisite. First of all, a literature research can only offer general insights into how relevant stakeholders perceive the acquisition process. Secondly, as mentioned, the literature review surfaces the success factors that should be present in an e-procurement system for medical devices. However, it cannot offer the perspectives of those directly influenced by the system. Lastly, the previous chapter indicated appropriate improvements for e-procurement systems, but, for the reasons of slim research in Romanian, it cannot offer contextual improvements.

4 Interview Results

Throughout this chapter, the findings following from the raw data captured during the semi-structured interviews, which was then analysed using ATLAS.ti will be presented. This will be done following the same structure and main themes of the interview guide presented in section 2.3.3. It is important to separate between how the procurement system is perceived by those involved (as a process), how the decision makers and evaluation criteria are seen, what is the attitude towards new technologies into the practices of healthcare and what needs stakeholders feel should be met in an adapted system. Having broadly 4 groups of stakeholders (i.e., acquisition personnel, medical staff, supplier and former individuals involved in acquisitions), each subsection will be analysed from the perspective of individual groups. A cross-analysis, together with the an in-depth analysis of the results will be presented in the following chapter.

4.1 The Current Acquisition System

In the first part of the interview, the research aimed at understanding what are the most important stages of an acquisition process. This was achieved by discussing with the respondents their experiences and perspectives in relation with the acquisition process and on what steps of the process different stakeholders put emphasis on. An overview of the results can be seen in Fig. 4, showing that the system is mainly perceived in a similar manner. However, the medical staff does not mention important stages, such as market consultancy or the awarding of the contract (i.e., framework agreement).

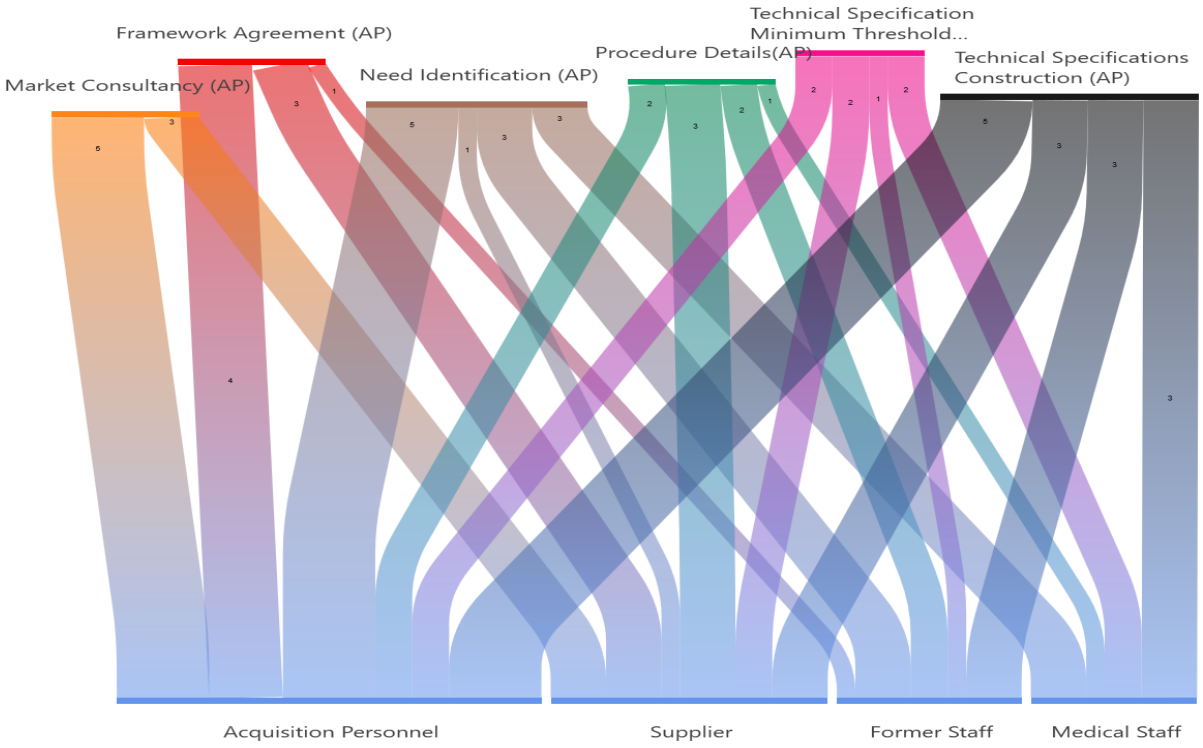

Figure 4: Stages of the Acquisition Process as Perceived by Stakeholders

The results will be presented below in more depth. Also, an overview of the process, as constructed from the results, can be seen in Fig. 5, with accolades representing the respondents who mentioned the respective stage of the process and the rounded boxes showing who is responsible for each step.

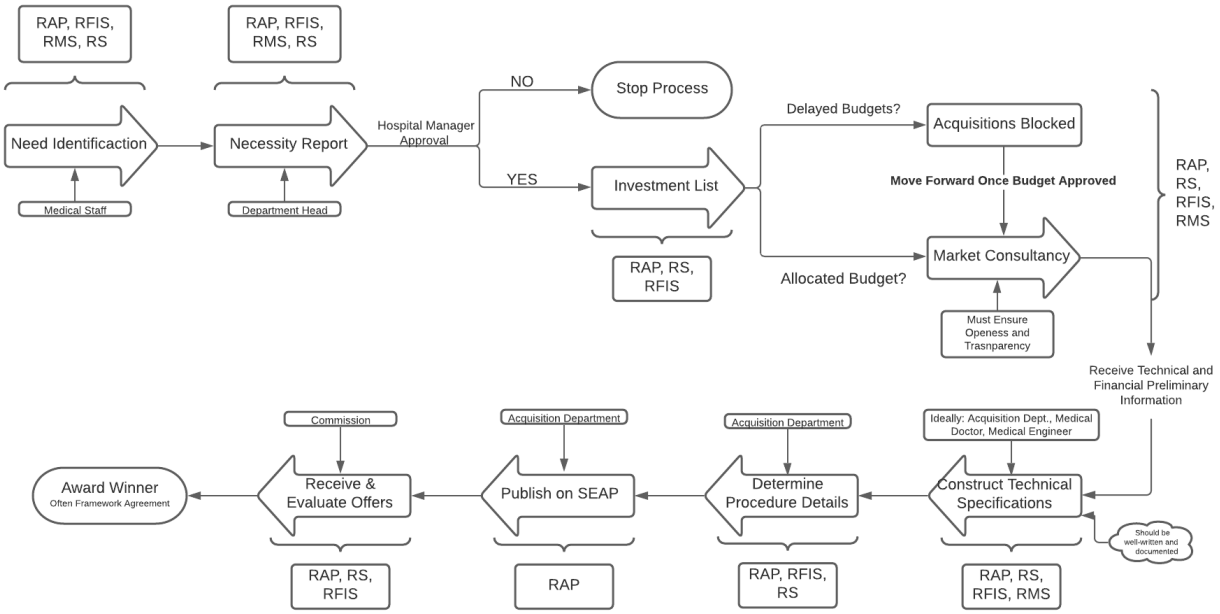

Figure 5: Important Stages in the Acquisition Process

Initiating the acquisition process requires, as the very first thing, the identification of a need, mentioned by all of the individuals directly involved in the procurement process. However, the respondents have stated that this is usually completed by the medical staff, most frequently the department head (RMS2, RMS1, RMS3, RAP1, RFIS2).

Normally, the head of the department, seeing the needs and the state of wear of the device, makes a report of necessity in which he establishes the minimum requirements that an equipment must meet without being very specific. - RMS1

One of the respondents argued that this must be done by the medical personnel, as the acquisition department cannot know what the hospital requires and, on top of this, medical staff is the most knowledgeable about the needs of the department, following a bottom-up approach.

We, in acquisitions, have no way to know what equipment the doctors need for procurement in their departments ... and then the head of the department makes a report requesting the equipment, justifying what it is used for ... after which it gets in the circuit - RAP3

After the need has been identified, a necessity report must be completed which, depending on the organigram of the hospital, must be approved by relevant departments (e.g., legal, financial etc.) and lastly by the manager

of the hospital. The approval of the manager has been found to be required irrespective of the hospital's organization. Should the necessity report be approved by all required departments, it is included on a list of investments (respondent RAP1), for the following year.

These needs, after being approved, are introduced in the Annual Public Procurement Plan, usually at the end of the previous year - RAP1

It is important to note that, in the Romanian public healthcare system, as mentioned by multiple respondents, hospitals receive their funding from public organizations (e.g., the Government or Ministry of Health) and their budgets must be approved by the end of the current calendar year (i.e., the 31st of December), for acquisitions taking place in the following year (RAP1 si RAP4). However, multiple respondents have stated that budgets are not approved at the deadline stipulated in law, this constituting one of the major issues, which will be presented in following sections (RAP1, RS1, RFIS2, RS2).

From the experience of the last 20 years since I have been doing business there has been no year when the budget was approved faster than March of the fiscal year to which the budget is addressed - RS2

Nonetheless, considering that the investment list is approved and budgets are allocated to the hospitals, the next stage (especially important for capital medical equipment) is that of a market consultancy (all respondents). A market consultancy supposes that basic technical requirements are published in the Electronic System for Public Acquisitions (SEAP). Respondents (RAP1, RAP3, RS1) view this step as an important one because it offers them a chance to receive information regarding the latest technologies available for their needs, as well as offering price estimates. However, interviewees have stated that special care must be taken during market consultancy in order to preserve openness and transparency (RAP2). According to RAP2 and RAP1 the publisher of the market consultancy should make sure to receive initial offers from multiple suppliers. Should there not be sufficient participants, in the case of CME where there is a limited number of vendors, the distributors can be reached directly and invited to the procedure (RAP2). When looking from the perspective of the medical staff, interestingly, they are detached from this stage, not mentioning the necessity of a market consultancy.

As mentioned earlier, it was found that the main purpose of the market consultancy is to provide the buyer (i.e., hospital) with relevant technical and financial information. Based on these, the hospital can then construct the technical specifications (*'caiet de sarcini'*) and a maximum price estimate, which then permit the hospital to initiate a public tender. Technical specifications usually represent the backbone of the tender and, as interviewees mentioned, these are minimum requirements which should be met by all participants submitting offers (RAP1, RAP3, RS1, RS2, RMS1). The need of a technical specification is mentioned by the supplier as well, recognising its high relevance.

Yes, there are those categories, but we are still in the area of high-performance, high-quality equipment. It is very important, again from my point of view, to define very well what we want. - RS2

This shows the importance of well-written technical specifications which ensures that the hospital receives the technologies it requires. However, as discussed by various respondents, this does not always happen, resulting in purchasing lower quality equipment (RAP2). Depending on the type of equipment that must be purchased, the law permits the selection of various types of procedures which can be initiated (normally influenced by varying price estimates thresholds). Considering the scope of this research (i.e., capital medical equipment), a public tender is the only permissible process.

[...] tender, direct purchases ... depending on the amount I estimate and how urgent the equipment is - RAP2

Depending on the type of procedure to be established for the respective equipment, because it can be direct purchase, framework agreement, multi-annual contract and then they (colleagues within the department) establish according to the type of procedure - RAP2

Once the tender is published, suppliers/distributors have a maximum timeframe during which they can submit offers or make contestations relating to the technical specifications. These are then evaluated by the contracting authority (i.e., hospital initiating the procedure) and a winner is selected. One interesting finding, mentioned by those involved in acquisitions, is that, even though the systems is supposed to be on a digital platform, they are still required to print all submitted documents (RAP2, RAP4, RAP3). This is necessary especially during the period of offer evaluation, in order for the evaluating commission to make comparisons between potential products. What is more, according to the current law, hospitals are required to archive all necessary documents, in print, for at least five years after the procedure has been finalized (RAP4, RAP3).

Based on the approved budget and price of the equipment, various purchasing agreements between the contracting authority and the bidding authority (i.e., supplier) are possible. What was found from the analysis, is that the most preferred choice is that of a framework agreement ('acord cadru'), as mentioned by (RAP1, RAP3, RS1, RS2, RFIS2). This type of agreement permits the hospital to initiate, run and finalize a tender without having the budget for a specific equipment available at the time of tender. Such an agreement can run for two to four years and allows the hospital to request the supplier to deliver the product once the budget is approved. However, while a framework agreement is legal, its purpose has been adjusted by contracting authorities in order to avoid certain barriers imposed by the system. Finally, once the budget is available, the supplier deliveries, installs and commissions the equipment and only now the process is complete.

At the level of the European Union, the framework agreement is a gentlemen agreement, practically - RAP1

4.2 Perceived Barriers and Advantages of the Acquisition Process

When trying to adapt the acquisition process of medical equipment, it is important to understand the barriers, as well as the benefits, as perceived by the actors involved. Therefore, this subchapter will present the bottlenecks and the relatively slim number of benefits that the current acquisition system inherits, faced by all interviewed stakeholders, in a clustered manner. Lastly, the subchapter will offer an overview of all issues mentioned by the participants.

Before presenting the issues faced by each subset of stakeholders, it is important to look at the full picture. From Fig. 6 it can be seen that most often mentioned barrier, faced by all respondents, especially by the acquisition personnel is that of long periods for procurement procedures to take place. This is then followed by the issue of delayed budgets, which does not allow acquisition procedures to take place. In the following sections, the two mentioned disadvantages, together with others, will be discussed individually, depending on the group of actors mentioning it. A distinction needs to be made across the stakeholders as barriers identified can differ. Even though the respondents understand the (entire) system in a similar way, they interact only with some stages of the process and, as a result, they face different crucial barriers.

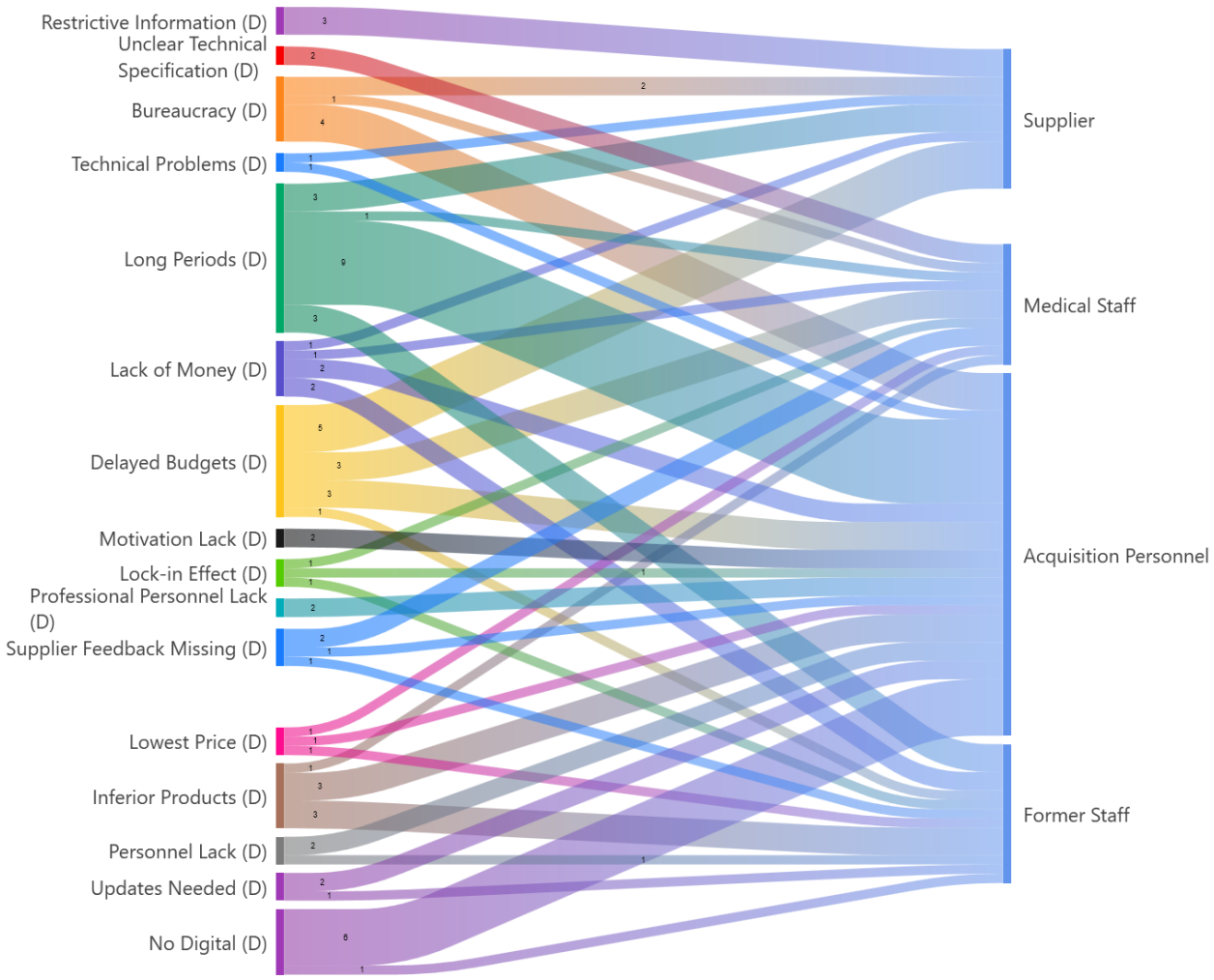

Figure 6: Barriers and Advantages: Overview

4.2.1 Acquisition Personnel

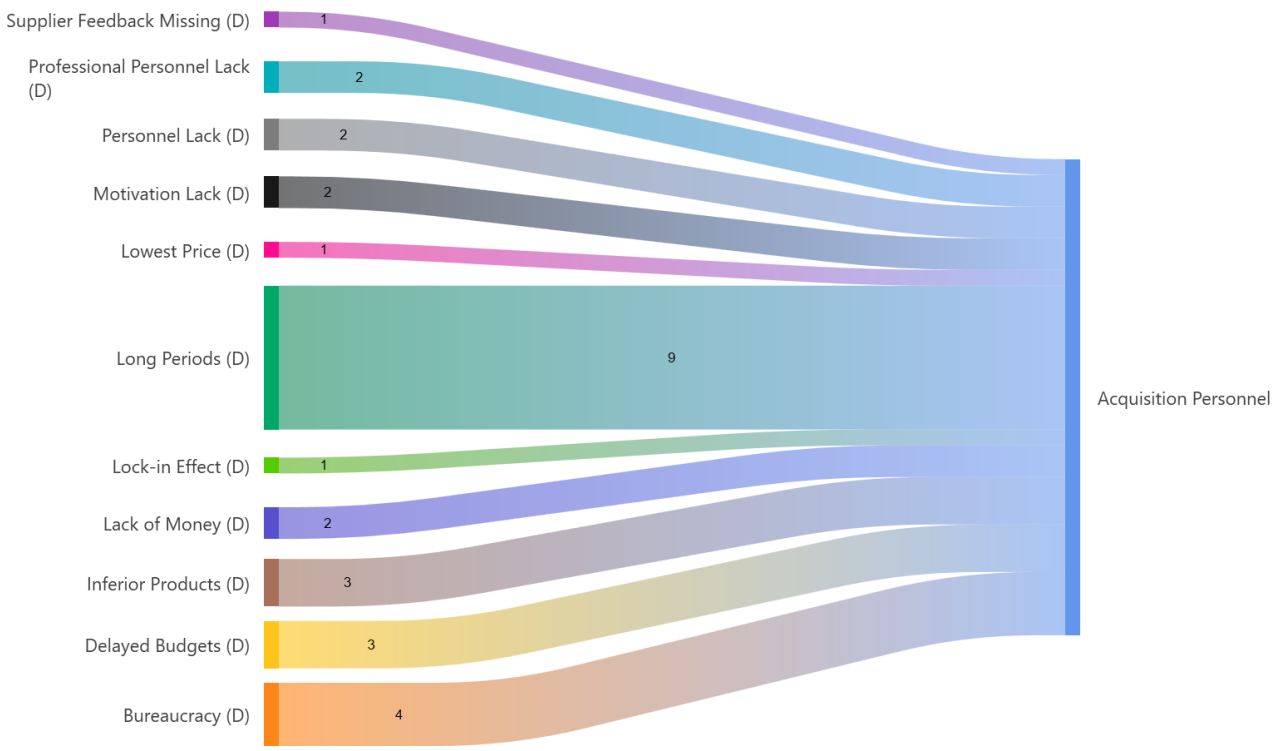

Figure 7: Barriers and Advantages: Acquisition Personnel

First of all, it is important to take into account that differing time limits are set for each stage of the process, irrespective of the status of required documents submission, which are seen as too long by some respondents (RAP1, RAP2).

