Explaining variability in surgical decision-making:

Developing qualitative and quantitative models to characterize surgeons' choice of treatments

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Abstract

Surgeons commonly face situations in which they must be ready to make a decision. Their expertise and capability, both obtained by surgical training and experience, as well as guidelines, guide them in the decision making process. Nevertheless, evidence reported in the literature points out for a large and unexplained variability in surgical decision making, even in areas in which scientific evidence exist. In some contexts, such as for the treatment of acute cholecystitis, there is a lack of evidence and tools to assist doctors in their decisions.

This thesis develops and applies multicriteria methods to explore how surgeons make decisions concerning the treatment of acute cholecystitis patients, as well as constructs a decision support model to assist surgeons in the choice of treatment. A multimethodology based on the MACBETH approach is built to meet those objectives. It starts by using exploratory interviews to understand and structure the multiple factors that surgeons consider in the evaluation of patients and in treatments' choice. Then, making use of a web-based platform that makes MACBETH based questions, it is constructed an individual model that captures the views of each one of ten surgeons from Hospital de Santa Maria in Lisbon. Then all surgeons are set to participate in a decision conference and a MACBETH group model is built.

With the application of this multimethodology, we could explore the variability across surgeons' views, the convergence towards a group model and, based on the group model, to build a decision support model to assist them in future surgical decisions. Results shows that, despite giving different qualitative judgments, most of surgeons end up evaluating the patient state in a similar way, which generates similar results in the different models; regarding the decision support model, there was agreement by the surgeons, however, work needs to be done to have the information that the model needs to evaluate the patient state according to each way of treatment.

Keywords: Surgical Decision Making; Variability; Acute Cholecystitis; Decision Support Model; MACBETH.

Resumo

Os cirurgiões enfrentam constantemente situações em que têm de estar prontos para tomar uma decisão. As suas capacidades e perícia, obtidas pela instrução e experiência, tal como as diretrizes existentes orientam-no na tomada de decisão. Ainda assim, a literatura demonstra a existência de bastante e indesejada variabilidade na tomada de decisão em cirurgia, mesmo em áreas com evidência científica disponível. Em alguns contextos, tal como o tratamento da colecistite aguda, há falta de evidência e ferramentas que apoiem os médicos nas decisões.

Esta tese desenvolve e aplica métodos multicritério para explorar a forma como os cirurgiões tomam decisões em pacientes que necessitam de um tratamento de colecistite aguda, além disso, constrói um modelo de apoio à decisão para auxiliar os médicos nesta escolha de tratamento. Uma multimetodologia baseada na abordagem MACBETH é construída para alcançar estes objetivos. Começa-se por usar entrevistas exploratórias para perceber e estruturar os múltiplos fatores que os cirurgiões consideram na avaliação de pacientes e na escolha de tratamentos. Depois, usando uma plataforma *web* com questões baseadas na abordagem MACBETH, é construído um modelo individual que captura a opinião de cada um de dez cirurgiões do Hospital de Santa Maria em Lisboa. Todos os cirurgiões são depois reunidos numa conferência de decisão e um modelo MACBETH de grupo é criado.

Com a aplicação da multimetodologia foi possível explorar a variabilidade entre as opiniões dos cirurgiões, a sua convergência em relação ao modelo de grupo e, baseado no modelo de grupo, construir um modelo de apoio à decisão para auxiliar nas futuras decisões cirúrgicas. Os resultados demonstram que, apesar dos diferentes julgamentos de atratividade dados, a maioria dos cirurgiões acaba por avaliar o paciente de forma similar, o que gera resultados semelhantes nos diferentes modelos; em relação ao modelo de apoio à decisão criado, notou-se concordância por parte dos cirurgiões, no entanto, trabalho tem de ser feito para obter a informação que o modelo necessita para avaliar o paciente de acordo com cada opção de tratamento.

Palavras-Chave: Tomada de Decisão Cirúrgica; Variabilidade; Colecistite Aguda; Modelo de Apoio à Decisão; MACBETH.

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Abbreviations

AAC – Acute Acalculous Cholecystitis;

ACC – Acute Calculous Cholecystitis;

AHP – Analytical Hierarchy Process;

DMII – Diabetes Mellitus Type II;

ELC – Early Laparoscopic Cholecystitis;

EOS – Early-Onset Scoliosis;

ILC – Interval Laparoscopic Cholecystitis;

MACBETH – Measuring Attractiveness through a Categorical Based Evaluation Technique;

MCDA – Multicriteria Decision Analysis;

OA – Osteoarthritis;

TKA – Total Knee Arthroplasty;

USA – United States of America.

1. Introduction

Surgeons must be always prepared to make a decision. They are expected to have the capacity of making good decisions, i.e., they are expected to choose the procedure that solve the problem of the patient, to perform it at the right time, and to perform it well. But how do they make a decision? How do they choose what to do in a situation?

There are four strategies mostly followed by surgeons to make a decision: intuitive, rule-based, analytical and creative. Intuitive is when the answer is immediate, being this capacity improved with their experience; rule-based happens when a standard procedure is followed, often used by the novices; analytical is when there are several options remembered and the doctor decides what he thinks it is the best to the situation and creative strategy occurs when the doctor creates a solution. Intuitive and rule-based strategies are the most used in surgical decision making.

Additionally, to instruct themselves with all the possibilities, doctors have access to the scientific updates. The medicine area is always an interesting study object and there is always something to explore and discover. Scientific data are always updating and doctors can access that data.

Nevertheless, despite the known strategies of thinking and the access doctors have to the more recent scientific evidence, there is a lot of variability in surgical decision making and it exists not only in the cases where the evidence is low, but also when there is scientific data available on the subject. Variability occurs when similar patients receive different treatments depending on the doctor, the demographic region or the period of time they are treated but it is defined as unwanted when it is not explained by patients' preferences [1].

Even with the known strategies, the decision making process is not so linear, surgeons remember different situations and their experience can be considerably different, which contributes a lot to their way of thinking. Besides that, there are factors that affect their decision making capacity and that can also trigger the variability such as fatigue, sleep deprivation, stress or biases, which all human beings are exposed [2].

The procedures that present more variability are the preference-sensitive care procedures, which are the ones that imply serious trade-offs to the patient, affecting his quality and length of life. The variability in this procedures occurs either by the doctor beliefs about the effectiveness of the procedures or by how the doctor includes the patient preferences.

In the surgery field, it was already demonstrated that surgeons' opinions influence a lot the decision making process: 70% of the times surgeons choose a treatment according to their preferences instead of looking to the circumstances [3]. Thus, this thesis aims to observe the variability in surgical decision making as a consequence of the different opinions of the surgeons.

A specific disease, acute cholecystitis, will be used to illustrate how surgeons evaluate their patients state, which is the basic information used to choose a treatment. Acute cholecystitis was chosen because of the controversy that exists worldwide in the choice of treatment for patients with more than 72 hours of symptoms. Basically, there are two main ways of treatment, while in one the patient has a surgery with the tissues inflamed, which is associated with more technical difficulties, in the other there is a waiting time for the tissues to calm down before the surgery, with the patient treated with antibiotics,

and during this time complications can occur leading to a surgery with the body in a worst state. There is not an optimal choice.

Merging the lack of consistency in the treatment choice for this disease with the interest of studying the variability, this thesis intends to understand how surgeons make decisions concerning the treatment of acute cholecystitis, applying multicriteria methods, as well as constructs a decision support model to assist surgeons in this decision. The methods will be applied to a group of ten surgeons of Hospital de Santa Maria, individually, and then as a group. This way, it could be possible the exploration of the variability between the opinions, either individually or between each surgeon and the group and, at the same time, the model of the group provides a decision support model that can be a useful tool to the hospital.

During this work, first, a literature review was made to understand the disease and its possibilities of treatment and see the reason why there is not a standard measure for the patients. As this treatment choice was mentioned in first meetings in the hospital as a decision with several areas of concern, multicriteria decision analysis in healthcare was also reviewed.

Then, the proposed multimethodology to obtain the models according to the surgeons, individually and in group, for the exploration of the variability and the development of a decision support model for the hospital was planned. The models are multicriteria and their development followed the MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) approach.

The multimethodology involves first the structuring of all the models, since individual and group models will have the same structure to be comparable. For this phase, exploratory interviews with all the surgeons, individually, will be made to explore the decision context and all the needed information for the structuring itself.

Then, the individual models will be made first, for the surgeons not to be influenced by the other opinions. To develop the individual models, a web-based platform will be implemented with MACBETH based questions to obtain all the needed information about the individual opinions of the surgeons.

The compromise model for the group is then developed. This development will also need information about the opinion of the surgeons, but this time it is a group opinion. For that, a decision conference will be made, creating the model on-the-spot.

These steps allow the accomplishment of the objectives since the individual and the compromise models can be used for comparisons, observing its differences and exploring the variability associated with the opinions of the surgeons, and the compromise model can also be used as the decision support model for the hospital. The decision support model supports the decision of the treatment for acute cholecystitis because it will evaluate the patient state according to the expected outcomes of each treatment and consequently it can be seen how much a treatment is beneficial for a specific patient, providing the doctor the information of which treatment contributes in a more positive way for the quality of life of the patient.

Regarding this document, besides this introductory chapter, it is divided in six more chapters. In chapter 2 it is presented the context of the decision: how do surgeons make decisions, how that leads to variability and how can the unwanted variability be decreased. Chapter 3 is the literature review and in this chapter the acute cholecystitis is explained, as well as its options of treatment. The variability

studies in health in literature are mentioned and the multicriteria decision analysis in healthcare is explored. Chapter 4 is dedicated to the methodology and application of the methods of this thesis. The results are presented in chapter 5 and the discussion in chapter 6. Chapter 7 is dedicated to the conclusions and future work.

2. Context

2.1. Surgical Decision Making

The ability to operate and the capacity to make good surgical decisions are essential qualities in every surgeon. Surgeons must choose the right procedure, the right time to do it and do it well. These are characteristics that everyone expects in a surgeon and, in fact, they can be improved: repeating procedures, receiving feedback and updating skills will be reflected in the surgeon's dexterity and through learning, experience and reflection their decision making capacity can be improved, as well [2].

Surgeons repeatedly face situations in which they must be ready to make a decision. In the operating room, for example, they have to be prepared to decide whether the situation is familiar, with common problems, or whether it is an unexpected event thus, they must be able, in the moment, to make a decision under uncertainty and deal with situations they have never dealt before. To do that, they have to be well informed about their patient condition, biomedical and non-biomedical data and the events of the patient history that can be related with his disorder [2]. These factors combined with the surgeon's expertise and capability, both obtained by surgical training, experience and feedback, will guide the decision making in the surgery field [2].

Surgeons make decisions through four different strategies: intuitive, rule-based, analytical or creative. In the intuitive strategy, the situation and the answer are quickly recalled, being this strategy improved with the surgeon's experience. The rule-based strategy occurs when the surgeon applies a standard procedure, remembered or looked up, and it is often used by the novices. The analytical strategy is also named option comparisons because the surgeon evaluates a certain number of reminded possibilities and decides the best according to the situation. And, finally, the creative strategy occurs when the situation is a new one and the doctor has to come up with an innovative solution, which is barely used in situations of high time pressure and risk [4]. According to these strategies, Flin *et al.* presented a naturalistic model, which has two steps: assess the situation and making a decision, presented in figure 1. Naturalistic decision making is an approach where the decision makers are studied in operational environment, the operating room in this case, and it is expected to obtain a description of how they make decisions in risky situations [4].

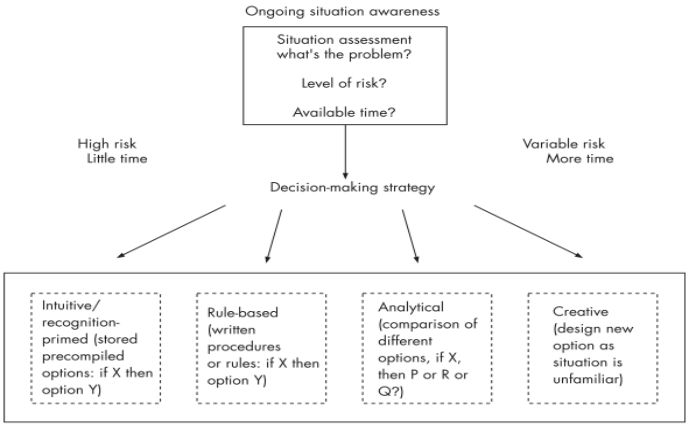


Figure 1. Naturalistic model of intraoperative decision making [4].

There are more studies focused on surgical decision making in nonroutine situations, i.e., focused on intraoperative decision making. These studies follow and show evidence of, mainly, three different approaches: (1) the possibility of decompose and identify decision making steps and influences for a certain procedure, (2) the predominance of intuitive and analytic strategies, and (3) the existence of a "cognitive shift" when surgeons foresee a challenge, that is, a "slowing down" moment as a response of an unexpected occurrence [5]. With all these facts established by previous research, Cristancho *et al.* sought to enrich information on how surgeons perceive and solve a situation, providing a naturalistic model based on surgeons' behaviours and their reflections, after the surgery, describing their actions [5]. The model shows that the surgeons begin surgeries with a planned course of action (CoA, in figure 2), which is continuously assessed. It is a cycle, so, the course of action can be referred not only to the planned before the surgery but also to each minor phase of the operation [5].

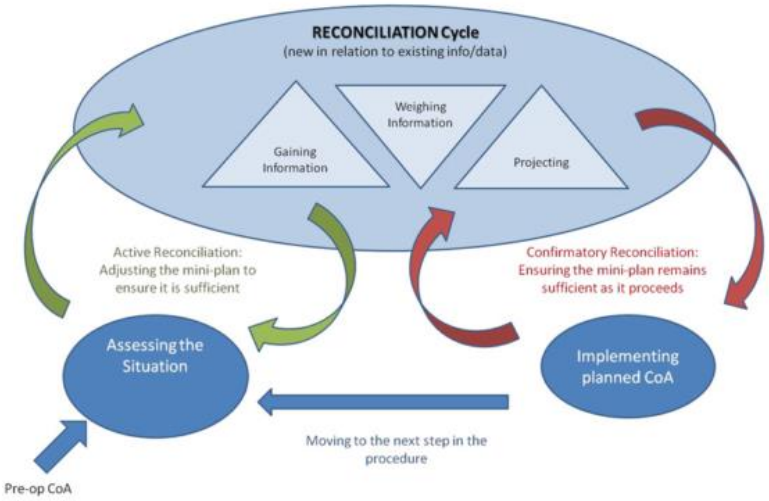


Figure 2. Naturalistic model provided by Cristancho et al.[5]

Despite of the training that surgeons receive in his lifetime and the attempts to understand how surgical decision making is made, surgeons have not the same cases, the same operating room conditions or even the same thinking. Thus, when they make a decision they recall different events and think differently providing sometimes a solution that can vary from surgeon to surgeon. There are, also, other factors that affect the decision making capacity, providing a different result between surgeons and even within the same surgeon to different situations, such as fatigue, sleep deprivation, mood, illness and stress, which can be raised by time pressure, for example [2]. The biases that a surgeon can follow, as a human being, together with these aspects can contribute to trigger the clinical practice variability.

2.2. Variability

Variability was first pointed out by James Alison Glover, a British paediatrician, in the 1930s. He observed an increase in the variation of tonsillectomy (operation for tonsillitis) rates in children of a

school area, despite of not existing significant difference in tonsillitis. Glover found that a single physician was responsible for the medical choices. With the arrival of another physician at the school, the tonsillectomy rates there fell and stayed low for years. Then, Glover concluded that the difference in rates was due to different "medical opinion" instigated by the two different doctors [6][7].

Despite not having a standardized definition, P. Kennedy *et al.* gave to the clinical practice variation the following definition: "patients with similar diagnoses, prognoses and demographic status receive different levels of care depending on when, where and by whom they are treated, despite agreed and documented evidence of "best practice"". The variability is difficult to quantify but it is known that what is considered effective is not always what occurs in practice. Dartmouth Medical School showed that 30% to 40% of regional Americans receive care inconsistent with recent evidence, many times care reveals "clinician or organizational preference, not patient needs", and 20% to 25% of care is not necessary, being, sometimes, harmful [1]. Regarding surgical rate, variations between observed and expected rates are presented in figure 3, below, where it is possible to see it for different procedures among hospital regions, in the United States. The main reason pointed for this regional variation was the different physicians' opinions indicating for surgery [8][9].

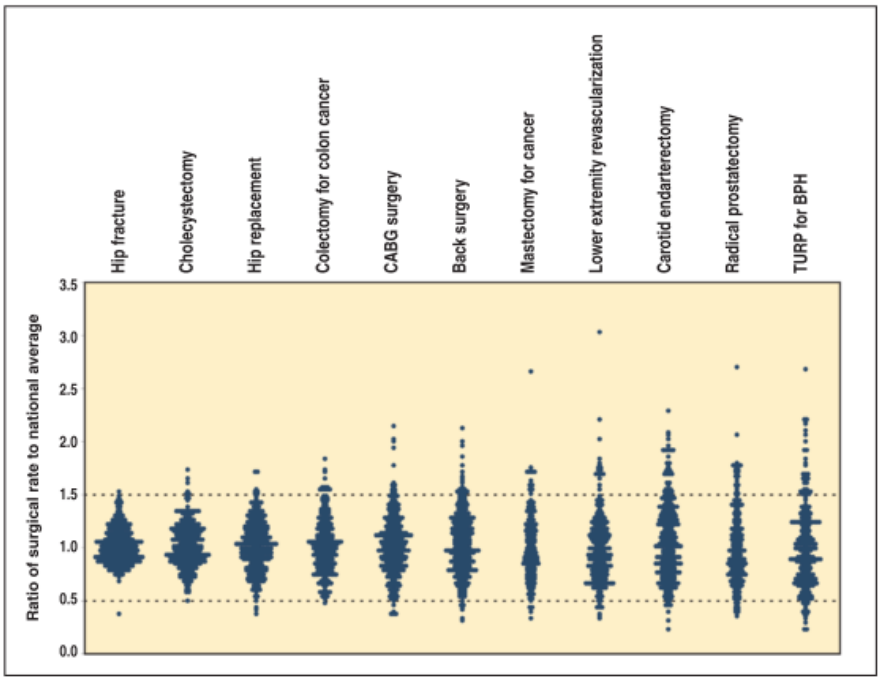


Figure 3. Variation profiles of 11 surgical procedures among hospital regions, in the United States. Each point represents the ratio of observed to expected. [8].