There are some legal deadlines that must be respected and they are very long - RAP2

[...] those very long auction periods in which the procedure has to be in SICAP - RAP1

The fact that the announcements are sent to the European Journal are 5 days lost, then wait for 35 public days until the participants submit the offers, after that I don't know how many days of contestations. It is a very long period in which the acquisitions take place - RAP1

In addition to this, suppliers have the right to submit contestations, usually referring to the technical specifications, which should assure openness and not be restrictive. Therefore, in the opinion of respondents, contestations represent an extremely important barrier in delaying the acquisition process. On top of this, interviewees stated that suppliers can submit contestations without being penalised in any form, should the contestation be ungrounded. The case of contestations is especially sensitive in the case of CMEs. While competition is a desirable characteristic of a public acquisition system (RAP2, RAP4), offering suppliers the freedom of unaccountable contestations, can have serious effects on the introduction of technologies in hospitals.

Competition will always occur for expensive equipment. The companies will fight because having a high price they will fight to win the tender and they will do everything possible to secure their first place. Contestations, all kinds of unpleasant things, which irritate us and delay our acquisition process. - RAP2

Long periods are also affected by budget approval. While financial resources should be allocated to hospitals by the end of the calendar year, experience has shown that this normally does not happen. As a result, hospitals are required to initiate procedures with significant delays (RAP4, RAP1, RAP3). In addition, through contestations, suppliers may influence the technical specifications. This is because of the importance paid to not having restrictive tenders, so some characterises of the desired product that are seen as restrictive will be deleted, potentially resulting in inferior quality products (RAP2).

We have the annual budget. Look, for example, this year only in April the approved budget came. We were blocked in January, February, March - RAP1

Then what bothers me a lot is that you can't buy the equipment you want because you always have surprises in a tender. And also because you get an operator with inferior equipment from a technical point of view, but it complies with the requirements set out in the technical specification, but the equipment is much more inferior to the rest of the equipment submitted and you cannot disqualify it and you are obliged to take it. - RAP2

Taking a different perspective, the acquisition personnel have made multiple references to the human factor involved in the process. Three of four of the respondents have stressed the lack of trained and skilled personnel in the acquisition offices. Two of them have even mentioned that a shortage of personnel exists. In their opinion, lack of trained personnel can lead to other effects such as motivation lacking (RAP1) or fear of action (RAP1, RAP2).

The staff working on acquisitions in Romania is not professionalized in this field - RAP1

Lack of staff and their demotivation and there is no professionalization of those working in procurement - RAP1

Thirdly, even though approximately 90 % of the tenders (RAP3) must pass at some point through the digital platform, other disadvantages were identified through interviews such as that of the still existing high-level of bureaucracy. This refers to the fact that, as mentioned earlier, the contracting authority has the obligation to complete multiple stages of the process manually, on paper, as well as archiving documents for multiple years, even though the acquisition process is supposedly online (RAP3, RAP2 RAP4).

First of all, let's give up the documents we print, that is, everything should be electronic. Because the law also refers to working electronically, but unfortunately it is not possible. The program should be slightly updated. - RAP3

A very interesting finding is that bureaucracy has shifted. Whilst in the past, the supplier was required to submit all documents on paper, now it is the responsibility of the hospital to access the online platform and download all necessary documents (RAP3, RAP4). Moreover, RAP4 RAP3 and RS1, have also discussed technical issues of the SEAP platform. These technical difficulties refer to platform crashing during high-importance tenders and still being a very basic platform, not offering sufficient capabilities.

We don't print anymore, we scan, we do everything electronically and we stayed at this way of working... we paste them in .pdf, we edit them in .pdf... I haven't printed anymore and it seems normal to me - RS1

4.2.2 Medical Staff

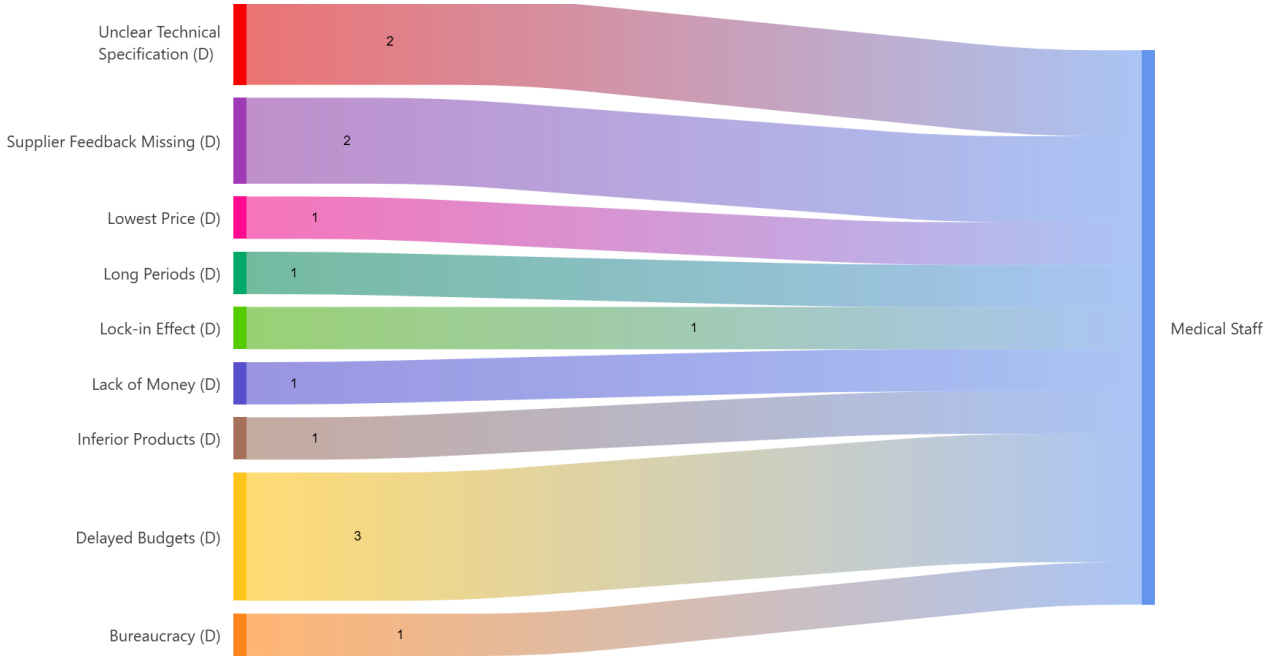

Figure 8: Barriers and Advantages: Medical Staff

During the interviews with practitioners, both disadvantages and disadvantages of the current acquisition process were attempted to be identified. However, data shown that no mentions of advantages were made by the participants. On the other hand, the most frequent barrier cited by the medical staff is that of long time periods for budgets to be approved (RMS2, RMS3).

To identify the need, find out what technical solutions exist and then start applications for funding - RMS2

Even though it may be argued that budgets are the responsibility of other departments in the hospital (e.g., acquisition, financial), doctors are indirectly affected when considering their inability of receiving the needed technologies at the right time. Not only do doctors need to wait for hospital-wide budget approval, they also need to convince the management that their need is real and should be fulfilled (RMS2).

Once we are convinced that we could use a certain device, the first barrier is funding or access to funding because you have to convince those who run the hospital that, from the existing bag of money where more departments would have access to, you must also receive some - RMS2

Secondly, when looking at the technical aspects of their needs, medical staff interviewed has indicated other disadvantages experienced under the current acquisition system. One of this is relating to unclear technical specifications. RMS2 mentioned that on the online catalogue available on SEAP, the product description can be vague or even untrue. This makes it difficult for purchasing equipment directly.

The strangest part would be the detailing of the characteristics of the medical devices. Well, they are either very vague or inaccurate or it even happened to be untrue - RMS2

Another aspect pertaining to technical aspects is that the equipment supplied might be of an inferior quality than what was required. This can happen because of the most frequently used evaluation criteria: lowest price. Apart from sometimes purchasing inferior products, an interesting finding was that of a lock-in effect (RMS3), where the buyer is dependent on the supplier (e.g., for servicing). This is important to mention because in the case of high-cost medical equipment, such as an accelerator, servicing can only be performed by one of the few specialized companies for the entire lifetime of the product. With this duration being of around 10 years, a significant lock-in effect can be experienced by the buyer.

[...] in France you leave from there on your knees, you as a firm. And you accept the conditions that the market is very competitive. And you can't afford to play. Now Romania has steadily started to set conditions - RMS3

Lastly, another disadvantage identified during the interviews is that of feedback following signing the contract. As there is no digital connection between the medical staff (i.e., end-user) and the vendor, no advancements can be made neither in the acquisition process nor the equipment's specifications (RMS2).

[...] efficiency that no one is measuring - RMS1

The first impulse would be to say no... .but I don't want it to be so... but I don't believe... - RMS2 when asked about supplier asking for feedback

4.2.3 Supplier

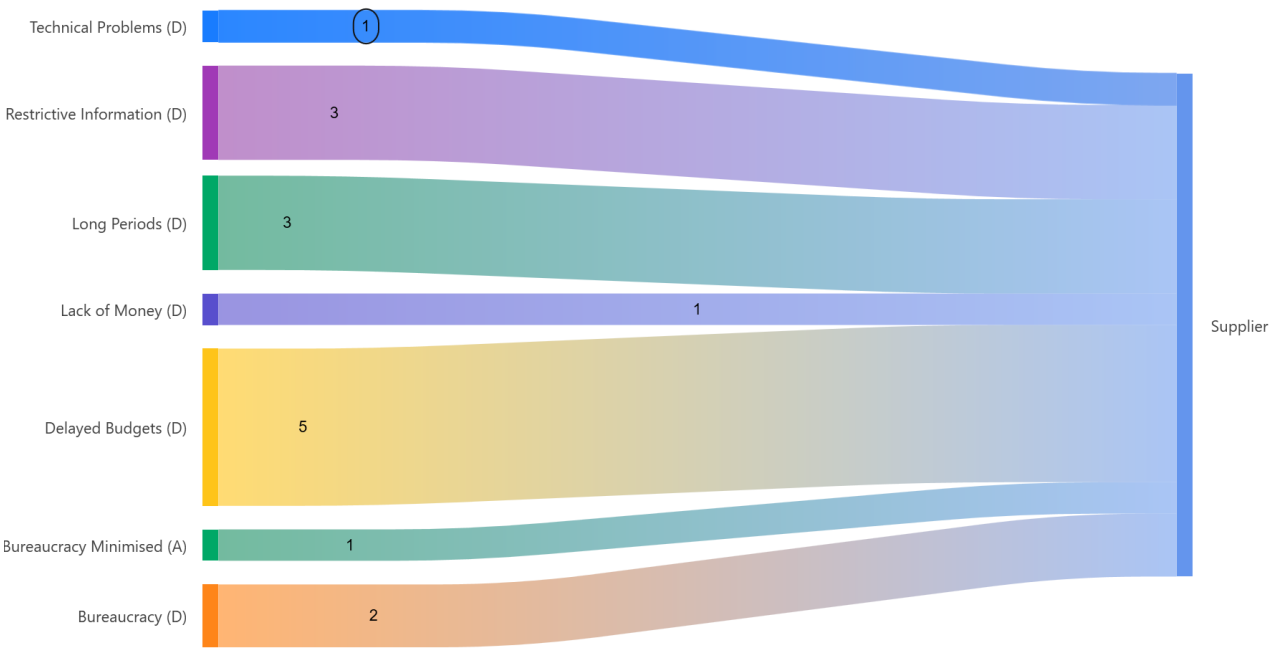

Figure 9: Barriers and Advantages: Supplier

The most frequently stated disadvantage by the supplier side relating to the current process, is that of long periods for conducting procedures (mentioned by both respondents). Two main causes were mentioned. The first one relates to lack of money and long periods for budget approval from the public institutions. Similar to other clusters of respondents, references were made towards the failure of the government to meet the deadline for composing the next calendar year's budget. One participant mentioned that budgets can be delayed even for up to six months (RS2), which are then followed by over 190 days for tender duration (i.e., for CME).

We have reached 135 days with another 60 days, we are at 195 days which means 6 months [for the product] to come. After which comes the period to install; or maybe in the 60 days we do the installation and put into operation - RS2

Other barriers faced by the supplier, similar to other stakeholders, refers to the high level of bureaucracy present within the system. RS1 mentioned that redundant information is required at different stages in the process. Even though a DUAE system is in place (similar to an electronic signature, acting as a proof for other documents), suppliers are still required to submit the documents which should be included in the DUAE. On the other hand, it is important to note that suppliers view SEAP as a facilitating platform, permitting them to use less "pen and paper". However, as interviews with acquisition personnel have shown, the task has now shifted towards the contracting authority.

The stamp is still used and requested to the maximum, which as far as I know it has been a few good years since it is no longer needed in Europe... there are remains that I think will be very difficult to heal - RS1

When looking at the digital platform (SEAP), other barriers were identified through interviews with suppliers. Data has shown that the platform still faces basic technical requirements. As an example, RS1 mentioned that the platform may crash when multiple participants are active. Also, the platform is seen as restrictive. Whilst information relating to the final acquisition price is available, if multiple products are bought under one tender, one cannot identify the price per product, making company positioning difficult. Moreover, on SEAP there should be published interim reports which would permit the supplier to better understand its competition. This normally does not happen, as stated by RS1.

Here would be the only reservation... as a construction, it does not provide enough information that you should have from an award announcement - RS1

4.2.4 Formerly Involved Individuals

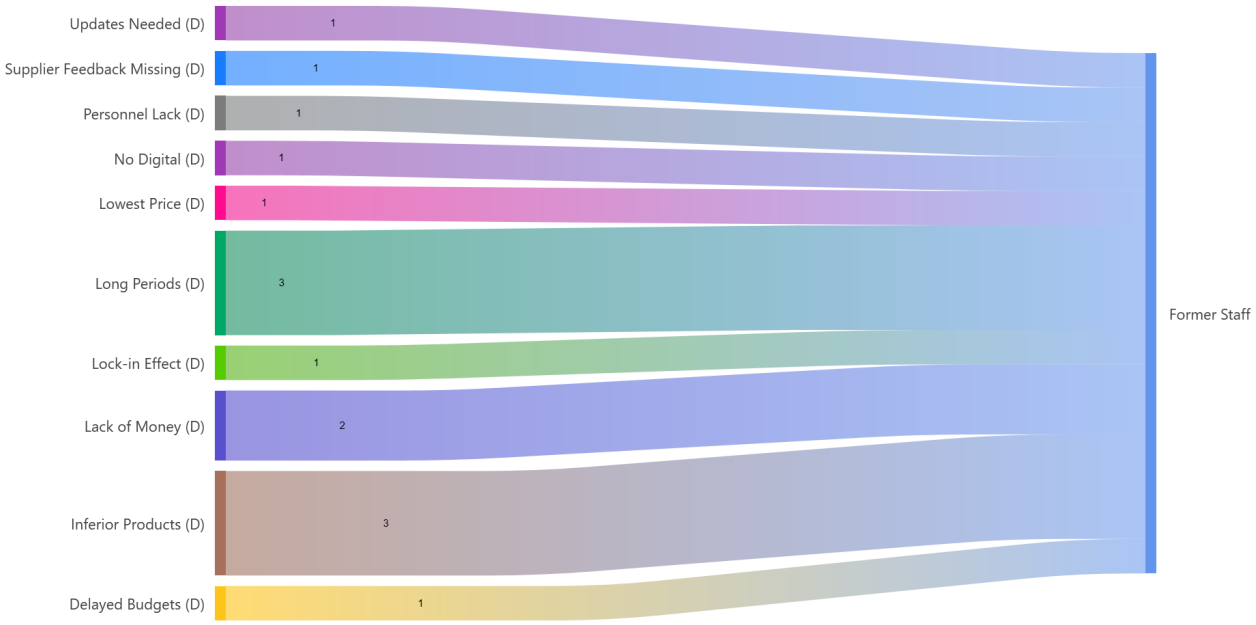

Figure 10: Barriers and Advantages: Formerly Involved Individuals

Finally, it is important to look at the barriers experienced by those who are no longer directly interacting with the system. Their opinions can be seen as highly relevant as these individuals are detached from the system, offering them more freedom in discussing issues related to the research under investigation.

One of the respondents (RFIS2) mentioned issues relating to the digital platform (SEAP). The participant argued for the necessity of updates carried on the platform in order to provide more efficiency and to simplify it. The participant also stated that even though the process is online, this is not necessarily true, with paper or face-to-face discussions still being required.

There have been several attempts in Parliament to somewhat simplify and streamline this platform. – RFIS2

[...]ideally it should be an acquisition platform or the current platform should be updated so much, as well as the Law - in the end everything starts from the law - to shorten these times as much as possible .... there are dead times for the hospital, for the patient. That is where, ultimately, these dead times and lack of equipment reflect - RFIS2

Other problems brought forward by the participants refer to the acquisition personnel. RFIS1 identified the problem of the reduced number of staff and especially that of skilled personnel. The respondent even added that there are no regulated courses that can educate individuals for public acquisitions. This is in line with what personnel currently working in acquisition who stressed the importance of courses in understanding and applying the law (RAP1).

Long periods for procedures were identified as issues within the current system. The causes for this are again twofold: lack of money and long periods or delayed budget approvals. Moreover, contestations were once again seen as a blocking factor in the acquisition process. These in turn can have an effect on how acquisitions are completed, based on the lowest price criteria, leading to inferior products being bought by hospitals. Finally, one respondent mentioned the lock-in effect (RFIS1) as a result of the acquisition system.