Over the past years, it was seen that variability is more frequent in procedures that involve significant trade-offs to the patient, affecting his quality and/or his length of life. These procedures are defined as preference-sensitive care and they are the ones that present more disagreement in the decision making in both diagnosis and treatment [10][6]. The disagreement is shown by, first, the surgeon beliefs: they diverge about the strategies that are optimal to a certain case and about the effectiveness of surgery; and second the patient preferences: the importance, and consequently the

level of inclusion, that the surgeon gives to them [10][9]. The patient's behaviour or the disease burden are not so much dominant in the variability [4].

Decisions in preference-sensitive care must reflect patients' preferences and, to make that possible, patients must have enough information and understanding on their situation [6]. For example, we can look at early stage breast cancer. In this type of cancer there are two main surgical treatment options that a person can be submitted: mastectomy and lumpectomy. The first is the absolute removal of the breast and the second is a local excision of the tumour that can include radiation and/or chemotherapy. Both approaches present about the same impact on survival, however, they also have other outcomes that are quite different. While a mastectomy involve the loss of the breast and possible prosthesis, the lumpectomy is associated with a risk of recurrence [6]. These consequences can affect women in a different way. Psychologically, while for some women the risk of recurrence is worse than the loss of the breast, for others it is not, and the aesthetic impact would bring more harm to their health. Nevertheless, it was suggested by the *Dartmouth Atlas of Health Care* that the variations in rates of the decisions in preference-sensitive care procedures are intensely influenced by local medical opinion and this opinion is not always the same as the one that a well-informed patient would have [6].

The influence of local medical opinion can be seen, for example and using the breast cancer cases, in the variation of the number of women undergoing lumpectomy in different regions in the United States. In a study in the 1990s, regions were found with no lumpectomy cases reported and, at the same time, regions where this procedure was selected in 50% of the cases, being some of this huge differences in adjacent regions. This brought curiosity, and even with arguments defending that this variation was due to patients' preferences, an investigative report visited Rapid City, where lumpectomy was the choice in only 1% of the women, and discovered that the surgeon there did not offer the option of lumpectomy and defended mastectomies, which enhanced his influence [6].

Many other studies have been made concerning variability. In 2007 it was shown that some characteristics of surgeons end in different outcomes for the patient. For example, regarding the number of procedures already made by the surgeon, it was noted an association between higher number of performed procedures and better outcomes for interventions like esophagectomy and pancreatic cancer surgery [11]. The number of performed procedures will be noticed in a surgeon expertise, due to the learning associated with the experience, and he also tends to follow an approach according more to his training and preference than to the compared effectiveness of the intervention [9]. So, additionally to the surgeons' different background on their instruction, their personalities also result in diverse decisions, deciding 70% of the times according to their favourite strategies while the circumstances influence only the rest 30% [3]. This leads to a considerable variation between regions, hospitals and even surgeons in the same hospital [9].

This surgeon preference is based on his recognition of patterns, according to his experience, but it can also be interfered with bias related to lack of information [12]. Despite of variability in practice being a common phenomenon even with agreed guidelines, the existence of evidence-based guidelines, frequently revisited, is believed to minimize the effects of surgeons' individual preference, without taking his independence, and allows a major focus on the patient [1][12].

2.3. Decreasing Unwanted Variation

F. Hajjaj *et al.* reviewed non-clinical influences on clinical decision making. They defend that non-clinical influences, presented in figure 4, must be identified to be considered in surgical decision otherwise these influences can lead to "sub-optimal decision-taking". The decision making process is something that physicians can be taught, during their training, allowing them to become more alert to these influences and choose more consistent paths and, also, more directed to their patients' interests, increasing the equality of treatment [13].

Examples of non-clinical influences on clinical decision-making
Patient-related factors
Patient's socioeconomic status
Patient's race
Patient's age, gender and other personal characteristics
Patient's adherence to treatment or inappropriate behaviour that may influence adherence (e.g. chaotic life style, frequent non-attendance for follow-up appointments)
Patient's wishes and preferences
Patient's attitude and behaviour
Patient's concerns and worries (medical and non-medical concerns)
Others: Influences of patient's family members and friends, faith, culture and quality of life
Physician-related factors
Physician's personal characteristics, age, gender, culture, faith and race
Physician's time constraints and work overload in the clinic
Physician's professional interaction; e.g. relationship with colleagues, hospital staff and with pharmaceutical industry
Practice-related factors
Type of practice (e.g. private vs public)
Size of practice, practice organization, geographical location, and availability of health resources
Management policies/implication of treatment cost

Figure 4. Non-clinical influences on clinical decision making. [13].

Nevertheless, to reduce unwanted variation, the most common measure is the development and implementation of guidelines, evidence-based paths and protocols. The implementation is not so simple because they have to provide an easy usage and doctors have to believe that the materials are appropriate to the situation. Some surgeons' common thinking, pointed out by P. Kennedy *et al.*, is that guidelines don't bring new information, just reinforce the methods already used, or that there is no need of learning new methods if the existing ones are enough to solve the problem. So, informing clinicians and involving them in the development and implementation processes are considered the best ways for them to recognize and use the materials [1].

Involving doctors in processes is associated with a personal level, but the organizational level of the hospital and the teaching system have influence in variation, too. So, to decrease the unwanted variation, efforts cannot be focused on just one level [1].

Decreasing the variation, a more standardized way of acting is achieved. A recent research identified standardization as one of the best practices in high-performing health systems in the United States. Besides, the reduction of the variation was also identified as important for the quality and safety dimensions, once it allows a decrease of mortality and morbidity and a more patient-focused care. Thus, increasing quality, safety and standardization of the procedures, greater efficiency can be reached [1].

Tracking patient outcomes was proven, by *The Dartmouth Atlas of Health Care*, to be also an effective approach to reduce variation in surgical treatments and it is easier nowadays with the development of technology than when the information was in paper records. Figure 5 allows the observation of the influence of information and uncertainty in the variation of the decisions. Shared decision making is another strategy that can decrease the variation, increase patient satisfaction and provide better outcomes. It allows the patient to really understand the situation, taking his preferences into the decision, avoiding him to be so influenced by the doctor individual opinion [8].

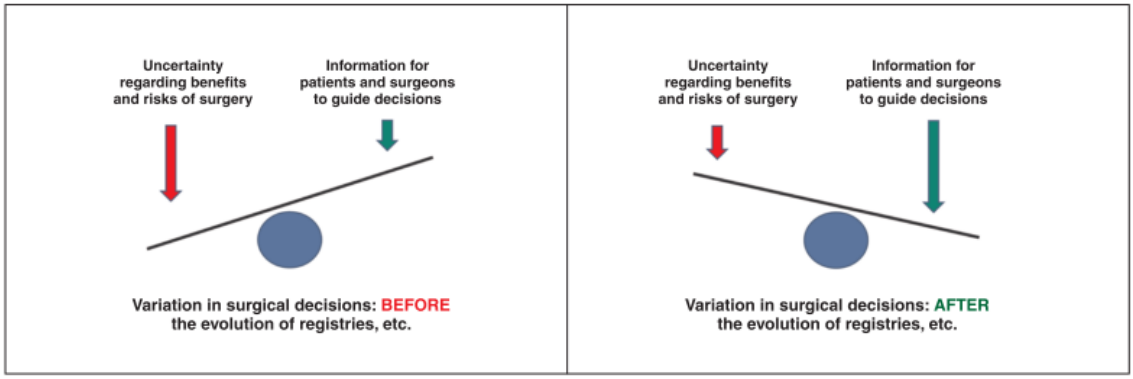


Figure 5. Information and uncertainty affecting variation in surgical care [8].

This thesis aims to study the variability in surgical decision making caused by surgeons' different opinions. Since the standardization of the procedures is a mean to reach efficiency, observing if individual opinions converge to the same solution is also a motivating subject to explore. To do that, it is interesting to use a specific case, a disease, and see how surgeons think and what they want to achieve when selecting a treatment option. Acute cholecystitis is a disease where controversy remains when choosing the right time to operate, so, it proved to be interesting to use it as a practical case. The next chapter is dedicated to learn a bit more of acute cholecystitis condition and its treatment's options as well as to explore the literature about variability and muticriteria decision analysis in healthcare.

3. Literature Review

Acute cholecystitis disease and its treatment options will be used in this thesis to illustrate how surgeons make decisions, how different are their opinions and how can a decision support tool be developed. Thus, this chapter provides an explanation of this disease and a review on the treatment choice issue.

Having the support of Hospital de Santa Maria's surgeons, it was perceptible, in preliminary meetings, that this is an innovative subject to explore especially for the cases of patients with symptoms for more than 72 hours because there is not so much literature focusing on these cases and the one available has much controversy associated. It was also perceptible that this decision brings concerns at several levels to the surgeons, so, here it is also reviewed the use of multicriteria decision analysis in healthcare for investigate the possibility of collapse all the surgeons multiple concerns about the result of the treatment choice in an overall score that translates its benefit for the patient.

Databases as Google Scholar, PubMed, B-on and ScienceDirect were searched for this literature review using expressions as *Surgical Decision Making*, *Choice of a Treatment*, *Multicriteria Models*, *MACBETH*, *Acute Cholecystitis*, *Variability* and its combinations.

3.1. Acute Cholecystitis

The gallbladder (figure 6 [14]) is the organ that stores temporarily the bile, after its production in the liver, and then releases it into the small intestine, where it helps the fat digestion. Due to the saturation of the bile with cholesterol and bilirubin, gallstones can be developed in the gallbladder, known as cholelithiasis, which affects about 5% to 25% of the population [15][16].

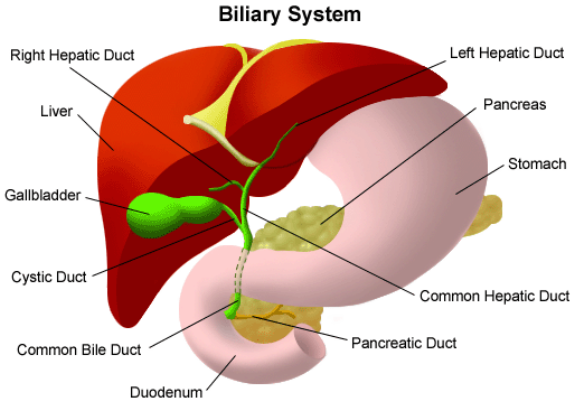


Figure 6. Biliary System [14].

Most cholelithiasis cases are asymptomatic, annually only 1% to 4% become symptomatic, and the symptoms can involve pain (biliary colic), obstruction of the bile's flow from the liver and gallbladder into the small intestine (obstructive jaundice – seen for example in the yellowish decolourisation of the body), bile infection (cholangitis), inflammation of the pancreas or inflammation of the gallbladder,

denominated cholecystitis, which can occur also as a consequence of the other symptoms (for example, it can occur in about 20% of the biliary colic cases by itself) [15][17][18].

Acute cholecystitis episodes cause intense pain and fever and occur, more frequently (95% of the times), after an obstruction of the cystic duct with gallstones and consequent gallbladder chemical or bacterial inflammation [16][18]. The cases associated with gallstones, i.e., associated with cholelithiasis are named acute calculous cholecystitis (ACC). However, about 5% of acute cholecystitis cases are not associated with cholelithiasis, it can be associated to conditions such as HIV or diabetes or, rarely, to tumours of the gallbladder, and are denominated as acute acalculous cholecystitis cases (AAC) [18]. Comparing AAC with ACC cases, the previous ones are more abrupt and are associated with "significantly higher morbidity and mortality" [19]. The latter cases, ACC cases, occur three times more in women than in men up to the age of 50 years. Then, occur about one and a half times more in women than in men [18].

The risk factors of this condition are the gender (females have more risk), the older age, being pregnant, being subjected to a hormone therapy, obesity, fast alterations of weight, diabetes (as said before) and being Native American or Hispanic [20].

The next section will explore the possible treatments that a person can be submitted, when having an acute cholecystitis crisis.

3.1.1. Acute Cholecystitis Treatment

Acute cholecystitis is one of the most common acute abdomen diseases in emergency room being its preferred treatment the removal of the gallbladder, named cholecystectomy [16]. In the UK, 60 000 cholecystectomies are performed annually, being 13 000 resulted by acute cholecystitis events [15]. In the United States, also per year, 120 000 cholecystectomies are performed due to cholecystitis cases [17].

Over time, acute cholecystitis cases had different treatment approaches. In 1882, Carl Langebuch, a German surgeon, performed the first open cholecystectomy [21][22]. Then, until the 1970s, the typical treatment was the inflammation control, as a first step, and only then an elective (planned, scheduled in advance) open cholecystectomy, 4 to 6 weeks later. However, many times complications occurred in this waiting time, leading to the earlier surgeries exploration. Early open cholecystectomies started to take place, after the 1970s, and rapidly became the treatment of choice, until the 1990s, and besides the complications' minimization it also revealed shorter hospital stay and less pain to the patient [23].

The first laparoscopic cholecystectomy was performed on September, 12th of 1985 by Erich Mühe, also a German surgeon, more than 100 years after the first open cholecystectomy [21][22]. Laparoscopic cholecystectomies (scheme in figure 6, [14]), after the 1990s, gradually replaced the open surgeries and became the standard treatment of acute cholecystitis. This happened due to the equipment development and improvement and, consequently, the expertise growth of the surgeons. In Portugal, the laparoscopic surgery was introduced in 1991 [24].

Compared to the open surgery, laparoscopic surgery brought faster patient recovery, even shorter hospital stay, better cosmetic results and a decrease in hospital costs. Nevertheless, 2% to 30% of laparoscopic cholecystectomies are converted to open surgeries due to the technical difficulties brought by the severe inflamed tissues which turns the anatomy unclear [23][25][26]. To avoid this conversion to open surgery due to technical difficulties, sometimes the laparoscopic cholecystectomy is performed after a conservative treatment, which is a period when the patient does antibiotic therapy, allowing the treatment to calm the inflammation first and the surgery takes place only when the body is not in an acute crisis, i.e., when the tissues are not so inflamed. On the other hand, in the time of conservative treatment, complications can occur, leading to urgent surgeries with the tissues still inflamed and with more technical difficulties associated with the urgency. There are, also, some patients who cannot undergo a surgery. For severely ill patients in intensive care and patients who cannot undergo anaesthesia a third approach is recommended, a cholecystostomy (placement of a tube in the gallbladder to drain it, figure 7 [27]) [28][29]. After the drainage, if the patient is feeling better, sometimes he can have a surgery [20].

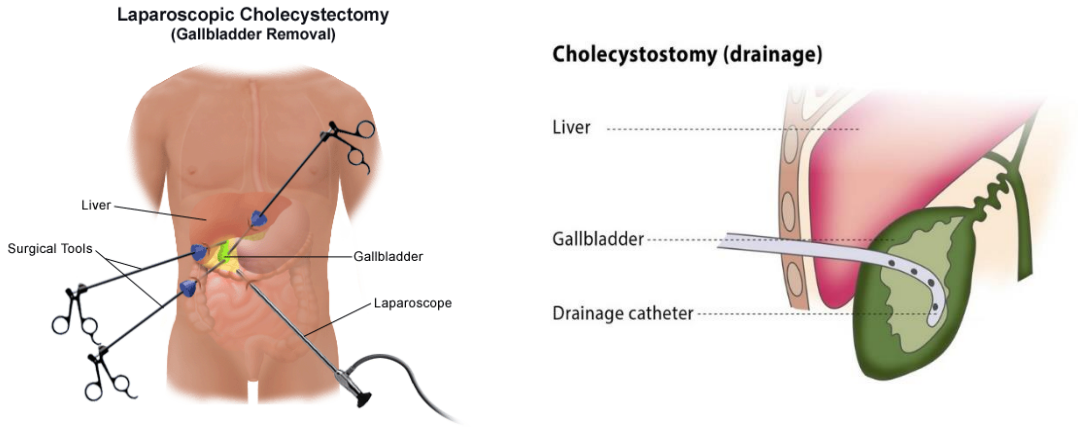


Figure 7. Schemes of laparoscopic cholecystectomy, in the left ([14]*), and of cholecystostomy, drainage of the gallbladder, in the right (*[27]*).*

Summing up, there are two main ways of treatment of acute cholecystitis, excluding the special cases of really ill patients who are recommended to undergo a drainage of the gallbladder (cholecystostomy), which are early laparoscopic cholecystectomy, when the surgery is performed in the acute crisis, in the first hospital admission; and interval laparoscopic cholecystectomy, when the patient undergoes an antibiotic therapy period and his surgery is planned for a period of time after the acute crisis and the antibiotic therapy. These two approaches have pros and cons, while the early approach is performed when the tissues are inflamed which brings more difficulties to the surgery, the interval approach has a waiting time that sometimes leads to urgent surgeries, even worst to deal with.

So, nowadays, the main question is when to operate: if immediately or after a conservative treatment, i.e., which way brings more value to the patient quality of life, the early or the interval approach? The next section presents a research on this timing problem, trying to point out what is known and what is not known yet.