[...] the only barrier was the budget and then the length of the procedure. – RFIS2

[...] not just for the sake of making a contestation and putting sticks in the wheels of a competitor - RFIS2

In Romania the customer is captive (e.g., consumables) - RFIS1

4.2.5 Overview of Barriers in the Acquisition System

In order fully grasp the problems faced by the participants and, ultimately, the individuals who are directly affected by the acquisition process, it is important to present an overview of the disadvantages identified. Thus, Table 5, presented further, contains all major issues or bottlenecks that have been indicated by the respondents in relation with the acquisition process in Romanian public hospitals

Barrier/Disadvantage	Brief Description	Stakeholders
Delayed budget approvals	Budgets allocated to public hospitals are not approved at the legal deadline	Acquisition Personnel, Medical Staff, Supplier, Formerly Involved Individuals
Long procedure periods	The time it takes for a procedure to finalize - effects on introduction of technologies	Acquisition Personnel, Medical Staff, Supplier, Formerly Involved Individuals
Contestations	Acquisations or clarifications brought forward by supplier, delaying the process	Acquisition Personnel, Formerly Involved Individuals
Lack of professionals	Missing staff that is skilled and experienced (both in acquisitions and medical staff)	Acquisition Personnel, Medical Staff, Formerly Involved Individuals
Bureaucracy	Need of exiting the digital space	Acquisition Personnel, Supplier, Formerly Involved Individuals
Technical specifications	The backbone of procedures - difficult to construct or evaluate	Acquisition Personnel, Medical Staff
Evaluation Criteria	Factors guiding decisions, mostly price, are outdated	Acquisition Personnel, Medical Staff, Supplier, Formerly Involved Individuals
Inferior quality products	Hospitals are not able to purchase the desired level of quality	Acquisition Personnel, Medical Staff, Supplier, Formerly Involved Individuals
Lock-in effects	For CME, hospitals are bounded to the supplier, for the lifetime of the products	Medical Staff
Digital platform limitations	Platform is crashing, outdated or is not offering sufficient information	Acquisition Personnel, Supplier, Formerly Involved Individuals

Table 5: Summary of Barriers and Disadvantages in the Current Acquisition Process

4.3 Commission and Evaluation Criteria

The second set of data that was gathered and analysed refers to the evaluating commissions and evaluating criteria. This type of data is highly relevant for the scope of research because it can offer insights into what stakeholders view as important decision makers, as well important characteristics when making decisions. Moreover, as already presented, one of the most important steps in the acquisition process is that of offer evaluation. This is the stage which determines what is ultimately bought from the technologies available at the suppliers.

4.3.1 Commission

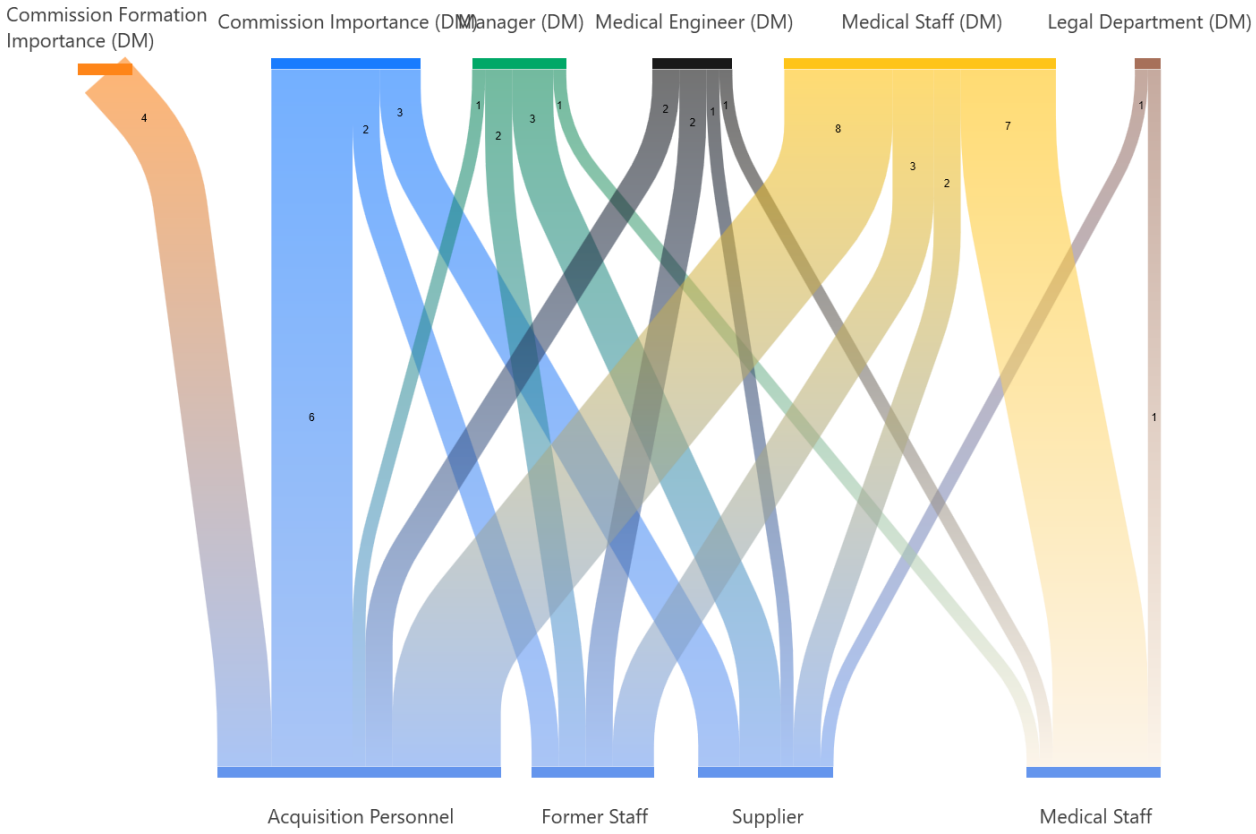

Figure 11: Decision-Makers as Perceived by Stakeholders

Procurement processes usually involve a large group of individuals with varying stakes. In the Romanian public hospitals, as seen in Fig. 11, the interviews shown that these can be categorised as follows: medical engineer, hospital manager, medical staff, legal department and commission. The commission, as mentioned in four instances by acquisition personnel is formed for each individual procedure and is normally formed by an elected president and at least two other members. The commission is recognised as having a significant impact on the process by three clusters of stakeholders: acquisition personnel, former individuals involved in acquisitions and the supplier. Interestingly, there were no references about commission from the medical staff. Moreover, some respondents stated that the commission has the ultimate power and no one else can have a higher level of power (RAP1, RAP2). The obligations of the commission are to evaluate the entire process and to construct

the technical specifications, as usually, those who identified a need are included in this panel (RAP2, RAP1, RFIS2, RS2).

During procedures, the commission is "God" and above the commission are the clouds, there are no other decision-makers in the procedure, without discussion. That there is a list of people who do not even have access to the procedure, these are people with decision-making power in the hospital but not over the commission - RAP1

Clearly those who drafted the specifications. When preparing the specifications, from my point of view there must be both a doctor who says what he wants but the doctor, attention, nota bene, has no technical knowledge - RFIS2

The second most important set of decision makers are the doctors, as stated by all interviewed individuals. First of all, they are the ones who initiated the procedure and are the most knowledgeable about what is required for their respective department (RAP1, RAP3, RAP2).

There is also the person who wants to use this equipment ... of course it will not be just one person ... but from which the report of necessity starts - RAP3

Moreover, the medical staff, specifically the department head, is the person responsible for writing the necessity report (RFIS2). Furthermore, doctors are those key people who are always in contact with supplier (RS2), finding information about new practices and technologies, having a wide knowledge of what should be introduced in order to improve patient outcomes. Nonetheless, respondents indicated that it is important to account for the fact that doctors do not hold technical information, nor should they (RMS1, RFIS2, RMS2), and as a result, a new group of decision makers is needed: medical engineers.

[...] to have a man from the technical part of the acquisition, procedures and documentation because we are doctors first of all. It is not the prerogative of the doctor to make all these acquisition steps - RMS1

Medical engineers are those individuals who have technical knowledge and are able to assess an offer from the engineering requirements perspective (e.g., electrical requirements of construction requirements). For this reason, respondents admitted that at least one engineer should be present on each team (six respondents), offering more possibilities to correctly document technical specifications, as well as evaluate the offers submitted. Moreover, as RFIS2 stated, a hospital is legally obliged to have one such person, but this does not always happen for reasons such as lack of money.

From my point of view it must be present, and how, of course, each hospital is obliged or should be required to have, a medical engineer in the structure hired. Together with that engineer they should come and write the technical specifications - RFIS2

The third category of individuals with implications in the decision-making process is the hospital manager. The roles of the managers are, however, more distanced from the acquisition procedure itself. This individual's role is to first approve (or not) a necessity report, as soon as a department head has submitted one such document (RS2, RAP1, RS1) and to include it on an investment list. In parallel to this, the manager is the key person in attracting funds to the hospital (RS2), together with the management team. However, the involvement of the manager relating to the acquisition procedure stops at the approval of a necessity report which has to pass then through other departments (e.g., legal – can assist and offer recommendations about applying or interpreting the law), before reaching the acquisition department where a commission is formed and the procurement procedure initiated.

The department heads make a necessity report. Those reports are approved by the manager of the institution. So the head of the department initiates an acquisition, the reports being approved by the manager - RAP1

I think the public procurement office and the manager, of course - RS1

The manager has a very big role in attracting funds - RS2

4.3.2 Evaluation Criteria

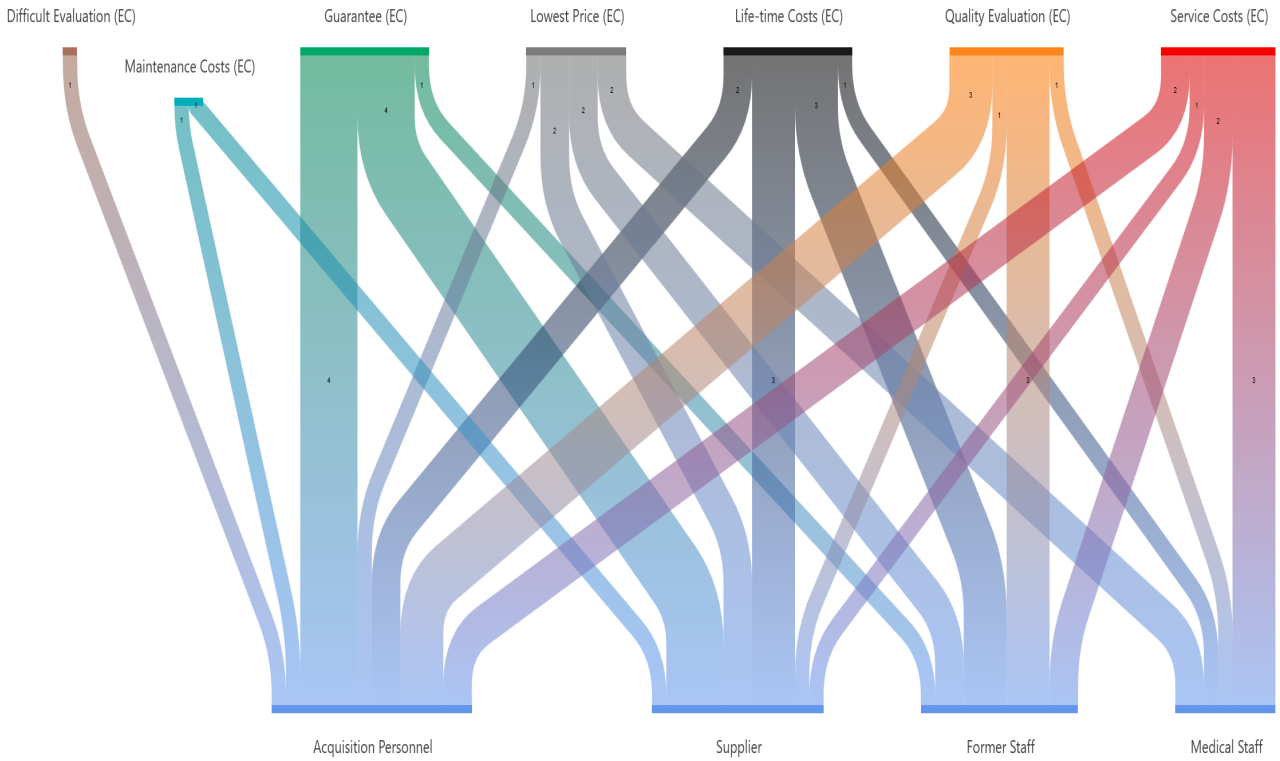

Figure 12: Evaluation Criteria as Perceived by Stakeholders

Evaluation criteria represent one of the most important characteristics in running a tender. These provide a way of standardization and allows all parties involved to follow the same rules. As it has been shown in section

3, there are four ways in which a tender can be organized, determined as the procedure is being documented: 1) lowest prices; 2) lowest cost; 3) best cost-quality ratio; 4) best price-quality ratio. Under the current conditions, data shows that the mostly utilized decision factor is that of lowest price, stated by all participants. Even though some acknowledge the existence and utility of other factors, such as the technical-economic ratio (RAP2), these are not frequently deployed.

There is also the technical-economic criterion but it is not applied or, if it is applied, it is badly applied: that is, the technical-economic criterion means that you score certain requirements, you give them a score (that they are superior), but they are worth 40 % of 100 % and 60 % is the price. So if someone with inferior equipment comes with the lowest price, he has all the chances, even if he does not meet the technical-economic characteristics and does not score points on them to win - RAP2

Results show that a desirable evaluation criterion should be that of quality, or a ratio between quality and price. Nonetheless, respondents mentioned that it can be difficult to assess the quality of a product (RFIS1, RAP2). This can be a difficult task because, needing to go through a tedious process when assessing product quality relying on paper-based evidence, one has to trust the supplier so differences might appear between reality and submitted offers.

Within direct acquisitions the quality cannot be realistically validated - RFIS1

The system does not allow for any automatization when comparing offers. As a result, the contracting authority has to download all technical offers submitted (where references towards manuals or other relevant documents are present – see Appendix D for an example of a technical specification) and check that all requirements are met, followed by a comparison between the characteristics of the products (RAP2).

There is no automated form: they submit the technical offer and we take the technical specification and compare. They make references in the manual: on the page of... Does it have or not? And it is checked there - RAP2

Research also showed that one factor that is usually not taken into account is that of life-time costs. When looking at CME, this can have an important effect on the decision (RFIS2), as there can be unexpected services or maintenance (RS1, RAP1, RAP3) and the up-time of the product might hinder economic benefits (RMS3).

In vain we buy a cheap thing that needs service repeatedly and we pay for that service and the warranty may not cover us at some point. Versus a solid device that is from a company known to perform in that field and which, in the long term, does not need interventions or does not fail so many times and clearly brings you long-term savings - RFIS2

I mean, if I have an accelerator and half of the time it is faulty and you ask me for 200,000 euros/year of service. And then it's not very okay, because I have to get that money to pay people, the service and to both amortize the investment and have a profit - RMS3

Also relating to life-time costs, respondents have made multiple references to the guarantee offered by the offering authority. The guarantee can offer multiple benefits, as discussed by all stakeholders. Given that the guarantee is for a longer period of time, it can provide certainty to the client that the product will not fail often (RS2). Moreover, a longer period of guarantee can help hospitals avoid expenses (RMS3). However, one responded (RS2) stated that the Romanian law does not define what guarantee should include and as such issues might arise between the supplier and the client. Thus, it is important to clearly state what the guarantee refers to when initiating a procedure.

The guarantee period is a very important factor. If you are able to give me a 5-year guarantee compared to one that gives me 1 year, it means that you trust the product you give me. Because no one want that during the guarantee period of the equipment, the equipment to broke I don't know how many times, to consume all the profits by spending money on repairs - RS2

We need a nuance here too... because what do we mean by guarantee.... - RS2

4.4 Technology in Romanian Healthcare

This section of the interview aimed at discussing the level of technology present in Romanian hospitals. Moreover, it offered insights into the relation and perception towards introduction of new technologies in hospitals, as well as the relation between technology adoption and the acquisition system. The results shall be presented further, with the most important findings shown in Fig. 13.

High-tech medical devices that are up-to-date with the existing needs and medical practices are considered extremely important by all stakeholders interviewed. Arguments in support of appeared to be similar, with all participants mentioning that medical practices or positive patient outcomes are no longer possible without new technologies. Through the nature of their work, doctors are constantly learning and it is important for them to always be knowledgeable of the latest advancements in both medicine and technologies supporting their work (RMS3, RMS2). It is for this reason that practitioners usually participate in conferences, courses or online presentations. During these they normally find out new and enrich their medical knowledge bank. Moreover, as one respondent mentioned, the patient also plays a significant role in the adoption of new technologies, by demanding certain procedures or technologies.

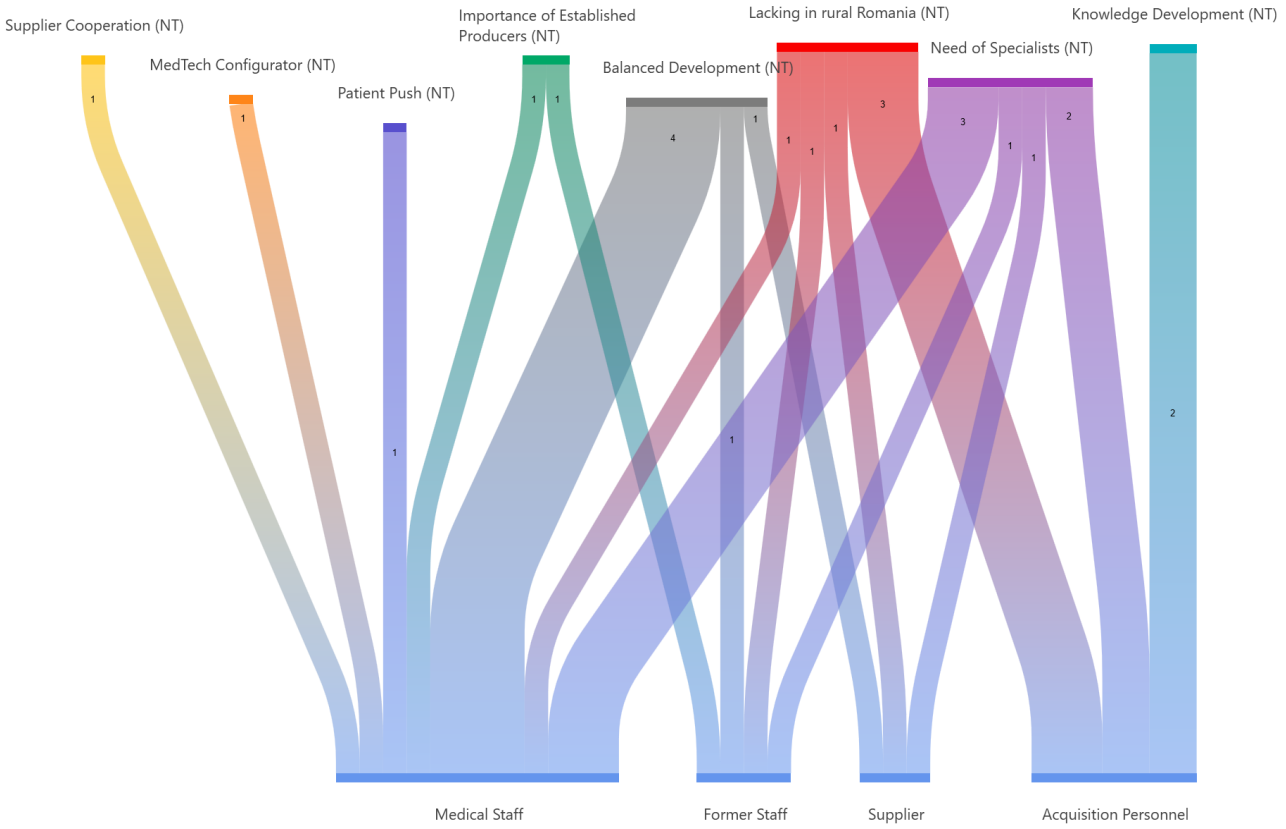

Figure 13: Attitudes towards New Technologies

We, doctors, who are confident and aware through the erudition we acquire through the information we gain at congresses, scientific meetings, participation in medical equipment exhibitions where new acquisition techniques and new technologies are presented. And certainly their effectiveness in certain segments of pathology or in certain treatments. And then most of the time doctors are the ones who force the acquisition of technologies - RMS1

In this age of such fluid and rapid communication, patients are often the ones who force the development of the system - RMS1

However, when discussing the current context of Romania, data revealed certain issues. While there are identifiable advancements in technology adoption within public hospitals, respondents have indicated that this is taking place only in certain healthcare centres (RAP1). The participants have argued for the necessity of a balanced and equitable evolvement (RMS3, RFIS2, RMS1, RFIS1).