3.1.2. Early versus Interval Cholecystectomy

Early laparoscopic cholecystectomy (ELC) and interval laparoscopic cholecystectomy (ILC) are compared in several studies and recent randomized trials had recognised that both approaches are as "safe and effective" [30]. However, controversy remains. The problem is that, although the numerous studies comparing both procedures, there is not a consensual definition of early, many studies involve few patients and antibiotic routine in conservative treatment is not standardized [28]. In a review article, of 2014, the clinical safety and outcomes of these approaches were compared, and it is possible to observe the lack of a consistent definition of early, which in the compared trials varied "from 24 h to 7 days after either the onset of symptoms or the time of diagnosis at hospital admission", presented in table 1 [16].

Table 1. Information of a review article. It is possible to see the lack of consistency when talking about the timing of early surgeries [16].

Study		Participants	Interventions
Review article, 2014 [16] **– Literature Search**	(Gutt et al. 2013)	Adults with acute cholecystitis	2 random groups: -ILC (<24 hours of admission, n=304); -DLC (delayed by 7-45 days, n=314).
	(Yadav et al. 2009)	Adults with acute cholecystitis. Exclusion criteria: (1) symptoms more than one week; (2) common bile duct stones or ductal dilatation; (3) contraindication for laparoscopic surgery; (4) people who refused to undergo laparoscopic surgery.	2 random groups: -ELC (as soon as possible, n=25); -DLC (delayed by 6-8 weeks, n=25).
	(Kolla et al. 2004)	Adults with acute cholecystitis. Exclusion criteria: (1) symptoms more than four days; (2) previous history of upper abdominal surgery; (3) contraindication for laparoscopic surgery; (4) common bile duct stones.	2 random groups: -ELC (<24 hours of randomization, n=27); -DLC (delayed by 6-12 weeks, n=36).
	(Johansson et al. 2003)	Adults with acute cholecystitis. Exclusion criteria: (1) symptoms more than one week; (2) older than 90 years old; (3) bilirubin more than 3.5mg/dL.	2 random groups: -ELC (<7 days of diagnosis, n=74); -DLC (delayed by 6-8 weeks, n=71).
	(Davila et al. 1999)	Adults with acute cholecystitis	2 random groups: -ELC (<7 days of diagnosis, n=27); -DLC (delayed by 2 months, n=36).
	(Lai et al. 1998)	Adults with acute cholecystitis. Exclusion criteria: (1) symptoms more than one week; (2) previous history of upper abdominal surgery; (3) contraindication for laparoscopic surgery; (4) common bile duct stones; (5) acute pancreatitis or acute cholangitis.	2 random groups: -ELC (<24 hours of randomization, n=53); -DLC (delayed by 6-8 weeks, n=36).
	(Lo et al. 1998)	Adults with acute cholecystitis. Exclusion criteria: (1) symptoms more than one week; (2) previous history of upper abdominal surgery; (3) contraindication for surgery; (4) more than three days of admission; (5) uncertainty about diagnosis; (6) peritonitis; (7) pregnancy.	2 random groups: -ELC (<72 hours of admission, n=45); -DLC (delayed by 8-12 weeks, n=36).

Regarding the problem of timing, recent studies tried to define how early should a cholecystectomy be and demonstrated that until 72 hours after the onset of symptoms a

cholecystectomy is safest [26][31]. So, nowadays it is settled that until the 72 hours the surgery is more effective than the conservative treatment, but the problem remains in patients who present symptoms for more than this time.

Tokyo guidelines were made in 2007 [32] concerning the timing and the optimal treatment for acute cholecystitis and were revised in 2013 [33]. Patients were divided by grade of severity: mild, moderate and severe. Having more than 72 hours since the beginning of symptoms is a characteristic to fit in moderate category and this cases don't have a unique optimal treatment, early cholecystectomy is advised however the inflammation can produce technical difficulties and in that case "(…) medical treatment and delayed cholecystectomy are necessary" [32]. Thus, this guidelines do not answer to the problem investigated here: the patients with more than 72 hours of symptoms.

After 72 hours since the onset of symptoms, the gallbladder wall thickening can be a problem so, in one hand, an interval cholecystectomy could be the answer, since its initial conservative treatment could treat the inflammation first but, in the other hand, it is not so simple because complications can occur in the waiting time (failing of the conservative treatment) leading to urgent surgeries, which can be worse than an early surgery with technical difficulties caused by the inflamed tissue [30]. This urgent surgeries happen in 18% of the interval cholecystectomy patients [34]. It is the difficulty after this time that this thesis aims to explore: After 72 hours of the onset of symptoms, which treatment brings more value to a patient, in the surgeons' point of view? The surgery when the patient is admitted to the hospital or the surgery only after the conservative treatment (antibiotic therapy)? It is important not to forget that patients are different and there are co-morbidities that have influence in the result of each way of treatment, so, patients can be grouped in similar cases but it is not possible to use a single patient case to represent them all.

While exploring what would be the procedure with more benefit to each patient, surgeons have to explain their concerns and opinions. Observing first their individual opinions, independently, allows the exploration of the variability between them, and then it is possible to observe if their opinions, even when different, converge to the same recommendations to the patient. Additionally, observing the opinion of the group, it is possible to see how the compromise opinion is different from the individual ones.

3.2. Reporting Variability

The Dartmouth Atlas of Healthcare, in the series "Variation in the Care of Surgical Conditions", is dedicated to the observation of many cases of surgical variability in the United States. Over time, quality in surgical procedures increased but many times there is not enough information about the benefits and the risks of all alternatives because the report of the outcomes differ across hospitals and doctors. Additionally, when and if doctors advise their patients to make a decision, the patients don't fully understand the implications of their choice. As said, the variation in care that are not explained by the patients' preferences or needs is unwarranted and, in this series, it is defended that it reflects both

gaps in outcomes exploration and poor quality in patients' decisions and many times it is explained by the influence of local medical opinion, as mentioned before [8].

To explore the variability, in this series they studied a set of health conditions with a previous structured report. Since the differences in outcomes reporting was defined by them as a problem that contributes to the variation in care, using a structured report they could obtain consistent information to be possible the comparison between treatment alternatives. Their protocol included four sections: the time before, during, after and beyond surgery. Thus, all the challenges in care could be monitored, being possible to observe what situations bring more disagreement, and ways of increasing population's health and decreasing costs could be explored [8].

This section presents two more examples of studies made concerning variability on physicians' recommendations for treatments, to observe how the variability was demonstrated in these cases.

3.2.1. Total Knee Arthroplasty (TKA)

In 2014, L. Fraenkel *et al.* explored the factors influencing physicians' recommendations for using TKA in the treatment of knee osteoarthritis (OA). TKA is considered an effective treatment for knee OA cases and it is one of the most performed procedure in the world. Nevertheless, there is significant differences in the number of TKAs performed across regions and it happens not only due to the patients' preferences or the disease state but also due to unwanted sources of variability such as the patient ethnicity, gender, motivation and the physician's opinion [35].

For the observation of the variability in doctors' opinion, in this study they used composed scenarios of patients and obtained, by an online survey, doctors' recommendations for a TKA, in a scale from 1 to 6, where 1 meant a very strong recommendation for a TKA and 6 a very strong recommendation for not to do it. There were two groups of surgeons, orthopaedic and rheumatologists, and each one completed a random scenario, chosen using a computer generated list of random numbers. The scenarios had a mutual layout, which was a 62 year old person with knee OA with moderate knee pain limiting vigorous activity despite medical management, and they varied only in the patient gender, employment status (business manager versus retired/housewife) and x-ray (mild versus moderate OA), since it was expected to observe the effects of these characteristics on the doctors' opinions [35].

In conclusion, they observed that patient and doctor characteristics had influence on the decision and the different surgeons, orthopaedics and rheumatologists, presented different ways of making a decision. For example, it was observed a gender bias only in the orthopaedic doctors, who, for the same cases, were less likely to recommend a TKA if the patient was a woman. However, it is important to note that this study has the limitation of the composed scenarios not represent the truth complexity of the clinical practice [35].

3.2.2. Early-Onset Scoliosis (EOS)

Vitale et al., in 2011, studied the variability in surgical decision making for treatment of children with EOS. Scoliosis is a deviation of the spine axis and, despite having a set of treatment options, there is not a most appropriate one [36].

For the observation of the variability, thirteen experienced spine surgeons submitted, electronically, a case of EOS and they were presented with twelve cases, all cases except the one they submitted. They were asked, and the variability was assessed, about four areas: choosing type of treatment, choosing type of construct, choosing construct location, and saying whether a thoracotomy (a procedure to access the thoracic organs) should be executed. Six months later, surgeons gave a second set of responses, following the same instructions. The results were analysed descriptively and using a software of statistical analysis [36].

In the second assessment, some recommendations of the surgeons changed. The study contributed to demonstrate the surgical variability, as intended. As it happens with many other studies, this study exhibits the importance of the development of strategies to help surgeons decide in a more standardized way, especially in diseases that don't have an optimal treatment, as in the EOS cases [36].

As seen in these studies, there is a particular interest in the study of the variability resultant of doctors' different opinions. Additionally, the standardization of the procedures seems to be a curious subject to explore. The next section searches the use of multicriteria decision analysis in healthcare, which can be a useful way of observing opinions and develop a more standardize way of acting.