In hospitals, there are major differences in equipment - RFIS1

And then of course you always have to make an audit and keep a balance between these acquisitions - RMS1

It has been noted that university healthcare centres or large county hospitals are close to the European average

(RFIS2), however, as one analyses municipal hospitals or smaller facilities, it was stated that the technologization level is extremely poor.

The degree of technologization, if we speak strictly of the university centers, the degree of technologization is quite high. From my point of view, we are approaching the European average or we are close, somewhere at 70 % of what we find in Europe at the moment - RFIS2

I understood that in some hospitals in the country the level is pathetic - RAP1

Not only is there a difference between hospitals based in different regions, but disbalances can be identified within the same hospital. As one interviewee argued, it is necessary for a hospital to be able to provide the same level of healthcare across all its departments, as it can otherwise be irrelevant to have sophisticated diagnostic devices, without capable treatment devices (RMS2).

You can't make an island of new technologies within a hospital that has outdated technology. That is, all areas of a hospital should be raised or upgraded in a balanced way. Now speaking of imaging, operating rooms... That is, you have to take it from diagnosis, treatment. All stages should be raised in a balanced way because in vain you have a step that is top and the others that are left behind. The results do not fit. - RMS2

While new technologies are seen as necessary, these can be useless without the personnel to utilize it. Responses showed that, first of all, there is a lack of doctors in Romania (RFIS1). There are multiple causes for this, however this is out the scope of this research. What is important is to note the reduced number of doctors to manipulate medical devices. In addition to lacking human resources, participants also mentioned that out of the existing practitioners, an important number of them are not trained sufficiently (RMS2, RMS1). When purchasing an equipment, it is crucial to assess the capabilities within the healthcare facility or the devices will remain unutilized (RAP1, RAP2).

4.5 Ideal World

During the interviews, the final question related to an ideal world, offering respondents the chance to design an ideal purchasing system. This is an important part because, as it will be shown in further sections, not only does it provide potential improvements, but when analysed carefully, the responses can indicate other barriers faced by the stakeholders, expanding the range of possible advancements.

As the figure below shows (Fig. 14), the most often mentioned enhancement to the acquisition system of medical devices relates to the accountability of suppliers. This has been argued as a necessity by all interviewed stakeholders with the exception, as expected, of the supplier. Three of the individuals acting as acquisition personnel stated that it is desirable for suppliers to take responsibility for their actions. One of the participants

stated that it is necessary for vendors to upload accurate and reliable description of their products, as well as their actual prices. Having this, would permit the system to ensure standards are respected, avoiding the need of double-checking and, as a result, would lead to more efficiency within the system (RAP1).

I would ask for more accountability from the economic operators and firms which upload products on this platform. A little control over them - RAP1

Economic operators should improve their seriousness in terms of servicing the equipment, maintenance, because most tend to blame something else just to exclude the guarantee. - RFIS2

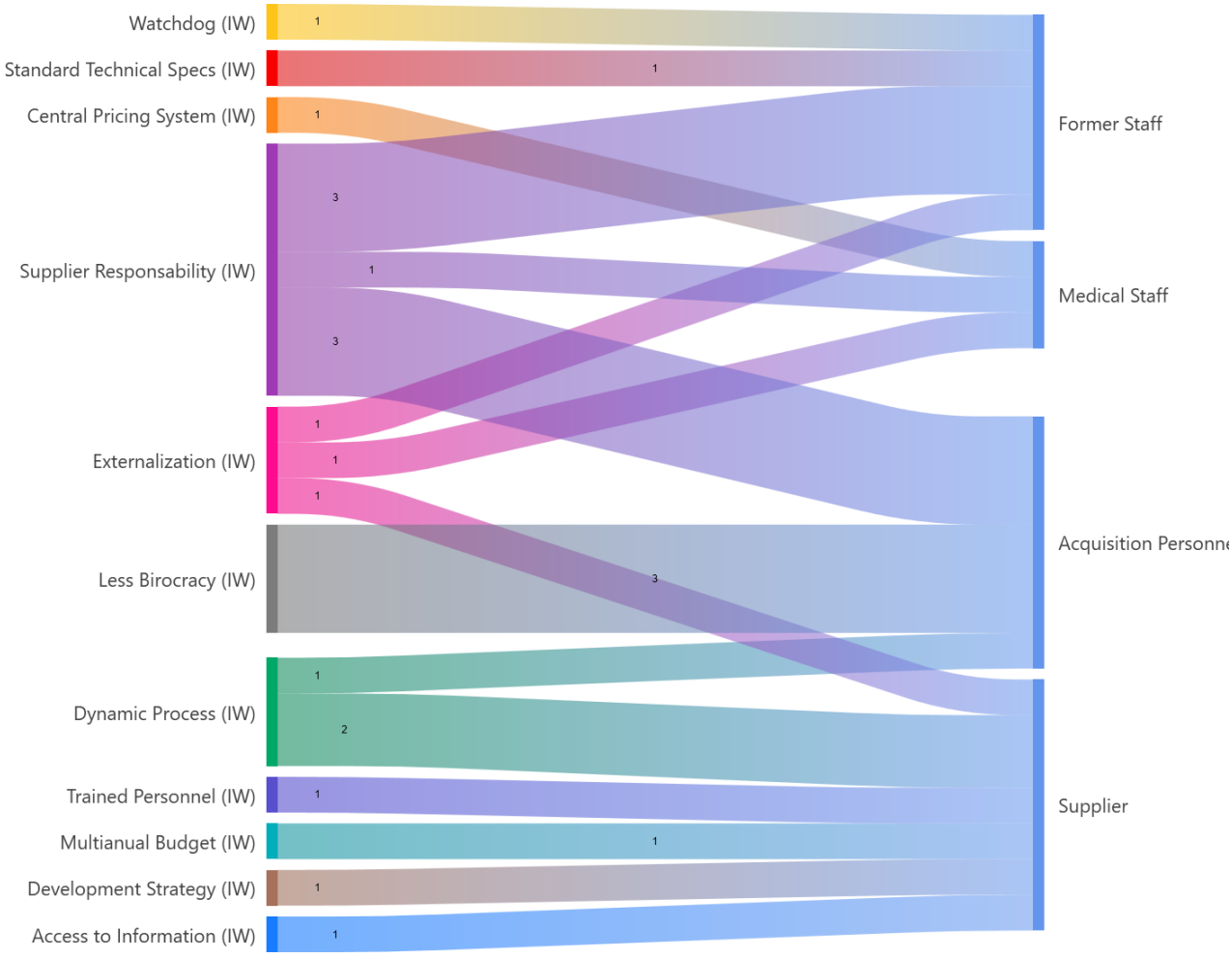

Figure 14: Improvements towards the Acquisition System Proposed by Respondents

Following along the same lines, other respondents (RAP2, RAP4) consider that suppliers benefit from too much freedom by being able to submit contestations or refusing to sign contracts, leading to delayed acquisition procedures which has an effect on the technologies available to practitioners and the patient. The same issue of contestations was identified by both former staff (RFIS2) and doctors (RMS3).

So, that would be a negative part because I think that companies are given too much freedom, so the companies participating in the tenders have too much freedom. They should be sanctioned if their requests are unfounded, so they should know how to take responsability for this. To make some well-founded "accusations". - RAP2

They will press ahead with contestations, regardless - RMS3

Data analysis also showed that the parties involved in the procurement of medical devices perceive as an ideal world a system which requires less bureaucracy and is more dynamic. These two characteristics are interconnected. Especially important to the acquisition personnel (RAP1, RAP3, RAP4), who as shown in previous sections, are the ones having to frequently move outside the digital space for various reasons (e.g., compare offers, sign documents, archive documents for long periods etc.). Reducing the need of exiting the digital platform, would permit the system to be more dynamic and adapt to changes faster. Designing a more dynamic process was acknowledged by both suppliers and acquisition staff (RS1, RS2, RAP2).

Less bureaucracy, much less. - RAP1

Probably a form of legislation could be found to help in this process, perhaps in a more dynamic way - RS2

When looking at how information is being gathered and offers evaluated, two findings resulted from the data. Frist of all, doctors would see a central pricing system as an efficient way of conducting business. This supposes that there are maximum prices for each product category, above which tenders cannot be won. However, this also correlates to having standardized technical specifications.

A very good procurement group, centralized at the ministry level to make a kind of price list on various products. So it can say the needs of a system can be covered if product x falls under the maximum price after we have scanned the market, in the maximum price of... to say for an MRI of 650,000 euros. Purchase from wherevere you want, but you can't spend more than 650,000 euros because the market has been scanned and this is what it is - RMS1

As discussed earlier, it can be difficult for a contracting authority to assess and compare submitted offers due to ever changing formats. Therefore, being able to access reliable information (RS2), together with maximum allowable prices within the whole system (RMS1) and standard technical specifications (RFIS1), in the view of respondents, would help the healthcare facilities to have faster and efficient access to new technologies.

[...] or to have an ideal IT system that provides with data in such a way that, against a monthly / annual payment, I have access to very good information that is made by a very good team. That is, not to make a procurement team within a hospital, because I do not make purchases every day, and I can outsource this service but I can have a system that provides me with the information I need. - RS2

Moreover, new technologies are heavily influenced by budgets approvals, which, as shown in previous sections, are usually delayed or allocated inequitably between hospitals and within hospitals. (RS2) mentioned that having a multiannual budget, as well as a nation-wide development strategy would be two characteristics of an ideal medical devices procurement system.

If they had a multi-annual budget then they could make a strategy, like in 3 years, if it is a 3-year budget, I have to equip a department / section / hospital - RS2

While discussing the barriers identified the participants, it was found that the staff involved can have an effect on medical devices procurement. As a result, having highly skilled and educated personnel is perceived as an ideal world (RS2). Interestingly, two respondents argued that this can be achieved through externalization (RS2, RFIS1, RMS3).

These should be validated by an external technician - RFIS1

First of all, documentation of technical specifications, followed by offer evaluation could be carried by individuals outside the contracting authority, ensuring a more detached and professional approach to acquisitions. Secondly, one of the respondents formerly involved with the acquisition system (RFIS1), proposed the implementation of a watchdog, an external organization. The purpose of this organization would be to oversee acquisition procedures and classify healthcare facilities based on their correct judgement of procurement activities. Depending on their classification, the system would permit hospitals to have access to better deadlines or enhanced freedom.

4.6 Chapter Closing Remarks

This chapter offered the results following from the field research (i.e., interviews). By analysing the data, multiple barriers were identified in the acquisition system. Moreover, a thorough analysis was performed on the critical part of the procurement process, that of commission and evaluation criteria, noting the key decision makers and the factors that guide the decision making process. Following, the perspectives of the respondents about introduction and need of new technologies in healthcare were analysed. Finally, the chapter showed the results relating to what the ideal world should be, from the perspective of relevant actors.

5 Analytical Results

Simply noting a problem, without a deep analysis of the causal links, can often lead to the erroneous identification of a 'scapegoat'. A critical research assumes that all factors that can affect a process. For this purpose, through the in-depth exploratory interviews, the research aimed to capture the roles of all involved actors, both human and non-human, along the entire process of public acquisitions. Starting from the previous chapter, describing the results of the research, in combination with the literature review from chapter 4, this chapter has the scope of discussing the most important levels – key moments – of the acquisition process with special attention being paid to the identified barriers. This section has the role of pinpointing the multitude of negative factors which coexist across the entire acquisition system. The results from the interviews and from the literature are dependent on each other – a mutually exclusive analysis would provide more clarity, but it could reduce from the reality of the study, isolating factors which are, actually, interconnected. Thus, this chapter sets to present the barriers of the acquisition system by discussing the following identified issues: delayed acquisitions, bureaucracy, the effects of the human factor, actions during and after the acquisition of a medical device and, lastly, the digiztalization of the process.

5.1 The Acquisition System: Contestations, Bureaucracy and Time Limits - A Problem of the System or the Implementation?

The main and most important system which permits bringing new and needed technologies into public hospitals is the acquisitions process. As presented both in the theoretical part and the results chapter, the acquisition system is governed by the Law of Public Acquisitions and is carried mostly through a digital platform (SEAP), acting as an intermediary between a contracting authority and a supplier/distributor of medical devices (Romanian Parliament, 2016). Results have demonstrated that the system, looking from the perspective of the steps that must be followed and the legislation, is perceived as a positive one by most of the stakeholders. It has even been argued that the legislation allows all parties' interests to be met.

If we take the legislation on public acquisitions, from my point of view, it is an European legislation, adapted, I can't say whether it is good or not, to the needs of the Romanian market. Nonetheless, it is a legislation that, from my point of view, allows hospitals to achieve their goal regarding public procurement - RS2

On a macro scale, it may seem that the acquisition system assures the necessary and beneficial framework for conducting public acquisitions within hospitals. With the public acquisitions being based on a European legislation and being regulated on a European Community-wide base, it is thus formed on a clear base, not arising negative reactions from the respondents.

Nonetheless, the obstacles which delay and, sometimes, even block acquisitions from taking place, or to reach the desired outcome, appear to be unsolvable. This means that it is important to truly understand where the

problem is. Given that, broadly speaking, the system and law are well-functioning, it is crucial to understand the small aspects which can cause great issues.

When looking at the process, one of the most frequently cited barriers was that of long periods for procedures to finalize (which can take even up to 6 months, for a single product). The causes of these, as stated by the respondents, can be traced back to three main themes: freedom enjoyed by supplier in relation with the hospital during an acquisition procedure, (sometimes) unnecessary longer time limits of the procedures to develop and take place and a high level of bureaucracy. . Interestingly, this comes in opposition with the benefits that digital platforms and e-procurement are trying to solve, as identified by previous researchers, not managing to improve efficiencies (Aggarwal & Travers, 2001).

As opposed to the healthcare facilities which are public institutions, the suppliers are private entities, over which fewer sanctions are usually imposed. This can lead, inevitably, to establishing a bargaining power in the favour of the supplier which becomes the entity with a higher level of authority, especially during an acquisition procedure. The power games, commercial interests, ungrounded contestations, play a significant role in delaying the acquisition process.

Competition will always occur for expensive equipment. The companies will fight because having a high price they will fight to win the tender and they will do everything possible to secure their first place. Contestations,all kinds of unpleasant things, which irritate us and delay our acquisition process. - RAP2

Considering the principles on which the legislation is built, present in Romanian Parliament (2016), as well as documented in research (Bof & Previtali, 2007) it is crucial for a tender to be open and unrestrictive. While this can be seen as beneficial, it should be noted that, in reality, it can have an adverse effect by facilitating the supplier the ground to submit ungrounded contestations. The purpose of the contestations, as described by the respondents, is for the offering authority to convince the contracting authority to change technical specifications which are seen as restrictive. Contestations, for example, can lead to lowering the threshold for the minimum technical specifications, allowing one supplier to win a tender because of its product's lower price (i.e., a highly relevant evaluating factor). Not only does this delay the process (even up to 6 months for a single product), but it can also lead to purchasing an inferior product. The focus is, thus, shifted from fulfilling a need from a public hospital with a product with the best quality-price ratio (that is from ensuring a favourable climate for maintaining public health), to a fight between two private suppliers. These delays, caused by the multiple contestations (again, on financial grounds) are translated into the incapacity of the healthcare system to procure the most suitable devices, resulting, in reality, in inefficient services for the patients.

Sure, there is also a sometimes an unfair agreement between the big producers. Very often, and this is related to their tactics, very often they do not contest each other, they do not come to a tender on a very expensive installation. They prefer to leave it for a single producer who participates with a very high price and then they do not go to the next tender - RMS1

A second cause of delayed procedures can be traced back to the legislation governing public acquisitions. One of the issues identified in the legislation is that, according to the articles present both in the Romanian law, as well as the European Directive, there are certain minimum time limits that are required. For example, when going through an open tender procedure, there is a minimum of 35 days time limit for suppliers to submit offers. Moreover, when discussing CME (i.e., products above 139,000 Euro), every contracting authority has the obligation to announce the procedure in the Official Journal of European Union, which is seen as wasted time by respondents. While having certain time limits would offer the possibility of all suppliers to submit offers and, as a result, allowing the hospital to enlarge the range of available products, respondents perceive these time limits as significant delays for medical devices procurement. In addition, the real benefits of having multiple offers to choose from are not always true, because the expected number of participants is not met. With all procedures having a given time limit, form the starting point and up to the final of an acquisition procedure a long period of time may past, which has the adverse effect of seriously delaying the process.

There are some legal deadlines that must be respected and they are very long - RAP2

[...]those very long auction periods in which the procedure has to be in SICAP - RAP1

Lastly, the previous chapter showed that the introduction of new medical technologies is heavily influenced by bureaucracy, such as delayed budget approvals or the need of processing data manually. At the same time, the precarious political state in Romania has an important effect on the acquisition process. For example, budget cuts for the healthcare system were present in 2013, as documented in chapter 3, as well as for the year of 2021, compared with 2020, with a cut of 11.2 % (Pavaluca, 2021). Moreover, in the last 30 years, the political context within the Ministry of Health has changed multiple times,having almost 30 Ministers of Health during this time frame (Nastase, 2021). This public-private duo is therefore heavily influenced politically, through bureaucratic means. The problem of bureaucracy in Romania is that it temporally extents, on an indefinite period, the potential solutions to various situations which require immediate resolutions and it introduces actors whose goal is to double-check on the surface only, without having an in-depth evaluation. This will be explained further, in the following paragraphs.

As identified in the literature review, public hospitals are receiving financial resources from public institutions (i.e., government, Ministry of Health) and the budgets should be approved by the end of the current calendar year, for investments in the following year. However, as noted by interviewees, this does not usually happen. The ending of quarter 1 of the current calendar year, or the beginning of the second quarter, was most often mentioned as the period when budgets are usually approved. This means that, for the months preceding March/April, no plans or strategies can be made. Adding this to the already existing long periods of the acquisition procedures, it normally happens that the procedure of a capital medical equipment takes place close to the end of the calendar year, should the budgets not be relocated. Correlating this with the fact that, given the current political context in Romania, managers and administrative staff may change, a situation where the acquisition is not taking place is possible. This then means that the acquisition procedure needs to be restarted during the following year – with potentially new variables and needs.

We have the annual budget. Look, for example, this year only in April the approved budget came. We wereblocked in January, February, March - RAP1

Moreover, within hospitals, every identified need has to be approved by the management and, without having a hospital-wide development strategy, imbalances, in the degree of technology available, can appear between departments. The lack of an investment strategy can lead to having high-technological equipped departments, while others do not have access to the same level of technology. As a result, situations can appear such as having the possibility to diagnose patients, but without being able to treat them (or the other way around). Also, as noted in the results chapter, Romania presents important discrepancies between regions where hospitals have access to new technologies and other regions with low-end or even outdated technologies. The results of this research identified crucial differences within healthcare centres in Romania, with attention being paid to large medical institutions (e.g., University Centres) or large Romanian cities (e.g., Bucharest, Timisoara), while other healthcare facilities having a bare minimum. This lack of a nation-wide strategy for introducing medical equipment in hospitals in a balanced and equitable manner, can lead to overcrowding medical departments from large cities, and, as a result, increase patient wait times (potentially even longer that it may be possible for patients). On the other hand, medical staff within adequately equipped hospitals may become overstretched, with respondents tangentially noting the unfavourable climate within medical staff. Therefore, not developing a clear investment strategy (which is not to be changed on a yearly basis), leads to enlarging the discrepancies between regional healthcare facilities. A similar mismatch between regions of high interest and those ranking lower, has also been noted by others. For example, WHO (2010a) has identified the problem of not having equitable and cost-effective allocation of public health resources across the world. Moreover López-Bastida et al. (2010) suggested for the particular case of Spain, that equity is considered for the economic evaluation of healthcare technologies.

Bureaucracy also negatively contributes to the long procedural periods through the obligation of respecting obsolete protocols, which have not been updated and adjusted to the current technological era. This is an issue often seen in Romania, regardless of the industry, where it is usually preferred to complete process using 'pen and paper', rather than using digital platforms. In order to offer context, it is worth noting the following example. Public institutions (e.g., city hall or taxation institutions) require that most of the economic activities are carried by using paper (only in one of Bucharest's district halls it was found that the institutions used 5 million A4 white papers annually, which means approximately 100 pages per day per employer (Birzoi, 2021).

The issue of bureaucracy can be identified in the public acquisition system, as well. While the digital platform (i.e., SEAP) is regarded as an electronic means for the public acquisition system, the parties involved are still required to exit the online space in order to finalize various steps. The results have shown that two opposing views exist, in relation with the level of bureaucracy on the digital platform that of the acquisition personnel and that of the supplier. The first group of actors perceive as unnecessary the need of printing whole documents and archive them for at least five years. Interestingly, on the other hand, the suppliers believe that the need of bureaucracy and printed documents has reduced. This shows that, even though the digital platform was

intended to reduce the workload and necessity of paper documents, as argued both in the literature and the legislation, it has only achieved this very thinly and only partially. Through the current state of the platform, the responsibilities have merely shifted from the supplier to the hospital, without necessarily increasing the efficiency of the process.

Having discussed above some of the most pressing issues of the current acquisition system, it appears that, on a general level, the legislation and steps necessary for procuring a medical equipment are in line with the goals they have. However, there are problems which still complicate the process: avoidable long times, bureaucracy and too much freedom of suppliers. This poses the question if these issues are due to the procurement system or its implementation. When considering that procedures are delayed both by budgets not approved on time (i.e., implementation), as as well as long time limits (i.e., system); that bureaucracy is affected both by protocols (i.e., system) and the inefficient usage of available resources (i.e., implementation); and that freedom enjoyed by suppliers is visible through the contestations (i.e., system and implementation), the answer to the question cannot make a clear cut between the two dimensions. From the above it results that an alignment between system and its implementation could aid in the process of acquisition.

5.2 Human Factors - Objective Detachment vs. Subjective Implications

The acquisition process, regardless of how objective it might attempt to become, it is currently completely dependent on the human factors involved in the process. As in other situations, the human work force can be influenced by power games or lobbyism and, in addition, it cannot comprehend all existing knowledge. Moreover, the clash between generations is much more significant than in other parts of Europe, due to important differences and reminiscences from the socialist system (Stan, 2012). Many of the actions of the current stakeholders in power have been grown in a different system, leading to various collaborations between different generations to be governed by lack of trust. As the literature review identified, it is important to develop trust and confidence among users in the attempt of improving the procurement of capital medical equipment (Mackey & Cuomo, 2020, Wang et al., 2015).

The findings of the study suggest that doctors choose their products following rather subjective criteria than objective ones, with vendors who are already trusted by the practitioners at the top of the list. Burns et al. (2007) state that having a comparative evaluation can aid in supporting (or not) vendors' claims and information asymmetry in the seller-buyer relationship can be overcame. However, it was found that this does not necessarily happen in Romanian acquisition system. Having a comparative analysis would provide, without doubt, an extremely valuable tool in selecting the right medical equipment, but this might not overcome practitioners' tendencies towards selecting a supplier or manufacturer that they trust. This can be traced back to the economical and political turbulence which diminished trust both within public, as well as private entities.

[...] a solid device that is from a company known to perform in that field and which, in the long term, does not need interventions or does not fail so many times and clearly brings you long-term savings - RFIS2

Another issue identified and worth discussing, apart from selecting suppliers based on personal preferences, refers to the lack of specialized work force in the field of public acquisitions. The previous chapter, presenting the results, showed that challenges are faced within the acquisition department when it comes to the personnel involved, as there is either a lack of staff altogether or a lack of specialist and trained individuals. The Law of Public Acquisitions is extremely broad and often changing. Thus having expert individuals is crucial in interpreting the legislation so that the best course of action is always selected. As L. M. Miller (2014) and Vincent & Blandford (2017) have noted in their research, the role of the acquisition personnel is usually authoritative and considering that technological solutions can be imposed by the acquisition personnel, it is important to have a knowledgeable team of individuals. Not only does this affect the technologies bought by the hospital, but it can also have an effect on the legal security and involvement of acquisition department employees. This is important to mention because the results have identified a fear of action within acquisitions. Fear of action is caused by the constant worry that audits might be imposed on them. This in turn has an effect on the motivation of people to take initiatives and to develop their understanding of the acquisition system. Going further, a vicious cycle may create with people being affected by fear, not wanting to take action, leading to a demotivation of the personnel and a stagnation of the entire development of the healthcare system. Fear of action can be traced back, on the one hand, to the lack of experience in relation with public acquisitions and the lack of specialization courses which could train individuals for performing this specific task. On the other hand, mistakes that might arise from small bureaucratic erros can have large implications and lead to other adverse effects on the ones involved. As a result, extensive bureaucracy diminishes the motivation of employees to initiate action and to involve themselves in acquisition procedures to the best interests of the institutions they work in.

So this is the big problem that at the moment exists in the procurement system and in the public system: it exists a demotivation of the staff, people are being hunted, accused of stealing - RAP1

The lack of accountability and initiative taking is further enhanced by the volatility present in assigning responsibility and those who should be responsible, especially, as observed during the interviews, when it comes to forming the commission for acquisition procedures. It was showed in chapter 5 that the commission, once a procedure is initiated, has full control over the tender. A commission is usually formed for each tender and it should be composed of minimum three individuals: a president (can be from the acquisition department), the medical staff who identified the need and a medical engineer. Firstly, the doctor is necessary for the clinical inputs, the medical engineer for the technical inputs and the president for leadership and objectivity. The Law of Public Acquisitions also stipulates that the committee should be formed in this manner (Romanian Parliament, 2016). However, research has identified that this does not always happen, with stakeholders having different views.

From my point of view it must be present, and how, of course, each hospital is obliged or should be required to have, a medical engineer in the structure hired. Together with that engineer they should come and write the technical specifications - RFIS2

The acquisition personnel argues for the necessity of doctor's involvement, but the doctors see their involvement as minimal considering their limited technical knowledge. Moreover, the interviews surfaced a lack of technical experts who could aid in creating technical specifications or in argumenting the need of various requirements. However, in reality, this commission composition is not respected and, what is more, it can differ substantially from case to case. Not having a standard way of forming evaluation commissions can also lead to subjective evaluations, one-sided and reducing the necessary rigour. In addition, without having one of the key actors (i.e., medical staff, medical engineer, acquisition staff) it is highly possible that not all interests are equally represented: the clinical needs of the patients/hospital, the technical characteristics of the equipment or the lack of a knowledgeable individual in relation with the system of public acquisitions. The need of complete and expansive evaluation commissions has also been identified in the literature, with others arguing for the need of deep integration and motivation of all parties involved (Johnson, 2013, Lin et al., 2010, Visconti & Morea, 2020).

5.3 New Technologies - From Need to Technology Adoption

It is without doubt that new and innovative technologies can greatly and positively influence the medical practices. This is sustained both by the specialized literature, as well as by the contextual reality, with stakeholders interviewed indicating a consensus towards the need of new and (more importantly) qualitative medical technologies. The procurement of new medical equipment is influenced by a series of factors.

New technologies within the healthcare industry are constantly evolving, but the high pace of change leads to a difficult mission in knowing all possible innovations at any given time. Moreover, considering that all possible solutions are identified, it can be difficult to select the best medical equipment for meeting the identified need. Thus, these two factors (abundance of medical devices and selection criteria) can create a good environment where only the most visible products are selected. This means that hospitals might find themselves in positions of choosing that equipment which are manufactured by already large or established producers, or those products which are highly marketed within medical staff environments. This is identified in the literature where it was argued that decision makers have a tendency towards favouring the familiar in selecting medical equipment (Diaconu et al., 2017).

At the same time, in the medical world, there is not consensus on what best courses of actions are. This means that every medical doctor interprets and selects the treatment considered, from their own perspective, to be the best. However, opinions can be different across hospitals and within hospitals. Nonetheless, the ultimate goal is the same, that of correctly treating a patient, but the actions leading to this can differ from doctor to doctor. Therefore, a situation where need of change (affected by the introduction of new medical technologies) is identified by all stakeholder, however there is no consensus over what the change should look like or how it should be implemented.

In addition, it should be noted that, as discussed in previous sections, the introduction of medical equipment is

influenced greatly by the budgets (discussed above) and, what can be regarded as the backbone of the acquisition procedure, the technical specifications. The procedure for purchasing medical devices, under the Romanian and European legislation, requires that a technical specification is completed, laying down all requirements for the product to meet. Designing the technical specifications, it is important to respect the value of openness (Romanian Parliament, 2016) and to not have restrictive characteristics. Moreover, through a technical specification, there should be no advantage offered to any of the potential suppliers. Thus, it is crucial to design well-written technical specifications so that the best fit is found between a product and the needs of the hospital. Technical specifications do not only assure the required level of quality is met, but they can, through e-procurement, safeguard public officials through transparency (A. D. Smith & Flanegin, 2004). However, when trying to purchase capital medical equipment, it can prove an extremely tedious process to construct an accurate technical specification. CME usually inherit a relatively high number of options and software choices, with each product being personalized to the particular need. This has the effect of increasing the complexity of technical specifications, both for those constructing these documents, as well as for those evaluating or having to interpret them. On the one hand, technical specifications must meed the requirements of the identified need.

As a result, the committee within the hospital has to translate into technical terms what is to be purchased. Problems might arise when detailing the technical characteristics which, given the high complexity of capital medical equipment, are personalized for each procedure and described in-depth. For example, for purchasing an MRI, there are multiple clinical software which can be purchased, dependent on the type of investigations to be performed. Also, there are a series of technical requirements (e.g., electric network) which are highly important to be understood when purchasing an MRI. It is for these reasons that having both a medical practitioner and a medical engineer is crucial in making informed and accurate decisions.

It is very important, again from my point of view, to define very well what we want. - RS2

On the other hand, taking a different perspective, when designing the required technical specification, the contracting authority is also designing the evaluating criteria. The initial research has shown that the current system is focusing on lowering costs, with cost as the main criteria when selecting the best offer (Kiralyova et al., 2017). Reaching a decision based only on costs does not necessary lead to the best outcomes, especially when technical specifications are not well-documented. Having minimum requirements that are well documented can ensure the bringing of high-quality products; this can also lead to price only evaluations, as the must have features are already met. This is supported both by literature and the reality found in Romanian healthcare system.

If I manage to make a technical specification in such a way as to make sure, to be convinced of the desired quality level and I say that from here downwards I am not interested and from here onwards, as long as I have the lowest price, we are interested in anything, then I can to put evaluation factor the lowest price. - RS2

For example, should a hospital purchase an MRI, it should evaluate its necessities and then construct a technical specification with all requirements from the producer, including all characteristics that are considered critical.

Following, as offers are received, according to the current system's design, the contracting authority can follow the principle of lowest price in making a final decision. Otherwise, given that some characteristics are not well-documented, it is highly possible that an inferior quality product is purchased, should a supplier have a lower price than its competitors. As the system is currently focusing on lowering costs, and thus choosing the lowest cost, research has shown that more advanced methods are necessary so that adequate and added-value technologies are selected (Kiralyova et al., 2017).

One other aspect in relation with technical specifications, that was identified during the interviews, refers to the stage of evaluating the quality score of the offers submitted. Once offers are received by hospitals, the digital platform does not allow for any automatization or standardization of the evaluation process. According to the stakeholder's responses, the offers are printed and the evaluation is carried 'by hand', checking whether or not all requirements are met. This implies that delays are possible and, in addition, it can be an extremely tedious process.

There is no automated form: they submit the technical offer and we take the technical specification and compare. They make references in the manual: on the page of... Does it have or not? And it is checked there. -RAP2

Nonetheless, difficulties with procurement of capital medical equipment may also arise once the tender winner is announced, in the opinion of stakeholders working in healthcare facilities. With the current system, buyers may find themselves in a lock-in with the supplier (especially for capital medical equipment). It has been found that due to the nature of the legislation, the hospital is usually bounded to the winner of the contract for the duration of the product's life (i.e., for maintenance, servicing etc.) (ConsiliulConcurenteiRomania, n.d.). The lock-in effect is regarded by the interview participants as having a significant negative impact, given the lack of power over suppliers. As such, respondents have argued that there may be situations when the supplier does not complete servicing or maintenance works in a timely manner. Expectedly, this is seen as irritating by the hospital, as well as causing other problems: higher costs for the hospital or the inability to conduct medical activities.

When looking at the period after the procurement has finalized, the interviews revealed the fact that feedback is missing once the procedure is completed. The supplier does not complete any follow up, nor is it obliged by the legislation/platform to do so. This signals that an important success factor for digital platforms, as identified by Abdulsalam & Schneller (2020) is missing: a strong relationship between supplier and buyer.

The first impulse would be to say no... .but I don't want it to be so.. . but I don't believe... - RMS2 when asked about supplier asking for feedback

5.4 Digital Platform - Problems and Perspectives

Taking into account all issues identified previously in relation with the current acquisition system of capital medical equipment, one might consider that a digital platform could represent the most efficient solution. A digital platform could reduce the time allocated to bureaucracy, as well as human errors, through a better standardization and it could diminish subjective choices based on personal preferences towards products or suppliers. It is true that this is sustained in theory. Replacing time consuming activities performed by individuals with a more transparent and secure solution, realized online. It is important to note that various commercial entities or administrative from other industries have, over the time, implemented multiple digital solutions, as research proven. E-commerce platforms are viewed as efficiently matching buyers and sellers having as a result the reduction of search costs and information asymmetry and improving efficiencies (Aggarwal & Travers, 2001, Hermes et al., 2020). However, in order to propose a functioning and reliable digital framework for healthcare, a discussion is necessary around the dysfunctionalities in the current digital state of Romania and what are the causes of the problems among involved actors.

As already discussed, the digital platform currently in use for public acquisitions of medical devices is the Electronic System for Public Acquisitions (SEAP). With the help of SEAP, the contracting authority can conduct tenders and fulfil its needs. Moreover, SEAP already contains an electronic catalogue (e-catalogue) for multiple medical devices where direct acquisitions are possible.

The interviews revealed that, in the first instances, respondents do not consider that the available digital platform directly negatively affects the process and that they do not identify major issues. However, narrowing down the discussion, the results surfaced a series of issues that interfere with the acquisition process.

What I can say is this: the platform is useful, it is beneficial, the process is quite difficult. - RFIS2

First of all, under the current state of the digital platform, which is seen as basic and requiring updates, the information available is not complete for acquisition of medical devices. As mentioned, SEAP integrates an e-catalogue which is supposed to include full description of available equipment, together with their prices. The aim of the e-catalogue is to facilitate a direct acquisition, without the need of intermediaries. The main problem identified after the analysis of the interviews, revealed that the products included under the e-catalogue do not always raise to the expected quality level. Not only this, but it was found that it can be extremely difficult to assess the quality of products available in the e-catalogue. Moreover, the prices usually present on the e-catalogue are found to be higher than the real market prices. This forces the healthcare facility to directly contact the supplier in order to negotiate.

But it is advisable to first talk to the company, to do a market consultation, to have an informal discussion with the company you want to buy from - RAP2

Looking at the technical specifications, these can be either misleading, incorrect or even missing, making the evaluation of the products an impossible process. Considering that detailed descriptions are missing and the lack of an entity to guarantee for the quality of the products or that technical specifications are in line with reality, the trust in using the e-catalogue is found to be minimal. This points to the critical success factor needed for e-procurement identified in literature: the importance of confidence amongst users (Mackey & Cuomo, 2020, Wang et al., 2015. As a result, even though a solution for uploading suppliers' offers in the digital platform exists, the current design of it is seen as far from a working and viable framework for conducting e-procurement. At the same time, erroneous technical specifications and untruthful prices puts a limit on a correct comparison between suppliers.