3.3. Multicriteria Decision Analysis (MCDA) in Healthcare

Since the surgeons mentioned that deciding the treatment in acute cholecystitis patients has several concerns and dimensions to evaluate, the possibility of collapsing all the dimensions in a score that evaluates how beneficial is the treatment seems to be a suitable approach to follow. MCDA approach allows obtaining a score that translates the overall value of an option, providing an ordering of the options' set [37][38]. In 1976, Keeney and Raiffa were the first ones to completely expose MCDA using decision trees to settle multi-attributed consequences [38].

In 2014, G. Adunlin *et al.* conducted a systematic review and bibliometric analysis about MCDA in healthcare. It included English language studies since January 1, 1980, until October 1, 2013. For this period of time, electronic databases were accessed and conference proceedings were hand searched for the investigation. MCDA was noted as one of the most often used approaches in decision making and it has been applied in several areas, with success, being recognised as a big potential approach for improving and supporting decisions in health. Its potential is characterized by its capacity to turn the decision process more "explicit, rational and efficient". This systematic review differentiates itself because it tries to include all the MCDA techniques and not only focus in a specific one. To be included in the review, the studies had to describe the used MCDA method, to answer a health related problem and to explicit the stakeholders' preferences and/or values. The review included 66

publications, and it is possible to see the number of studies per year, in the graph presented in figure 8, below [39].

This review has some limitations: it is possible that it does not include all the publications, because it only included English language studies and some could have not been identified; there is not a standard report for the included studies, which affects the quality of the review; and some publications could have bias. Nevertheless, it has a more strict and clear approach for reviewing and it has larger time frame than previous reviews [39].

Previous studies had emphasized that the application of these techniques could improve the decision making, which was confirmed by this review. Moreover, the number of studies over the years reveals the growth of MCDA in healthcare area [39].

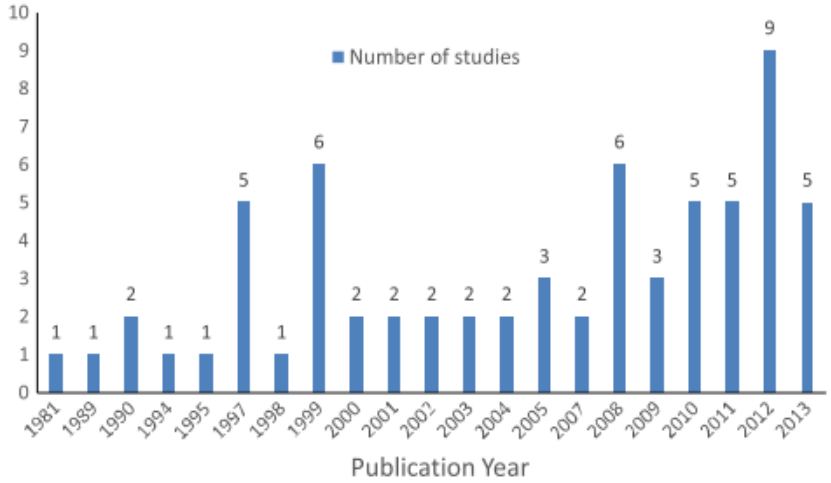


Figure 8. Number of publications included in the systematic review per year of publication [39].

The most used technique recognized in the studies was Analytic Hierarchy Process (AHP), the top area of application was “Diagnosis and Treatment” (39% of the studies), cancer was the most researched issue and the country with more studies was the USA (United States of America) [39]. Despite AHP technique being used in several studies it is criticised by several studies. One of the criticisms, presented by C. Bana e Costa and J. C. Vansnick, is that it violates the “Condition of Order Preservation”, which defends that in a set of alternatives the order of preference must be preserved as well as the order of intensity of preference [40].

MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) is another approach of MCDA. It is, according to C. Bana e Costa, an “humanistic, interactive and constructive approach” and it allows building a quantitative model based on qualitative judgements of difference of attractiveness [41]. Expressing the preference judgments numerically was already characterised as difficult and cognitively uneasy [42], so the possibility of obtaining a quantitative model based on qualitative preference judgments is an impressive characteristic of this approach.

Typically, this approach starts by a structuring phase where the problem context is explored, defining the multiple criteria of the decision and their descriptors of performance. The descriptors of

performance allows to turn the criteria comprehensible, providing a performance scale that allows to characterize an option's performance on each criterion. The performance scales are then converted to value scales by comparing the levels, two at a time, and collecting qualitative judgments about their differences of attractiveness. When comparing the levels, the qualitative judgments are asked to be given according to a set of categories: no (when the levels are equally attractive), very weak, weak, moderate, strong, very strong and extreme; being allowed hesitation between more than one consecutive categories. When some judgment is given, the consistency of all the judgments collected until then is verified and if there are inconsistent judgments suggestions are made to correct it [42][43].

After building all the value scales, the criteria weights are also obtained considering qualitative preference judgments. The value scales have always two reference levels, 0 and 100, and improvements on all the criteria, between these reference levels, are compared, ranked and its attractiveness is classified in a MACBETH category providing the weights to the criteria [43].

MACBETH approach was already used in several studies in the healthcare context in matters such as hospital auditing [42], prioritization of community care programmes [44], evaluation of health and safety risks [45], planning of decisions in long-term care [46] or assisting in the diagnosis of Alzheimer's disease [47].

3.3.1. MCDA in Surgical Decision Making

In the healthcare area, MCDA techniques are used to several ends, such as new technologies' evaluation, incorporation of stakeholder preferences, resource allocation, prioritization of investments and evaluation of new drugs.

However, considering what is intended in this thesis, there are not so much examples to report using a MCDA technique to evaluate treatment options. A comparison was made between AHP and Conjoint Analysis to observe the differences in detecting patient preferences for treatment alternatives for stroke rehabilitation by surveying the patients using questions according to the two methods [48]. Nevertheless, patient preferences are not the purpose of this thesis.

Evaluating treatment options considering the impact to the patient quality of life, in the surgeons' points of view, is a more difficult matter to search. Seeing the problem from this perspective is believed to be an important issue, too, because surgeons many times already do what they consider the best to their patients' quality of life, without considering the patients' preferences, so, observe if they are doing it well and/or consistently becomes important since the moment they started to do it.

Until now, it was explored the variability in surgery as a consequence of the different opinions of the surgeons and it was elucidated the controversy associated with the decision of the treatment to acute cholecystitis for patients with more than 72 hours of symptoms. It was mentioned that when deciding which treatment to choose, a surgeon must take into account several parameters, which turns the decision process into a much more complex task, bringing the concept of MCDA to this thesis. Considering this situation, it became interesting the development of a multicriteria decision support

model to aid in the treatment choice for acute cholecystitis patients. As the exploration of the variability between surgeons' opinions remains as the initial proposed goal of this thesis, it would be interesting the merging of the two subjects: explore the variability in surgeons' opinions making use of multicriteria methods to explore and understand how surgeons make decisions concerning the treatment of acute cholecystitis patients, as well as build a decision support model to assist surgeons in the choice of treatment. To achieve it, a methodology is proposed and explained in the next chapter.

4. Methodology

To meet the mentioned objectives, the building of a multimethodology based on the MACBETH multicriteria approach as well as its application are explained in this chapter. The multimethodology will be applied to 10 surgeons from Hospital de Santa Maria in Lisbon and it starts by using exploratory interviews to understand and structure the multiple factors that surgeons consider in the evaluation of patients and in the choice of treatments. Then, making use of a web-based platform that makes MACBETH based questions, it is constructed an individual model that captures the views of each surgeon. Then all surgeons are set to participate in a decision conference and a MACBETH group model is built.

With the application of this multimethodology to surgeons, it is possible to explore the variability across surgeons' views, the convergence towards a group model, as well as, based on the group model, to build a decision support model to assist them in future surgical decisions. Therefore, some hypothesis can be investigated, such as:

- How does a surgeon choose a path for a patient? Will the surgeon behave the same way to other patients?
- And other surgeons, what would they do in the same situation? Will they be in agreement?
- And even with different judgments, the final result will be the same? How convergent will the opinions be, between each one of them and with each one and the group?

Before explaining in more detail each step of the multimethodology and its application, there is an overview of the steps and a section dedicated to the MACBETH approach, since it will be used in the modelling of the individual and group models. Then, each section of this thesis tries to answer the intermediate obstacles that must be overcame to achieve the objectives. First, the models have to be structured: section 4.2 is dedicated to the structuring of the models (definition of criteria and descriptors of performance), making use of exploratory interviews. After the structuring, the individual models are built in section 4.3, where there is a need for planning and implementing a web-based platform for collecting the judgments that allow the building of the value scales and the determination of the criteria weights. Finally, section 4.4 is concerned with the compromise model for the group, which involves a decision conference. So, in that section it is explained the planning and protocol of the decision conference and how the model is created, on-the-spot.