However, the difficulties discussed in relation with the existing e-catalogue are also influenced by the very nature of some equipment, such as capital medical equipment, which present a whole series of options, requiring that a personalized offer is completed depending on the needs of the hospital. Thus, while for some standard products it may be possible to have a functioning e-catalogue, in the case of capital medical equipment, the issue of standardization arises. As above-discussed, the supplier has to personalize the offer depending on the specific needs of the buyer. A potential resolution to this could be the creation of a digital 3D configurator where the buyer can update and pre-view a product based on the requirements. This solution could be a viable one, but only to a certain extent. The difficulties for implementing such a 3D configurator are found to be, on the one hand, the vast number of options available for CME. The large spectrum of available characteristics would make difficult the design of such a platform as one cannot consider all variables and a difficult and ever-changing platform would result. On the other hand, the design of a 3D configurator requires the collaboration of multiple manufacturers, so that healthcare facilities can find multiple solutions in one place. This could lead to even more difficulties given the sensitivity of the production of medical equipment. As a result, manufacturers might be unwilling to disclose sufficient information in order to maintain their market position and their uniqueness. It can be observed, thus, that the obstacles are not only technological in nature. The solutions are not missing, but they must consider all aspects so that new proposals do not repeat the mistakes of the current system.

Another issue identified by the research relates to the technical capabilities of the existing platform which often faces technical problems: it crashes or has unfunctional sections. Should a complete transition in the digital space take place, issues such as the ones mentioned before must not be present as this would translate into the whole acquisition process being stopped. At the same time, the digital platform should be more accessible and user-friendly, in order to be utilized as efficiently as possible.

Lastly, it is worth discussing what happens after the awarding of a tender, when, on SEAP, a report is updated where it is stated what supplier won the tender and what the final price was. It should be noted that an acquisition procedure can be initiated for a single product or for a group of products (i.e., a package containing multiple types of equipment). Looking at the second case, that of tenders for groups of products and not a single equipment, the price-related information available to other suppliers is only the total sum, not the price of each product.

If we are talking, for example, about a group of products with several points, you will certainly not know at what price each point has been awarded for. - RS1

This poses difficulties for sellers in assessing and compare the position in the market that they currently have. Thus, a much more transparent process would suppose the reveal of price-related information for each individual product. Having an opaque system in relation with the money being spent in the healthcare system can favour a disloyal competition and can facilitate the creation of various relationships which are not based on the principle of best price-quality ratio. This can change the acquisition system towards a process orientated towards a commercial fight on an individual level, rather than enriching the collective good.

5.5 Chapter Closing Remarks

Throughout this chapter, an analytical analysis was carried around the results of the literature review and, most importantly, the results of the interviews. The analysis was centered around four main themes: the problems within the acquisition system as a whole, the human factors involved in acquisition of medical devices, the introduction of new technologies and lastly, the digital platform facilitating the acquisition process.

The first part discussed the major barriers faced by a healthcare facility when trying to purchase capital medical devices. It was, thus, found that often acquisition procedures are seen as too long, from a time perspective. The causes of this are three-fold. The first one is represented by budgets not being approved on time, making it impossible for hospitals to develop procurement strategies in a timely manner. Secondly, acquisition procedures are usually delayed by supplier enjoying a too high level of freedom, being able to submit contestations regardless of their truthfulness. This is also seen as a consequence of tenders values such as openness and not being restrictive. The third cause of long times for technology adoption is affected by procedural time limits which are set by law and must be respected regardless of document submission status.

The second part of the analysis focused on the human factor which heavily influences the procurement process. In line with literature, it was found that personal preferences usually play a significant role in selecting technologies and that more advanced means of evaluation are needed. Moreover, the chapter discussed the issues around untrained and not specialized personnel, which can have an effect on motivation and action taking initiatives. This also has an effect on those key decision-making groups of individuals (i.e., commission) who must select the technologies from the multitude of available submitted offers. These committees are usually incomplete or constructed subjectively.

A third theme discussed throughout the chapter was in relation with the introduction of new technologies in public healthcare facilities. A consensus was discussed according to which stakeholders and literature view new technologies important, however, the process of doing so is inefficient. One reason for this is the selection of the familiar by the medical doctors, with each individual having different perspectives on the correct treatment scheme. A second reason for the inefficient process can be traced to the technical specifications and evaluation

of these during tenders. Technical specifications represent the requirements of a certain medical device intended to be purchased. However, these are not standardized, leading to problems in constructing them and, following, evaluating the offers.

The final section of the analysis looked at the digital platform acting as an intermediary in the acquisition process. It was discussed the presence of an already existing and implemented solution for online medical devices procurement (i.e., e-catalogue), however, the platform inherits certain problems leading to an inefficient or even nonexistent use of it. Moreover, a platform resembling a 3D configurator for capital medical equipment was discussed, showcasing its advantages and drawbacks, especially for high-cost medical devices.

6 Discussion

Initially, the aim of this research was to propose digital solutions for adapting the current acquisition of capital medical equipment to the context of Romania, which, in a medium- and long-term perspective, would have permitted a more efficient and transparent functioning of the entire process of public acquisitions within healthcare. Conducting, however, a literature review and realising the dimension of reality, identified through the in-depth interviews, the research showed that what, at first sight, seemed as a problem that could be solved through implementation of a digital platform is, in reality, caused by factors which cannot simply be resolved through deployment of (new) technologies. The research still showed that digitalization would have tremendous positive implications, but without overcoming the main negative aspects, its role would be insufficient. The real identified problems are more connected to the way in which the legislation is interpreted and applied, rather than simply a technological one.

Through the presented research, the main objective was to understand the current barriers and problems in Romanian healthcare procurement in order to be able to propose valid resolutions for bringing the acquisition system up to date. The stages for achieving this were three-fold.

Firstly, it was important to conduct a literature review. This helped identifying relevant scientific writings in relation with the topic of procurement of medical devices and e-procurement. The literature review aided in understanding what is the state of research analysing acquisition within public hospitals in Romania. Completing the literature review, it was then possible to, on the one hand, develop a clear image of how procurement works in public hospitals across multiple national systems. In addition, the literature review surfaced the requirements for the success of e-procurement for healthcare facilities. On the other hand, while a thorough search was carried, the literature review revealed that Romania finds itself in a serious lack of scientific research on procurement of medical devices, if not, on the public healthcare system altogether. Thus, for meeting the objectives it was important to find alternative scientific methods for analysing the research topic.

Following the results from the extensive literature review, a practical approach was required. This was achieved through carrying in-depth semi-structured interviews. The interviews were conducted with stakeholders in healthcare, directly interacting or being affected by the acquisition of medical devices. With the help of the interviews, it was possible to deeply understand and identify the contextual and real perspectives of the relevant actors, as well as the barriers they face when interacting with the acquisition system. While the research set out to determine the needs and wants of the stakeholders for a digital solution, it soon became clear that the problems are residing somewhere else.

The last stage of the research involved the analysis and discussion of the findings, as well as answering the research questions introduced at the beginning of the research. The analysis of the data led the research towards finding the main barriers and blockers that important stakeholders are facing. It was soon found that, as discussed previously, the individuals interacting with the acquisition system do not perceive merely

technological problems, but more system-wide issues. Nonetheless, putting together the literature review and the results of the research, it was then possible to answer the research questions.

6.1 Answers to Sub-Research Question 1: How do relevant stakeholders perceive the existing e-procurement process in relation to CME?

Offering answers to the first question was possible by analysing the process of acquisitions as a whole, combining findings from the literature review, together with the results from the interviews. Firstly, the scientific writings identified permitted to understand the general picture on procurement of capital medical equipment. Thus, it was found that medical technologies are heavily influenced by the procurement process, which is perceived as tortuous and complex. Moreover, the procurement of medical devices has effects over patient outcomes, medical practices, (national) budgets and what business become successful. The research identified that procurement of medical devices are selected rather on subjective factors, as opposed to having an objective evaluation system. It was also found that e-procurement, in multiple countries (e.g., Canada, Sweden, Germany), is only present as an intermediary between supplier and hospitals, not being able to fully conduct businesses in a digital space.

Narrowing down and analysing the context of Romania, similar results were found. While there are benefits of the current acquisition system, with the legislation being (in general terms) regarded as correct, several barriers became apparent. These included delayed budgets, unnecessarily long acquisition procedures, incomprehensible competition between private suppliers, lack of professionals, erroneous or outdated evaluation factors and acquisition of inferior quality products. Looking at e-procurement, research showed that a digital platform exists (SEAP), but which is mostly used for uploading/downloading documents and as a means of communication between buyer and supplier. Nonetheless, the platform does present a section for e-commerce which is rarely accessed and presents great inefficiencies. However, while some of them are due to technical capabilities, more are related to legislation and human factors.

Thus, it can be observed that e-procurement has not reached its full potential in Romanian healthcare system. The main causes that prevent the development of a successful e-commerce digital platform for medical devices were researched in an attempt to answer the first sub-question. The research showed that the barriers are not perceived only from a technology point of view, but there are also external factors having an decisive effect.

6.2 Answers to Sub-Research Question 2: What is the general tendency of relevant stakeholders towards a functional and adapted e-procurement system in Romania?

Similar to the case of the first question, answering the second question was possible through both literature review and the exploratory interviews conducted with relevant actors in the system. The literature research was important in determining, through scientific means, the factors that can lead to a successful implementation

of a functional e-procurement system in healthcare. Thus, it was found that advanced search of and access to information, as well as security of the platform are important factors. A successful e-procurement platform should be dynamic in adapting to changes and offering availability of renowned brands. Apart from the technical and information aspects, e-procurement should try to minimise opportunistic behaviour, alliances between actors and maximise integration of all stakeholders, users' motivation and involvement.

The data captured through practical research methods showed that similarities exist for the Romanian healthcare system, even though not directly aimed at e-commerce, but the acquisition system as a whole. The results brought forward the need of a more dynamic process (with reduced and adaptable time limits, timely budgets), accountability of stakeholders involved (development of strategies, being responsible for one's actions, standardized technical specifications), improvement of human factors (specialized individuals, removing subjective preferences, cooperation between actors) and offering more reliable digital resources.

Combining all presented results, it can be seen that the stakeholders interacting or being affected by the acquisition of medical devices have a wide range of needs that must be fulfilled before achieving efficient and reliable utilization of e-commerce. Nonetheless, the consensus is that a digital platform can enhance the process of bringing needed technologies in hospitals only after identified barriers are crossed.

6.3 Answers to Sub-Research Question 3: What are the improvements of e-procurement that provide a better fit with the needs and requirements of relevant stakeholders in Romanian healthcare?

The third question had as an aim proposing (technological) solutions for the e-procurement system in the healthcare system in order to meet the current needs of the stakeholders. However, by conducting the presented research, it was identified that the existing acquisition system does not only require technical solutions, but other blockers must be removed. It was shown that stakeholders involved in procurement of capital medical equipment in public Romanian hospitals are following a sinusoidal path. While there are solutions already in place or easily deployable, these are either not used by relevant actors or, at the very best, workarounds are found. Thus, it is important to reach a system-wide constant in order to identify and apply solutions, from a technology point of view (i.e., e-procurement).

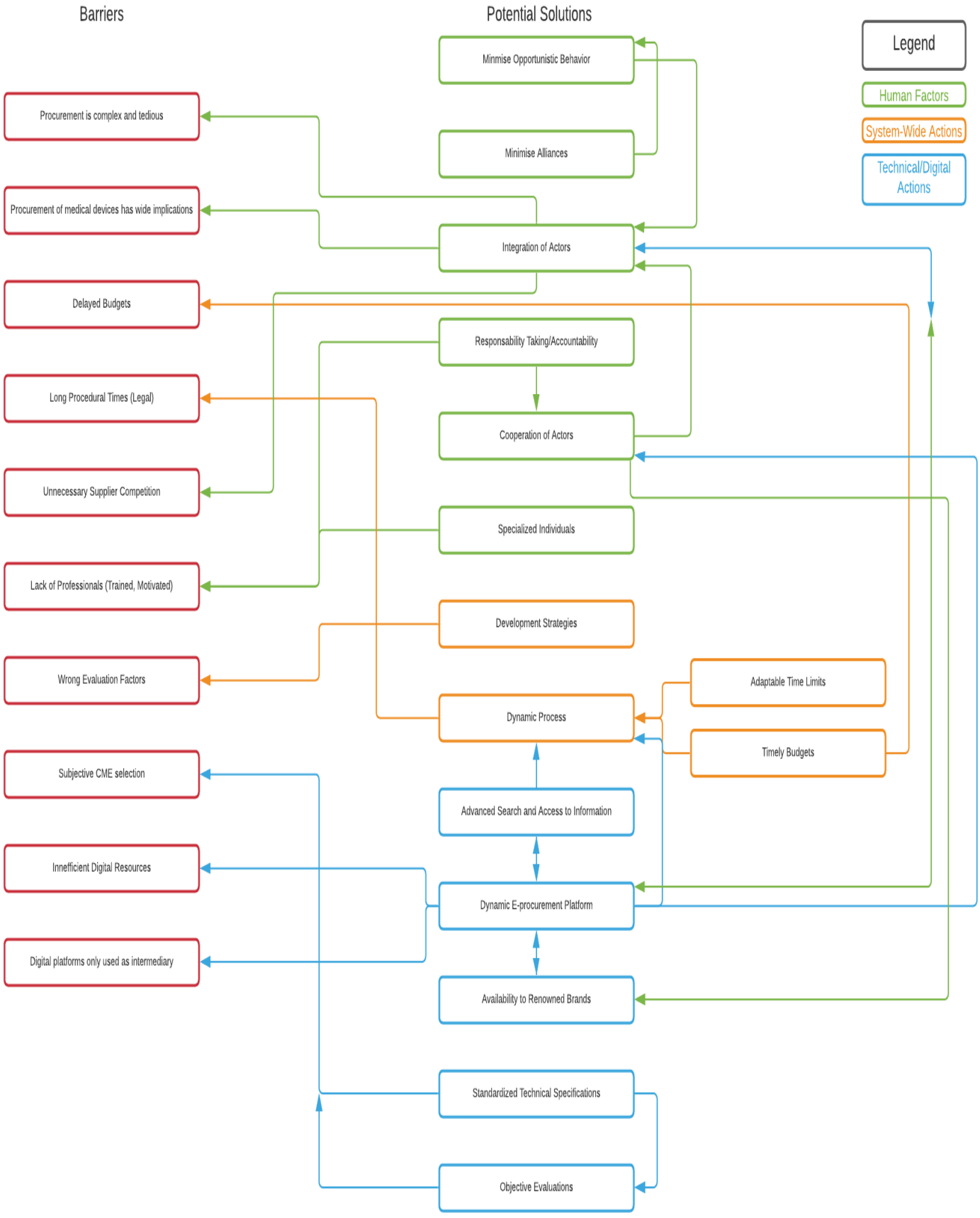

Figure 15: Potential Solutions (right) for Identified Barriers (left)

Fig. 15 presents an overview of all identified barriers, as well as potential solutions. The items on the left side showcase identified barriers both theoretically (i.e., through the literature review), as well as those identified through the practical research (i.e., interviews). On the right side, potential solutions identified through the main research methods used in the research are presented. The figure presents three major clusters of actions. The first one is represented by human factors and their influences (shown in green). These are actions which must be carried by those involved in and affecting the system such as the suppliers, acquisition personnel and medical staff. The second cluster refers to system-wide actions (shown in orange) where the involvement of all stakeholders is required, from hospital personnel, suppliers, all the way to regulators and policy-makers. Lastly, there are the technical actions (shown in blue) which have an immediate effect on the availability of digital resources which provide the basis for e-procurement.

Even though the potential solutions can be differentiated based on the three levels discussed above, it should be taken into account that a high interdependency is present between them. This means that it can be difficult to only apply one solution in order to offer a better fit with the needs of relevant stakeholders, without accounting for the underlying or complementary issues. For example, when looking at the case of the current digital platform (i.e., SEAP), which, as shown in chapter 5, is used only as an intermediary between supplier and buyer, it can be seen in Fig. 15 that a dynamic e-procurement would aid in this instance. However, having a dynamic digital platform is influenced both by technological capabilities (e.g., advanced search and access information), as well as human factors (e.g., integration of actors), which can be further affected by other underlying factors, such as cooperation of actors. Not only does a dynamic digital platform require other changes to be made, but this can also influence other potential solutions. As seen in Fig. 15, an efficient digital platform can have an effect on system-wide actions, such as the necessity of a dynamic acquisition process. Following along the same lines, a dynamic process would aid in solving the problem of long procedural times, identified through the interviews.

Therefore, while Fig. 15 provides an overview of all barriers and potential solutions identified through the presented research, it is crucial to note that improvements to the current acquisition system are possible only when an alignment exists between all relevant stakeholders. Moreover, it is important to consider the fact that, even though solutions exist, a single go-to solution cannot be provided and that it is necessary to have both short-term, as well as long-term perspectives. For example, while availability of renowned brands can be easily integrated within the current system (i.e., short-term solution), a much longer period could be necessary to achieve a cooperation between actors. Thus, as there cannot be identified a single root cause of the problem, and because interrelationships exist between solutions, it is important to account for the complexities of the acquisition system while designing an efficient e-procurement system that better accommodates the needs and requirements of relevant stakeholders.

6.4 Answers to Main Research Question: What are the improvements of e-procurement that provide a better fit with the needs and requirements of relevant stakeholders in Romanian healthcare?

In reaching an answer to the main research question, it was important to find the answers to the three sub-questions. By doing so, it was possible to identify, through both literature review and practical research (i.e., in-depth interviews), in the first place, how the existing system is being understood and perceived. This allowed the identification of major disadvantages and barriers present in the system of medical devices procurement, as answered under the first sub-question. Secondly, through the second sub-question, it was important to gain insights into what are the ideal enhancements to the system, as researched in the literature and as needed by the relevant stakeholders. Lastly, the third step was aimed at developing and proposing solutions to improve the e-procurement system. In an attempt to answer the third sub-question, it was found that more in-depth causes exist within the system and that imposing only technical solutions would merely lead to small incremental improvements.

The presented research has shown that multiple causes exist, with an effect on the inefficiencies within the procurement process of CME. While the research started with the scope of improving the e-procurement part of the acquisition system, more deeply rooted barriers were identified. The third sub-question, whose purpose was to identify potential improvements, indicated that an updated e-procurement solution can bring a series of advantages. However, only making the system to use e-procurement can lead to no clear benefits or, at best, offer the stakeholders more barriers which must be circumvented – such as the case of the current e-catalogue offered on the existing digital platform. Other identified barriers have to be removed, so that e-procurement can function as intended.

Thus, as both the presented research and Fig. 15 have indicated, the acquisition system of capital medical equipment showcases great complexities, with a wide range of stakeholders involved, not only from the clinical environment, but also from public administrative institutions. Moreover, a functioning and updated acquisition system is heavily influenced not only by technical capabilities, but also by much wider system actions (e.g., delayed national budgets). It is for these reasons that, while the presented research set out to identify digital improvements, it was discovered that e-procurement is not the immediate solution for efficient and effective acquisition of capital medical equipment within Romanian healthcare.

7 Conclusions and Further Research

7.1 Conclusions

Healthcare systems are especially important to be analysed and constantly improved, as they represent one of the critical infrastructures, with public health dependent on these system. One of the highly relevant factors influencing the state of healthcare is represented by medical technologies. These enable advancements in medical practices and, as a result, enhancements to the public health. However, introduction of medical equipment is heavily affected and influenced by the procurement process, with great effects on the adoption of medical equipment. Nonetheless, the acquisition system within hospitals is extremely laborious and involves a whole range of stakeholders and actors, from governmental powers to patients. For this reason, it is important to always have an updated and efficient procurement system.

This research has analysed and sought to propose improvements to the procurement system within Romanian public healthcare institutions. Romania is a developing country, confronting with a wide range of problems as it has been transitioning for the last 30 years from a socialist regime to democracy. The healthcare system was and still is affected by these transformations with important inefficiencies and barriers to be removed, also present within the procurement process of medical equipment.

Through this research, the most important barriers faced by the acquisition system were identified and discussed. Some of these relate to national budgets, conservative legislation, underdeveloped evaluation factors, lack of specialized workforce, private suppliers cooperation, lack of accountability or workarounds and underdeveloped digital resources. In addition, the research showed that needs and requirements of relevant stakeholders can be achieved only through intertwined and system-wide improvements. Thus, a digital platform (or e-procurement) is not seen as the immediate go-to solution for procurement of medical equipment in Romania, but a more diverse range of issues have to be addressed in the first instance. This requires a lot of work (theoretically and practically) both from those within the system, as well as those outside of it.

What was initially considered as being a cause-effect relationship (enhancement or the implementation of an updated digital platform could result in overcoming all inefficiencies from the acquisition process), following the presented research it was found that a complex network of interconnected issues and problems exists, where a cause can become the effect of another factor and vice versa. This is detailed in Fig. 15 which illustrates a part of these correlations between potential solutions and identified barriers. This showcases that a single go-to solutions – a digital platform – can prove insufficient in solving the current problems within the acquisition system. Taking a wider perspective, only implementing e-procurement would offer short-term benefits, however, looking prospectively, it would not succeed in overcoming identified barriers. Thus, the research shows that a digital platform which is functional and adapted to the Romanian context could have the potential to facilitate access to resources and information and could eliminate intermediaries, nonetheless, this would not guarantee that these objectives will be met before solving the other negative aspects identified throughout the research.

7.2 Limitations

Similar to most researches, the current study presents its limitations. One of the first limitations refers to the literature review. The presented literature research has identified relevant studies in relation with procurement of medical devices, e-procurement in general and e-procurement of medical devices, as well as research about the Romanian healthcare system. While the literature identified is extensive and offers a wide coverage of the topic under investigation, there was a lack of studies researching e-procurement systems in other industries. Analysing reports which present the successful implementation of e-commerce solutions in different industries, it could have potentially offered insights into what can be borrowed and applied to the healthcare system.

Secondly, various biases might be present in the above research. One such bias is connected with ignoring the familiar or the already accustomed to situations. As the research was developed based on having an understanding of the healthcare system and being involved in the process of acquisitions, it may be the case that some issues have not been considered. This could happen as a result of ignoring situations which seemed normal or familiar.

Other limitations are relating to the research method selected and its application. As presented, the methodology involved in-depth exploratory interviews with stakeholders in the public acquisition system. With Romania still being affected by reminiscences from the socialist period, respondents, especially those working in public systems, are not usually accustomed to scientific research similar to this one. As a result, respondents have a tendency towards perceiving interviews in a more journalistic manner, rather than a scientific research method. This has implications on the discussions carried with the participants who tend to not be as opened as expected, potentially limiting their responses. Moreover, following along the same lines, it was important to conduct face-to-face interviews. The reason for this were similar to the above, meaning that participants were prone to becoming reticent should discussions were carried over the phone. Thus, in person interviews were necessary, which, even though assured the achievable openness of the participants, it also had the adverse effect of imposing some limitations. The research could not provide a wide coverage of regional differences present across the Romanian territory. In addition, in-person interviews, with the selected actors having extremely tight schedules, confronted with situations where the discussion was interrupted or the participants did not have sufficient time to fully elaborate ideas.

7.3 Generalizability

At first sight, the findings presented above may seem as applicable only to the Romanian context. However, it should be noted that the acquisition system, as discussed in the literature review, is similar across all member states of the European Community. The legislation applicable in Romania is adapted from the European Directive. This holds true for other countries within the European Community. Thus, the findings of this research can be adapted and applied to other contexts as well, considering the similarities within systems. Not only is there a similarity from a legislative point of view, but as the findings of chapter 3 and 4 showed, various

similarities exist between what other have researched and what the presented research identified for the current context of Romania. This indicates that similar problems exist within acquisition processes across multiple systems and, as a result, this strengthens the point that the findings of this study could easily be adapted and applied to other contexts, as well.

7.4 Recommendations for Further Research

The results following from this research are only representing on of the first steps towards the research of the e-procurement system of capital medical devices. For this reason, further research is deemed necessary, especially for the Romanian context. In order for this to happen, several suggestions could be made towards having more accurate results and advance the public acquisition system of capital medical equipment:

1. Participants and Observatory Participation: As discussed, one of the most important limitation of the study was represented by the participants for the interviews. Therefore, for future research it is important, first of all, to enlarge the number of interviewees and regions where the participants are found, as well as having an equal participants' distribution across the regions, in order to construct a much more relevant set of data. Considering that it is necessary to conduct face-to-face interviews, sufficient time or human resources should be allocated for accurate and extensive results. Moreover, observatory participation could provide beneficial to future research. Studies should perform the needed step of being directly involved and assessing an acquisition process from start to beginning. This may surface important insights into situations overlooked by the respondents of an interview.

2. Improved Research Methods: While the research deployed a double research method, by using a literature review and exploratory interviews, it should be noted that the healthcare system is regarded as an extremely complex case which requires extensive research in order to capture most of the particularities. Thus, apart from enlarging the sample of interview respondents, it may beneficial to add further research methods such as surveys. These would not only allow an even more wide base of respondents to be reached, but also analysing, in a statistical manner, responses to specific situations.

3. Research on Potential Improvement Proposals: The initial scope of the research was to propose digital improvements for the e-procurement of capital medical equipment in public healthcare facilities. However, it was found that other causes, further away from technical solutions, are present for the inefficiencies in bringing new technologies in hospitals. Therefore, the presented research can be regarded as a basis for the Romanian context onto which further studies could build. Having studies which learn from the presented research and analyse how, through digital solutions, e-procurement can be brought to the stakeholders, could provide an important step forward.

References

Abas Azmi, K., & Rahman, A. (2015, 01). E-procurement: A tool to mitigate public procurement fraud in malaysia? *Proceedings of the European Conference on e-Government, ECEG*, *2015*, 361-368.

Abdulsalam, Y. J., & Schneller, E. S. (2020). Of barriers and bridges. *Health Care Management Review*, *Publish Ahead of Print*. doi: 10.1097/hmr.0000000000000278

Abedini, Z., Sari, A. A., Foroushani, A. R., & Jaafaripooyan, E. (2018). Diffusion of advanced medical imaging technology, ct, and mri scanners, in iran: A qualitative study of determinants. *The International Journal of Health Planning and Management*, *34*(1). doi: 10.1002/hpm.2657

Aggarwal, A. K., & Travers, S. (2001). E-commerce in healthcare: Changing the traditional landscape. , 12.

Birzoi, I. (2021, Jun). *Angajatii primariei sectorul 1 folosesc 5 milioane de coli a4 pe an. clotilde armand: "e ca si cum m-as fi intors 50 de ani in timp"*. Retrieved from https://ziare.com/clotilde-armand/stiri-clotilde-armand/primaria-sectorului-1-foloseste-5-milioane-de-coli-a4-pe-an-1680283

Bof, F., & Previtali, P. (2007, January). Organisational pre-conditions for e-procurement in governments: the italian experience in the public health care sector. *Electronic Journal of e-Government*, *5*.

Bravar, D., Carlini, G., Cortese, A., Dell' Aquila, T., & Pangher, N. (2001). E-management of medical devices in italy. In (Vol. 4, p. 3891-3893).

Burns, L. R., Bradlow, E. T., Lee, J. A., & Antonacci, A. C. (2007). Assessment of medical devices: How to conduct comparative technology evaluations of product performance. *International Journal of Technology Assessment in Health Care*, *23*(4), 455–463. doi: 10.1017/s0266462307070547

Burns, L. R., Housman, M., Booth, R., & Koenig, A. (2018). Physician preference items: what factors matter to surgeons? does the vendor matter? *Medical Devices: Evidence and Research*, *Volume 11*, 39–49. doi: 10.2147/mder.s151647

Chadha, S., Ennen, M., Parekh, R., & Pellumbi, G. (2020). Reimagining medtech for a COVID-19 world. , 8.

Coculescu, B., Coculescu, E., & Purcarea, V. (2016). Orientation to the patient as a marketing strategy in the romanian healthcare system. *Journal of Medicine and Life*, *9*(3), 302-305. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5154320/

ConsiliulConcurenteiRomania. (n.d.). *Studiu privind efectul de captivitate (lock-in) În sectoarele sensibile În domeniul achiziȚiilor publice, it ȘI echipamente/aparaturĂ medicalĂ*. Retrieved from http://www.consiliulconcurentei.ro/wp-content/uploads/2020/01/studiu_privind_efectul_de_lock-in-achizitii_publice_publicare_site_cc-1.pdf

Cosma, S. A., Bota, M., Flesériu, C., Morgovan, C., Văleanu, M., & Cosma, D. (2020). Measuring patients' perception and satisfaction with the romanian healthcare system. *Sustainability*, *12*(4), 1612. doi: 10.3390/su12041612

Deloitte. (2019). *2020 global health care outlook.* Retrieved from 2020-global-health-care-outlook

Diaconu, K., Chen, Y.-F., Cummins, C., Jimenez Moyao, G., Manaseki-Holland, S., & Lilford, R. (2017). Methods for medical device and equipment procurement and prioritization within low- and middle-income countries: findings of a systematic literature review. *Globalization and Health*, *13*(1). doi: 10.1186/s12992-017-0280-2

Directive 2014/24/eu. (n.d.). Queen's Printer of Acts of Parliament. Retrieved from https://www.legislation.gov.uk/eudr/2014/24/contents

EuropeanCommission. (2019). *State of health in the eu: Romania; country health profile 2019.* OECD E.C. Retrieved from https://www.euro.who.int/__data/assets/pdf_file/0009/419472/Country-Health-Profile-2019-Romania.pdf

EuropeanCommission. (2020). Health status. *Health at a Glance: Europe*. doi: 10.1787/45ba31ca-en

Hermes, S., Riasanow, T., Clemons, E. K., Bohm, M., & Krcmar, H. (2020). The digital transformation of the healthcare industry: exploring the rise of emerging platform ecosystems and their influence on the role of patients. *Business Research*, *13*(3), 1033–1069. doi: 10.1007/s40685-020-00125-x

Holmes, S. C., & Miller, R. H. (2003). The strategic role of e-commerce in the supply chain of the healthcare industry. *International Journal of Services Technology and Management*, *4*(4/5/6), 507. doi: 10.1504/ijstm.2003.003629

Hurjui, I., & Hurjui, C. M. (2015, 01). Impact on population health due to inefficient financing of investments in the field. *Proceedings of the European Conference on e-Government, ECEG*, *2015*, 361-368.

Johnson, M. (2013). Critical success factors for b2b e-markets: a strategic fit perspective. *Marketing Intelligence amp; Planning*, *31*(6), 698–727. doi: 10.1108/mip-10-2013-001

Ketikidis, P. H., Kontogeorgis, A., Stalidis, G., & Kaggelides, K. (2010). Applying e-procurement system in the healthcare: the epos paradigm. *International Journal of Systems Science*, *41*(3), 281–299. doi: 10.1080/00207720903326878

Kiralyova, E., Stekla, M., & Donin, G. (2017). Selection of a pet/ct scanner for the department of nuclear medicine. *2017 E-Health and Bioengineering Conference (EHB)*. doi: 10.1109/ehb.2017.7995428

Klein, T. (2015). The medtech revolution: the european medical technology industry. , 12.

KPMG. (2019). *Opportunities and challenges in an evolving market.* Author. Retrieved from https://institutes.kpmg.us/content/dam/institutes/en/healthcare-life-sciences/pdfs/2020/hcls-investment-outlook.pdf

Leidner, D. E., Preston, D., & Chen, D. (2010). An examination of the antecedents and consequences of organizational it innovation in hospitals. *The Journal of Strategic Information Systems*, *19*(3), 154–170. doi: 10.1016/j.jsis.2010.07.002

Lin, C., Huang, Y.-A., Jalleh, G., Liu, Y.-C., & Tung, M.-L. (2010). An exploratory study of factors affecting adoption and implementation of b2b e-commerce in australian health care organizations. *"International Journal of Electronic Commerce Studies"*, *1*(2), 77-96. Retrieved from http://academic-pub.org/ojs/index.php/ijecs/article/view/918 doi: 10.7903/ijecs.918

Lingg, M., Wyss, K., & Duran-Arenas, L. (2016). Effects of procurement practices on quality of medical device or service received: a qualitative study comparing countries. *BMC Health Services Research*, *16*(1). doi: 10.1186/s12913-016-1610-4

Lobont, O. R., Vatavu, S., Brindescu Olariu, D., Pelin, A., & Chis, C. (2019). E-health adoption gaps in the decision-making process. *Revista de Cercetare si Interventie Sociala*, *65*, 389–403. doi: 10.33788/rcis.65.24

López-Bastida, J., Oliva, J., Antoñanzas, F., García-Altés, A., Gisbert, R., Mar, J., & Puig-Junoy, J. (2010). Spanish recommendations on economic evaluation of health technologies. , *11*(5), 513–520. Retrieved from https://doi.org/10.1007/s10198-010-0244-4 doi: 10.1007/s10198-010-0244-4

Mackey, T. K., & Cuomo, R. E. (2020). An interdisciplinary review of digital technologies to facilitate anti-corruption, transparency and accountability in medicines procurement. *Global Health Action*, *13*(sup1), 1695241. doi: 10.1080/16549716.2019.1695241

McKinsey. (2020, Jun). *The next wave of healthcare innovation: The evolution of ecosystems.* McKinseyCompany. Retrieved from https://www.mckinsey.com/~/media/McKinsey/Industries/Healthcare%20Systems%20and%20Services/Our%20Insights/The%20next%20wave%20of%20healthcare%20innovation/The-next-wave-of-healthcare-innovation-The-evolution-of-ecosystems-vF.pdf?shouldIndex=false

Miller, F. A., Lehoux, P., Peacock, S., Rac, V. E., Neukomm, J., Barg, C., ... Krahn, M. (2019). How procurement judges the value of medical technologies: A review of healthcare tenders. *International Journal of Technology Assessment in Health Care*, *35*(1), 50–55. doi: 10.1017/s0266462318003756

Miller, L. M. (2014). E-health: Knowledge generation, value intangibles, and intellectual capital. *International Journal of Healthcare Management*, *8*(2), 100–111. doi: 10.1179/2047971914y.0000000094

Moreira, M. R., Gherman, M., & Sousa, P. S. (2017). Does innovation influence the performance of healthcare organizations? *Innovation*, *19*(3), 335–352. doi: 10.1080/14479338.2017.1293489

Morse, J. M. (2000). Determining sample size. *Qualitative Health Research*, *10*(1), 3–5. doi: 10.1177/104973200129118183

Nastase, A. (2021, Feb). *Trei decenii, aproape 30 de miniștri! cine a condus sănătatea după revoluție.* Retrieved from https://www.fanatik.ro/trei-decenii-aproape-30-de-ministri-cine-a-condus-sanatatea-dupa-revolutie-19426806

Paho. (2012, Nov). *Paho/who: World radiography day: Two-thirds of the world's population has no access to diagnostic imaging.* Retrieved from https://www.paho.org/hq/index.php?option=com_content&

view=article&id=7410%3A2012-dia-radiografia-dos-tercios-poblacion-mundial-no-tiene-acceso-diagnostico-imagen&Itemid=1926&lang=en

Palamas, S., Kalivas, D., Panou-Diamandi, O., Zeelenberg, C., & Nimwegen, C. V. (2001). Design and implementation of a portal for the medical equipment market: Medicom. *Journal of Medical Internet Research*, *3*(4). doi: 10.2196/jmir.3.4.e32

Pasiopoulos, A., Siskou, O., Galanis, P., Prezerakos, P., Moisoglou, I., Theodorou, M., & Kaitelidou, D. (2013, 03). The implementation of e-procurement system in health sector in greece: Attitudes of potential users and implications for hospital management. *International Journal of Health Research and Innovation*, *vol. 1*, 15-23.

Pavaluca, B. (2021). *Bugetul post-pandemie. ministerul sănătății va avea fonduri semnificativ reduse în 2021.* Retrieved from https://stirileprotv.ro/stiri/financiar/bugetul-post-pandemie-ministerul-sanatatii-va-avea-fonduri-semnificativ-reduse-in-2021.html

Pope, C. (2002). Qualitative methods in research on healthcare quality. *Quality and Safety in Health Care*, *11*(2), 148–152. doi: 10.1136/qhc.11.2.148

Radulescu, C., Radulescu, M., Bajenaru, L., & Alexandru, A. (2021). A multi-objective model for devices procurement with application in health care. *Advances in Intelligent Systems and Computing*, *1243AISC*, 274-283. doi: 10.1007/978-3-030-53651-0_23

Romanian Government. (2016). *Hotărârea guvernului nr. 395/2016 pentru aprobarea normelor metodologice de aplicare a prevederilor referitoare la atribuirea contractului de achiziție publică/acordului-cadru din legea nr. 98/2016 privind achizițiile publice.* (http://anap.gov.ro/web/hotararea-nr-3952016-pentru-aprobarea-normelor-metodologice-de-aplicare-a-prevederilor-referitoare-la-atribuirea-contractului-de-achizitie-publicaacordului-cadru-din-legea-nr-982016-privind-achiz/)

Romanian Parliament. (2016). *Lege nr. 98/2016 din 19 mai 2016 privind achizitiile publice.* (http://anap.gov.ro/web/wp-content/uploads/2016/05/L98_2016.pdf)

Rupp, S. (2020). *ecommerce and the medical device market - electronic health reporter.* Retrieved from https://electronichealthreporter.com/ecommerce-and-the-medical-device-market/

Saminadan, S. R. S. (2017). Factors influencing online information search among doctors with special reference to medical equipments. *International Journal of Sales amp; Marketing Management Research and Development*, *7*(4), 65–76. doi: 10.24247/ijsmmrdaug20177

Sekaran, U., & Bougie, R. (2010). *Research methods for business: a skill-building approach.* Wiley.

Smith, A., & Correa, J. (2005, 02). Value-added benefits of technology: e-procurement and e-commerce related to the health care industry. *International journal of health care quality assurance incorporating Leadership in health services*, *18*, 458-73.