4.1. Proposed Multimethodology

The proposed methodology to achieve the objectives mentioned before is a multimethodology because it combines different techniques that complement themselves [49]. The multimethodology follows a socio-technical approach since it involves a technical component, as the modelling of surgeons' choices in a multicriteria model, and a social component to obtain the information to be used in the modelling. The advantages of this approach, according to L. Philips and C. Bana e Costa, are that [37]: "(…) socio-technical process improves communication (…), develops shared understanding (…)

and generates a sense of common purpose (…)", very important goals to reach specially in the compromise model phase, once this phase produces the decision support model for the hospital, which must be accepted by all the members of the group. The steps of the multimethodology are presented in the scheme of figure 9 and the expected outputs in figure 10.

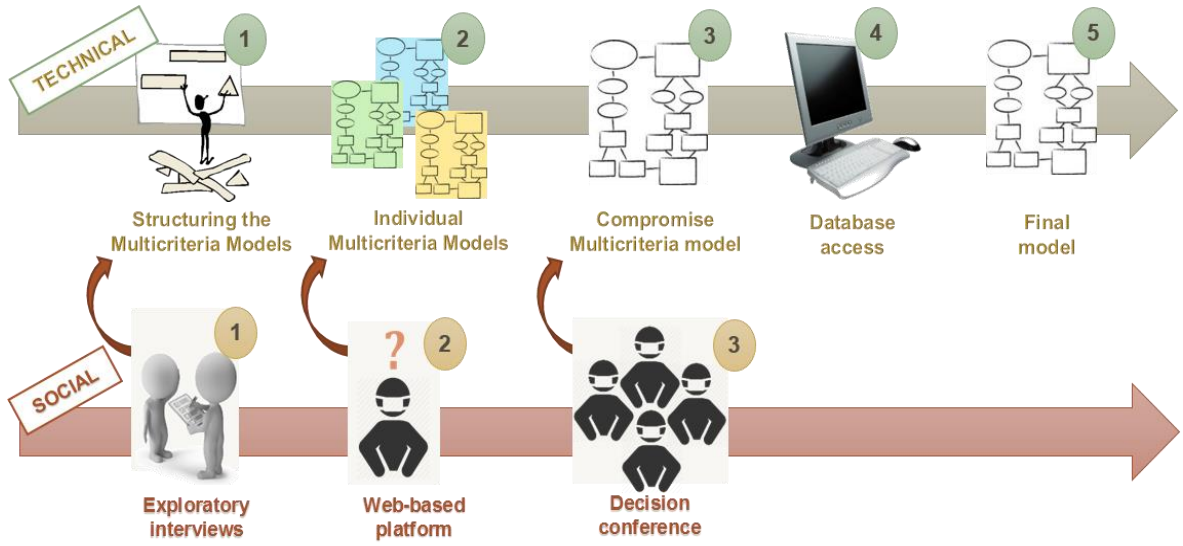


Figure 9. Social and technical components of socio-technical approach that describes the multimethodology. The numbers indicate the sequential order of the steps.

As said, the same steps of figure 9, above, are presented in figure 10, below, but together with the expected outputs of each step.

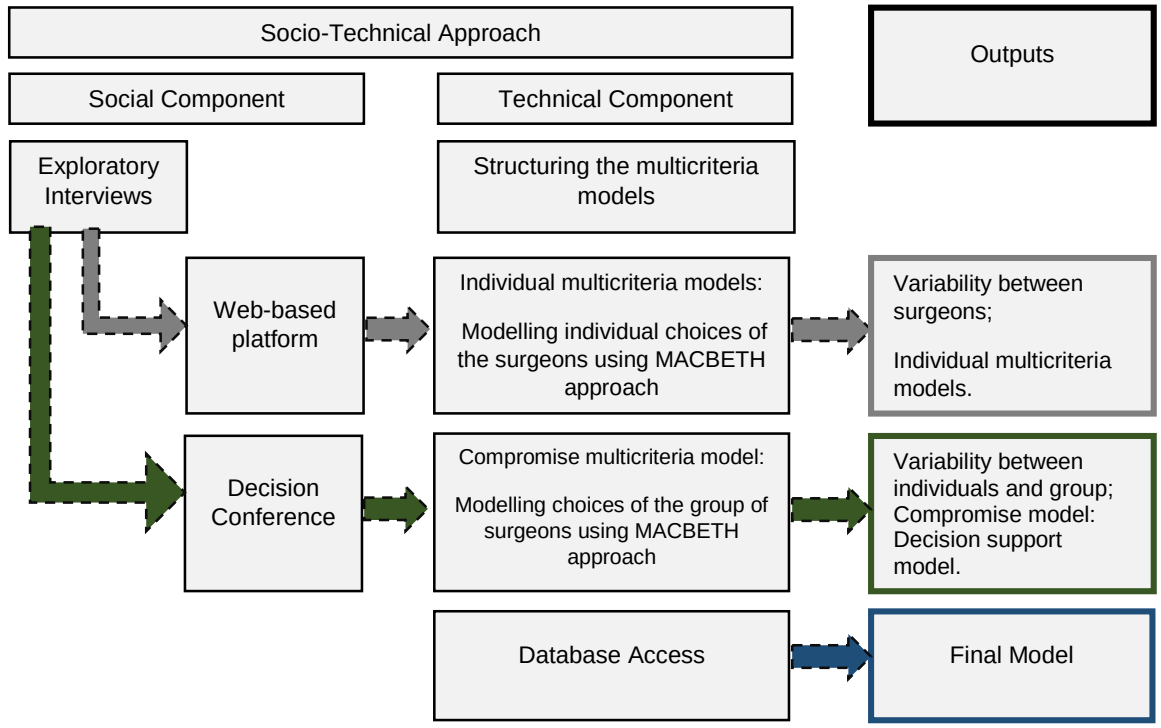


Figure 10. Socio-Technical approach that will be followed in this thesis. There are three paths, the grey, the green and the blue and the objectives of each path are presented at right.

The figures presented a set of connected steps that use different tools. The technical component will involve the use of MACBETH approach in the development of the individual and compromise multicriteria models. For that reason, next section is dedicated to this approach, since it makes sense to clarify it before entering in the detailed explanation of the steps of the multimethodology. The social component will support the technical component, providing the information needed for the development of the models using exploratory interviews, a web-based platform and a decision conference to interact with the surgeons.

Initially and following the schemes of the figures, the models must be structured, i.e., the criteria and their descriptors of performance must be defined for the decision problem. For that, individual exploratory interviews will be made. These interviews will allow the study of the decision context and the exploration if a multicriteria model is, in fact, appropriate for the problem. The answers of the surgeons will be open, they can speak about their concerns and their objectives about acute cholecystitis patients, but some relevant topics for the structuring of the models must be explored in all the interviews. This way, it is easier to obtain information that can be used to develop the models without restraining the surgeons' opinions. The information obtained will be organized and after the interviews it is expected to define the criteria and the descriptors of performance used to all the models, individual and group, which makes them comparable.

After structuring the models, they can be developed. However, the individual models have to be made first (as indicated in the numeration of figure 9), for the opinion of each surgeon not to be influenced by the others. Thus, next step is the development of the individual multicriteria models, which is made by building a value scale for each criterion and obtaining weights for the criteria. For accomplish that, some questions have to be made to each surgeon and is here that the social component is inserted, by the development of a web-based platform that provides all the needed information, enabling the development of the individual models and, consequently, the exploration of the variability between each surgeon.

Only after obtaining the individual models, the surgeons will be placed together for the development of the compromise model for the group. The compromise model will also depend on the building of a value scale for each criterion and obtaining weights for the criteria but, in this case, it will be made on-the-spot in a decision conference. The decision conference intends to collect the same type of information of the web-based platform, once again to allow the comparison of the models, but considering the opinion of the group. So, after this phase, the compromise model is concluded and the variability between the individual surgeons and the group can be also explored.

The compromise model provides a decision support model for the hospital, to support the decision of treatment of acute cholecystitis patients (with more than 72 hours of symptoms). The model evaluates, by an overall score, a patient state according to surgeons' opinion allowing to get information about how much each way of treatment contributes to improve the quality of life of a patient, telling the doctors which treatment would bring more benefit in each case.

After the development of the decision support model, it would be possible to analyse the differences between what was done in the past, in the hospital, and what would be done according to the model,

accessing the hospital database. This can be used to look for aspects that can be changed in the model, allowing its improvement.

Using this multimethodology it is possible to obtain a decision support tool to assist the doctors in evaluating which acute cholecystitis treatment brings more benefit to each patient. Additionally, and since the models are developed with a similar structure for individual and for the group, it is possible to observe the variability between the opinions of the surgeons, exploring the hypothesis brought up in the initial stage of this thesis.

After explaining the MACBETH approach, the following sections of this chapter provide more detailed information about the steps of the methodology. To provide an easy understanding, every section tries to follow a similar structure: first, the intermediate goals of the technical steps are mentioned; to achieve them the social components, if involved, are explained; and then the intermediate goals are accomplished (application of the methods).

4.1.1. Multicriteria Models – MACBETH Approach

Multicriteria decision analysis (MCDA) is a way of breaking a complex problem into "manageable pieces" and then putting the pieces together providing a global result to decision makers. A multicriteria model will allow the balancing of different criteria, inclusion of possible uncertainty and trade-offs [38].