Smith, A. D., & Flanegin, F. R. (2004). E-procurement and automatic identification: enhancing supply chain management in the healthcare industry. *International Journal of Electronic Healthcare*, *1*(2), 176. doi: 10.1504/ijeh.2004.005866

Sorenson, C., Drummond, & Bhuiyan-Khan. (2013). Medical technology as a key driver of rising health expenditure: disentangling the relationship. *ClinicoEconomics and Outcomes Research*, 223. doi: 10.2147/ceor.s39634

Sorenson, C., & Kanavos, P. (2011). Medical technology procurement in europe: A cross-country comparison of current practice and policy. *Health Policy*, *100*(1), 43–50. doi: 10.1016/j.healthpol.2010.08.001

Stan, S. (2012). Neither commodities nor gifts: post-socialist informal exchanges in the romanian healthcare system. *Journal of the Royal Anthropological Institute*, *18*(1), 65–82. doi: 10.1111/j.1467-9655.2011.01731.x

Terio, H. (2010, 02). Procurement of medical equipment in sweden. *Zdravniški vestnik*, *79*, 156-163.

Tiron, M. (2016). *Radiografia spitalelor: 367 publice, 187 private; 125.000 de paturi la public, 6.600 paturi la privat; doar 4% din cei 4,24 mil. pacienti internati, la privat.* Retrieved from https://www.zf.ro/companii/radiografia-spitalelor-367-publice-187-private-125-000-de-paturi-la-public-6-600-paturi-la-privat-doar-4-din-cei-4-24-mil-pacienti-internati-la-privat-15557013

Vincent, C. J., & Blandford, A. (2017). How do health service professionals consider human factors when purchasing interactive medical devices? a qualitative interview study. *Applied Ergonomics*, *59*, 114–122. doi: 10.1016/j.apergo.2016.08.025

Visconti, R. M., & Morea, D. (2020). Healthcare digitalization and pay-for-performance incentives in smart hospital project financing. *International Journal of Environmental Research and Public Health*, *17*(7), 2318. doi: 10.3390/ijerph17072318

Vladescu, C., Scintee, S., Olsavszky, V., Hernandez-Quevedo, C., & Sagan, A. (2016). Romania: Health system review. *Health systems in transition*, *18*(4), 1-170.

Wang, C., Mao, Z., Johansen, J., Luxhøj, J. T., O'Kane, J., Wang, J., ... Chen, X. (2015). Critical success criteria for b2b e-commerce systems in chinese medical supply chain. *International Journal of Logistics Research and Applications*, *19*(2), 105–124. doi: 10.1080/13675567.2015.1032228

WHO. (2010a). *Medical devices: managing the mismatch: an outcome of the priority medical devices project* (W. H. Organization, Ed.). World Health Organization.

WHO. (2010b). *More health for the money.* Retrieved from https://www.who.int/whr/2010/10_chap04_en.pdf

Woods, M., Paulus, T., Atkins, D. P., & Macklin, R. (2016). Advancing qualitative research using qualitative data analysis software (qdas)? reviewing potential versus practice in published studies using atlas.ti and nvivo, 1994–2013. *Social Science Computer Review*, *34*(5), 597–617. doi: 10.1177/0894439315596311

A Appendix A - Interview Guide

A.1 Introduction and Research Presentation

My name is Bogdan Miron and I am a student at TU Delft, the Netherlands, pursing a master degree in "Management of Technology". The following questions are part of my ongoing research for my final thesis project. The research has as an aim the understanding of the acquisition system in public hospitals and the needs as perceived by key decision-makers, directly involved in the process. Following these interviews, the research aims to identify and propose potential improvements to the public acquisition system so that the hospital needs are covered as efficiently as possible, and the necessary technology is introduced more easily, while accounting for the potential benefits.

A.2 Interview and Interviewee Details

Date

Hospital

Function

Role in public acquisitions

Interviewee name

Interview location

Contact (email/phone number)

A.3 Interview Questions

A. The Current Procurement System

1. What is your role in the acquisition process (both formal and informal)? Have you interacted with SEAP (e-licitatie.ro)?

2. Could you briefly tell me how acquisition of high-cost medical equipment works in your hospital?

3. What is your opinion on the current procurement process?

- What are the advantages of the current system from your perspective?
- What are the challenges you can identify in the present system?

4. Have you had any involvement in changing the procedures for the procurement system (either internally or externally)? If yes, how and what changes have you proposed?

B. Committee evaluation criteria

5. From your experience, which persons are the most influential during the procurement process?

- Do you consider necessary a committee/working group which supervises the entire acquisition process within a hospital?

6. In your opinion, what do you consider to be the most important evaluating criteria?

- According to the current procedures, the most relevant factor is cost/price at time of purchase. However, other costs are involved (both pre- and post-purchase, e.g., maintenance, servicing, training, guarantee etc.)
- In countries such as the Netherlands, based on a detailed evaluation, the hospital can select from what producer to buy (for CME). Would this be a suitable/desirable process for the Romanian context?

7. What differences, with the exception of bureaucratic ones, do you perceive in procuring low-cost devices compared to CME?

C. Technology in hospitals

8. How high-performance medical technology-orientated do you believe doctors should be?

- What do you consider to be the technology level in Romanian hospital?
- Do you consider new technologies relevant for medical procedures?
- What do you consider to be the relation between high-tech devices and the medical outcomes?

9. How do you find out about new technologies relevant to your specialization?

- Imagine a scenario where the online platform is directly available to you. How would this affect bringing new technologies into hospitals?

10. When identifying a new technology/need (specifically of high-cost devices) within your department/hospital how do fulfil these needs?

- What barriers do you face along the process and how do you overcome them?
- Do you consider that the current acquisition system has an effect on the introduction of new technologies?

D. Closing questions – Ideal world

11. If you had the possibility of implementing an acquisition system without any constraints, how would this look like?

- What criteria should the ideal system meet in order to introduce new technologies easier into hospitals and have better patient outcomes?
- Do you think that producers/distributors could do something in this regard?

B Appendix B - Literature Review Search Strings

Search String	Database
healthcare e commerce b2b	Google Scholar
medtech go to market	Google Scholar
medtech distributors	Google Scholar
Medical equipment AND e-commerce	Scopus
Healthcare AND e-commerce	Scopus
healthcare AND e-commerce AND marketing	Scopus
healthcare AND e-procurement AND marketing	Scopus
"medical technology" AND go AND to AND market	Scopus
"medical technology" AND online AND marketing	Scopus
"medical equipment" AND romania AND procurement	Scopus
"medical technology" AND procurement	Scopus
"medical technology" AND e-procurement	Scopus
"medical technology" AND e-commerce	Scopus
Healthcare E-Commerce medical equipment	TU Delft Library
"medical technology" AND digital AND business	Scopus
"medical technology" AND digital AND promoting	Scopus
marketing OR promotion AND medical AND distributor	Scopus
"medical equipment market"	Scopus
healthcare AND b2b	Scopus
e-commerce AND doctors	Scopus
e-procurement "medical device" OR "medical equipment"	Scopus
marketing strategy romanian "healthcare" system	Google Scholar
business AND healthcare AND vendors	Scopus
"medical technology" OR "medical equipment" vendor	Scopus
"medical technology" OR "medical equipment" digital AND marketing	Scopus
"medical technology" OR "medical equipment" digital AND promoting	Scopus
"medical technology" OR "medical equipment" promoting	Scopus
"medical technology" OR "medical equipment" marketing	Scopus
medical technology OR "medical equipment" acquisition"medical technology" OR "medical equipment" acquisition OR procurement OR purchase AND romania	Scopus
healthcare AND acquisition OR procurement OR purchase AND romania	Scopus
healthcare AND romania	Scopus
healthcare AND consultancy	Scopus
healthcare AND consultancy AND procurement OR acquisition	Scopus
"medical technology" AND promotion OR marketing AND sales	Scopus

"medical technology" AND romania	Scopus
"medical equipment" AND romania	Scopus
healthcare AND innovation AND romania	Scopus
health* technology adoption romania	WoS
medical device romania	WoS
health technology management romania	WoS
medical technology romania	WoS
heatlh* e-procurement	WoS
medical equipment romania	WoS
Hospital equipment procurement	WoS
capital medical equipment	WoS
capital medical equipment Romania	WoS
digital platform medical equipment	WoS
medical equipment online research	WoS
health* AND tech* AND procure*	Scopus
health* AND tech* AND procure* AND romania	Scopus
health* OR medical AND tech* OR equipme* AND procure* OR purchase AND romania	Scopus
Equipment AND supplies AND procur* AND purchase	Pubmed
purchas* AND hospital AND procure*	Pubmed
romania AND (procure* OR purchas* OR acquisition)	Pubmed
romania AND (procure* OR purchas* OR acquisition) AND health*	Scopus
digital AND platform AND medical AND equipment	Pubmed
digital AND platform AND medical AND equipment AND market	Pubmed
Hospital equipment procurement	Pubmed
e-commerce AND technology	Pubmed
e-commerce AND equipment	Pubmed
e-commerce AND romania	Pubmed
e-procurement	Pubmed
capital equipment	Pubmed
capital medical equipment procur*	Scopus
medical equipment procur*	Scopus
"captial medical equipment"	Scopus
"high cost medical equipment"	Scopus
"high cost medical technology"	Scopus

Table 6: Search Strings Deployed During the Literature Review

C Appendix C - Qualitative Data Analysis Software

A report of the ATLAS.ti analysis can be seen here. It presents the codes used, together with the number of their appearances.

Code	Grounded	Code Group
Framework Agreement (AP)	8	Acquisition Process
Market Consultancy (AP)	8	Acquisition Process
Need Identification (AP)	12	Acquisition Process
Procedure Details(AP)	8	Acquisition Process
Technical Specification Minimum Threshold Importance (AP)	7	Acquisition Process
Technical Specifications Construction (AP)	14	Acquisition Process
Bureaucracy Minimised (A)	1	Advantages
Commission Formation Importance (DM)	4	Decision Maker
Commission Importance (DM)	11	Decision Maker
Legal Department (DM)	2	Decision Maker
Manager (DM)	7	Decision Maker
Medical Engineer (DM)	6	Decision Maker
Medical Staff (DM)	20	Decision Maker
Bureaucracy (D)	7	Disadvantages Acquisitions
Delayed Budgets (D)	12	Disadvantages Acquisitions
Inferior Products (D)	7	Disadvantages Acquisitions
Lack of Money (D)	6	Disadvantages Acquisitions
Lock-in Effect (D)	3	Disadvantages Acquisitions
Long Periods (D)	16	Disadvantages Acquisitions
Lowest Price (D)	3	Disadvantages Acquisitions
Motivation Lack (D)	2	Disadvantages Acquisitions
Personnel Lack (D)	3	Disadvantages Acquisitions
Professional Personnel Lack (D)	2	Disadvantages Acquisitions
Supplier Feedback Missing (D)	4	Disadvantages Acquisitions
Unclear Technical Specification (D)	2	Disadvantages Acquisitions
Difficult Evaluation (EC)	1	Evaluation Criteria
Guarantee (EC)	9	Evaluation Criteria
Life-time Costs (EC)	9	Evaluation Criteria
Lowest Price (EC)	7	Evaluation Criteria
Maintenance Costs (EC)	2	Evaluation Criteria
Quality Evaluation (EC)	8	Evaluation Criteria
Service Costs (EC)	8	Evaluation Criteria

Access to Information (IW)	1	Ideal World
Central Pricing System (IW)	1	Ideal World
Development Strategy (IW)	1	Ideal World
Dynamic Process (IW)	3	Ideal World
Externalization (IW)	3	Ideal World
Less Birocracy (IW)	3	Ideal World
Multianual Budget (IW)	1	Ideal World
Standard Technical Specs (IW)	1	Ideal World
Supplier Responsability (IW)	7	Ideal World
Trained Personnel (IW)	1	Ideal World
Watchdog (IW)	1	Ideal World
Balanced Development (NT)	6	New Technology
Importance of Established Producers (NT)	2	New Technology
Knowledge Development (NT)	2	New Technology
Lacking in rural Romania (NT)	6	New Technology
MedTech Configurator (NT)	1	New Technology
Need of Specialists (NT)	7	New Technology
Patient Push (NT)	1	New Technology
Supplier Cooperation (NT)	1	New Technology
No Digital (D)	7	SICAP - Digital platform
Restrictive Information (D)	3	SICAP - Digital platform
Technical Problems (D)	2	SICAP - Digital platform
Updates Needed (D)	3	SICAP - Digital platform

Table 7: Qualitative Data Analysis Software Codes Report

D Appendix D - Technical Specification Example

Herein can be observed an extract of a 10 pages long technical specification for a single MRI

Specificatii tehnice (Technical Specification)	DA (Yes/No)	NU	Observatii , (se va indica unde se afla documentatia din care rezulta indeplinirea cerintei) (Notes (Should indicate page in manual where specification is mentioned)
CERINTE TEHNICE			
CONFIGURATIE			
Echipament de imagistica medicala prin rezonanta magnetica nucleara cu intensitatea câmpului magnetic de minim 1.5 T			
1. 1 buc Magnet superconductiv minim 1.5T 2. 1 buc Sistem de gradienti 3. 1 buc Sistem RF de emisie / receptie 4. 1 buc Masa de pacient 5. 1 buc Consola pentru achizitie şi reconstructie 6. 1 buc Set aplicatii Clinice complete definitive pentru: scanare, ajustarea parametriilor , reducerea anxietati, setare parametri de scanare, achizitii generale şi corectie miscare, tehnici de achizitie software particulare 7. 1 buc set antene 8. 1 buc Statie de posprocesare 9. 1 buc Set accesorii			
CARACTERISTICI TEHNICE			
1. Magnet superconductiv 1.5 T			
Intensitatea câmpului magnetic: minim 1.5 T			
Apertura gantry la izocentru : minim 60 cm			
Camp de vedere (FOV) de min. 45X45X 45 cm în toate directiile (x,y,z) cu omogeniatate garantata.			
Omogenitatea garantata a câmpului magnetic în interiorul unui volum sferic raportata la valoare sferica a FOV minimal 45 cm DSV: max: 3 ppm garantat,			
Stabilitatea pe termen lung a campului magnetic : maxim 0,1 ppm/h			
Ecranare cu shim activ si/sau pasiv			
Magnet cu ecranare activa impotriva influentelor exterioare			
Rata zero de evaporare a heliului			
Greutatea magnetului (icluzand criogen, electronica si gradient): conform expertiza tehnica anexata documentatiei de atribuire:5.000 kg max.			
2. Sistem de gradienti			
Sistem de bobine gradient cu intensitatea campului de gradient magnetic de min. 30 mT/m pe fiecare axa şi slew rate (SR) de min 100 T/m/s pe fiecare axa indeplinite simultan			
Valoare timp pe secventa SE pentru matrice de 256: max. in 2D: TE			

3.2 ms./ TR 9,6 ms			
Valoare timp pe secventa SE pentru matrice de 256: max. in 3D: TE 4,8 ms./ TR 8,6 ms			
Valoare timp pe secventa TSE pentru matrice de 256: max. in 2D: TE 2,2ms./ TR 9 ms			
Valoare timp pe secventa TSE pentru matrice de 256: max. in 3D: TE 4,8 ms./ TR 8,7 ms			
FOV in intreval min 5 mm- 40 cm			
3. Sistem RF de emisie/receptie			
Amplificator RF digital, racire cu aer sau apa			
Generare și pocesare digitala a semnalului			
Puterea de iesire a amplificatorului RF : minim 12 kW			
Factor de amplificare min 16 ori			
Numar de canale independente receptie : min 32			
4. Masa de pacient			
Greutatea maxima a pacientului (inclusiv în timpul mișcării pe verticală a mesei): min 200 kg			
Inaltimea reglabila in plan vertical posibila a mesei de pacient cat mai mare: precizati			
Viteza de deplasare blat masa: precizati			
Actionare automata verticala si logitudinala			
Domeniu de scanare pe orizontala: minim 140 cm			
5.Consola pentru achizitie și reconstructie			
Computer achizitie:			
-Procesor multicore sau echivalent, RAM: minim 16 GB, Hard disk: minim 200 GB, min 250,000 imagini stocate direct cu matrice 256x256			
-Stocarea imaginilor în format DICOM utilizand medii portabile: ex.: DVD-RW			
- Afisare de imagini pe monitor LCD color de inalta rezolutie: min.23 inch			
Computer reconstructie:			
- Procesor multicore sau echivalent, RAM : minim 32 GB			
- Viteza de reconstructie imagini: minim 10 000 imagini recon/sec, la FOV maxim, matrice 256x256			
6. Set aplicatii Clinice complete definitive pentru: scanare, ajustare parametriilor , reducerea anxietati, setarea parametri de scanare, tehnici de achizitie generale și corectie miscare, tehnici de achizitii software particulare			
Tehnologie de achizitie in paralel bazata pe imagine			
Tehnologie de achizitie in paralel bazata pe spatiul k			

Tehnologie de achizitie in paralel simultan in doua directii, aplicabila si in imagistica 3D abdominala			
Tehnologia de achizitie in paralel sa fie compatibila cu toate bobinele multi-element solicitate			
Asistenta software pentru utilizator pentru optimizarea setarilor de achizitie paralela			
Corectie de miscare cu lamele radiale:			
- compatibila cu achizitia paralela			
- regiuni de examinare: minim cap, coloana, abdomen, imagistica ortopedica			
- contraste posibile: minim T1, T2, FLAIR/Dark Fluid			
- disponibila in toate planurile, cu toate bobinele oferite			
Detectia si corectia miscarii (datorate respiratiei) a cel putin inimii si ficatului pentru secvente 2D si 3D de inalta rezolutie cu respiratie libera			
Reducerea artefactelor de susceptibilitate cauzate de implanturile metalice ortopedice compatibile RMN			
Detectarea autómata a pozitiei si orientarii bobinelor si indicarea lor pe interfata grafica de utilizator			
Detectarea automata si selectarea tuturor elementelor de bobina din campul de vedere (FOV activ)			
Compunerea automata a imaginilor pentru FOV extins			
Asistenta la scanare in cazul conflictelor intre parametri si indicarea unei solutii pentru rezolvarea acestor conflicte			
Imagistica de difuzie de inalta rezolutie, insensibila la efectele de susceptibilitate, inclusiv cu zgomot scazut pentru minim: prostata, cap, coloana			
Posibilitatea planificarii mai multor statii de achizitie (FOV extins) de la inceput, pe imaginile compuse ale localizatorului			
Compunerea manuala de imagini:			
-algoritme dedicate de compunere pentru minim: coloana si angiografie			
-masuratori de distante si unghiuri pe imaginea compusa			
Cuantificare flux:			
-cuantificare non-invazicva a fluxului sanguin si al celui crebrospinal			
- contrast de faza triggerat ECG cu suport de achizitie in paralel			
Harti parametrice, minim T1, T2 si R2, pentru imagisitia tesuturilor, minim: cartilagii,ficat, rinichi, prostata			
Functii DICOM complete: Send/Receive, Querry/Retrieve, Basic Print, Worklist, Storage Commitment, MPPS, raport structurat DICOM			
Posibilitate de schimb de date de protocol (ex.via internet) obtinute automat din imagini			