The MACBETH (Measuring Attractiveness through a Category Based Evaluation Technique) approach is a MCDA technique. The main advantage of the MACBETH approach is that it only needs "qualitative judgments about the difference of attractiveness" when comparing two elements in a set, at a time, being the judgments (about the difference of attractiveness) chosen from a given scale: no, very weak, weak, moderate, strong, very strong, extreme. It is a non-numerical method and it originates numerical scores from the qualitative judgments of the decision maker(s), which allows the creation of a value scale per criterion and weights for the criteria. For each option, the value score on each criterion multiplied by the criterion's weight are aggregated additively to all the criteria giving rise to the overall score of the option, translating its attractiveness [50]. In other words, the overall score V(p) of an option p considering n criteria is obtained by aggregating the partial values $v_j(p)$ of each option p in the criterion j (j=1, …, n), as follows [43]:

$$V(p) = \sum_{j=1}^{n} k_j . v_j(p) \quad with \quad \sum_{j=1}^{n} k_j = 1 \quad and \quad k_j > 0 \quad and \quad \begin{cases} v_j(good_j) = 100 \\ v_j(neutral_j) = 0 \end{cases} \tag{1}$$

being k_j the weight assigned to criterion j.

Besides additive, it is a compensatory model because a high performance in a criterion can compensate a low performance in another.

To develop a multicriteria model, it is necessary the definition of criteria. A criterion, also known as fundamental point of view, should have the following properties [38]:

- Relevance – relevant to the goals of the decision;

- Understandability – it must exist a shared understanding on its meaning;
- Measurability – each option should have its performance measured according to each criterion;
- Non-redundancy – two or more criteria cannot measure the same factor;
- Independency – the preference score given to a criterion should not be influenced by the preference scores of the other criteria;
- Exhaustiveness and conciseness – all the crucial aspects should be considered but, at the same time, the model should be simple.

After the definition of the criteria and according to the measurability property, a descriptor of performance has to be defined to each criterion, which turns the criterion intelligible. The descriptor of performance is constituted by a set of levels, ordered by preference. It measures, quantitatively or qualitatively, how a criterion is satisfied by an option, so, the levels must describe objectively the impacts on the criterion to not give rise to ambiguities when classifying the performance of an option. It is important to not insert redundancy in the model, so, each descriptor should be related to only one criterion, and, of course, every criteria must have one descriptor [51]. Besides the descriptors of performance, anchors must be defined, i.e., a level must be assigned to the 0 and another to the 100. It can be chosen an approach of considering the 'neutral' and the 'good' levels, representing the 0 and the 100 of the value scale, respectively. This anchors allows the improvement of the intelligibility of the criterion, because, for example, if level A is better than B it does not mean that A is good (with the anchor, one could compare level A with the 'good' level to see if A is worse or better than 'good'); anchors avoid choosing an option worse than 'neutral' even if it is the best option available; and this 'neutral'-'good' approach is valid with the theoretical framework of the additive model [52].

After the definition of the criteria and the descriptors of performance, the achievement of the value scales will be reached using the M-MACBETH software [50]. In the software, for every criterion, there is a matrix of judgments where the differences of attractiveness between each pair of performance levels, according to the judgments of the decision maker, can be assigned to the cells. It is not necessary to provide every judgment, if there are n performance levels, filling a minimum of (n-1) judgments is acceptable, however, the more judgments filled, the better [53]. The judgments not provided are filled by the software by transitivity. As each judgment is inserted in the software, it automatically verifies if the judgment is consistent with the judgments provided before, if it is not, the software identifies it as an inconsistency and offers suggestions of alterations to fix it [42]. The consistency is evaluated according to the following properties [41]:

- If level A is more attractive than level B, then the score of level A is higher than the score of level B;
- If levels A and B are equally attractive, then their score is the same;
- If the difference of attractiveness in two levels A and B is higher than the difference of attractiveness of another two levels C and D, then the score assigned to the difference between A and B is higher to the one assigned between C and D.

When the matrix is complete and consistent, a value scale is reached to the criterion, as in the example of figure 11. The given scale can be adjusted by the decision maker, in certain limits that

respect his previous judgments. The validation of the value scale occurs once the decision maker agrees with it [42].

Figure 11. Example of a consistent matrix of judgements with the assigned value scale [42].

After the determination of the value scales for all the criteria, a weights scale must be determined, to assign weights to the criteria. So, the next step of the model development is to obtain a ranking to the criteria, provided by the decision maker. This can be accomplished by asking him if all the criteria were in the 'neutral' performance level and he could improve only one criterion to the 'good' level which improvement he would choose. He must choose based on the improvements and not only in the criteria, if not he would fall in the "most common critical mistake" of decision making [42]. After his choice, he must choose what improvement he would do next, and do that until there is no more criteria available. When he does this choice, he must evaluate the difference of attractiveness of the improvements according to the MACBETH scale (no, very weak, weak, moderate, strong, very strong, extreme). This allows the filling of the weighting matrix of judgments in the software and the weights can be adjusted with the decision maker, within certain limits consistent with the judgments, as it happens in the creation of value scales [42]. With the value scales for the criteria and the attribution of the weights completed, the overall score of options can be acquired, after inserting the options and its performance in the software.

As it was showed in the proposed framework, it is expected to obtain a multicriteria model for each surgeon, and then a compromise model for the group, to allow the comparison and observe the variability and the convergence of opinions. Following the steps mentioned in this section, for the individual and group judgments, it is possible to obtain the expected models. In the next sections it is possible to see how the information about the qualitative judgments, needed to all these accomplishments, was obtained.

4.2. Structuring the Multicriteria Models

The first step to accomplish in the multimethodology of this thesis is the structuring of the models. As seen in the MACBETH approach section, structuring the models consists in the definition of criteria and descriptors of performance. To obtain relevant data for this definition, exploratory interviews will be made to 9 surgeons to explore the decision context and then the information must be organized to give the expected answer of this step. Professor Mendes de Almeida will support the organization of

the information in criteria and descriptors of performance, having a different role only in this step of the multimethodology. After that, the 10 surgeons will always have a similar role.

4.2.1. Exploratory Interviews

Usually, to make a decision, a person thinks about all the possible alternatives and then chooses the best one in the set, what is defined as “alternative-focused thinking” by Keeney *et al.* [54]. Here, the goal is to try to choose the path that puts the decision makers closer of getting all that they want, being this defined as “value-focused thinking” which defends “first deciding on what you want and then figuring out how to get it” [54].

Following a “value-focused thinking” approach to explore objectives and surgeons’ thoughts for the treatment choice of acute cholecystitis, exploratory interviews were made. They allow the exploration if a multicriteria model could really be the appropriate kind of model to this problem because they can provide information about all the concerns of the surgeons when deciding which treatment to choose. This information can be organized in a way to obtain what is expected in this phase (criteria and descriptors of performance), allowing, at the same time, the development of the next one.

These interviews are classified as unstructured and their use is recommended when there is not much knowledge in the situation [55], which is the case in this preliminary phase of the methodology. There will be few specific questions with open answers that must translate the perspective of each surgeon. Instead of being a restrict questionnaire with answers’ options, as it happens in the structured interviews, these interviews have some topics that are expected to explore but which are also expected to emerge naturally in the conversation [55].

The interviews should let each surgeon comfortable in talking about the issues of the decision, however, in every interview it must be accomplished the goal of obtaining relevant information to define the criteria and the descriptors of performance. Only then it will be possible the development of the web-based platform, the way intended.

In the beginning, each surgeon was asked to suppose that he has to treat a patient with an acute cholecystitis crises, with more than 72 hours since the beginning of the symptoms. The topics explored in all the interviews are mentioned below. The topics are presented as questions but they were not always asked with this specific structure:

1. What options do you have to treat the patient?
2. What do you expect to reach when you make a choice of treatment? What is the goal of the treatment, if you could explain it in one sentence?
3. Now, suppose that you chose an option of treatment. How can you evaluate the result? What are the factors that differentiate how successful was the intervention?
4. *To each factor:*
    a. Can this factor be subdivided in more components? Which ones?
    b. Can some of them be grouped?

c. If two patients have the same behaviour in these factors, is there another factor to differentiate the patients' result?

In this set of topics, the third and the fourth ones are especially dedicated to the exploration of the criteria. It is expected to obtain important evaluating factors about the impact of any chosen treatment in the patient quality of life, but always in the surgeon's point of view. After the interviews, the information was organized and clustered in criteria and the descriptors of performance were defined with Professor Mendes de Almeida's support, as it is possible to see next.

4.2.2. Defining Criteria and Descriptors of Performance

In the exploratory interviews, nine surgeons were interviewed, being three interns, three of general surgery and the other three of hepatobiliary speciality.

Regarding the first topic of the interviews mentioned before, the options of cholecystectomy, early (ELC – early laparoscopic cholecystectomy) or after the conservative treatment (ILC – interval laparoscopic cholecystectomy), were referred by all the interviews and cholecystostomy was referred by eight of the nine. As cholecystostomy is a specific approach for specific patients (severely ill patients, as mentioned in chapter 3), the models will consider two treatment's options: ELC and ILC. ELC describes the surgery made in the first hospital admission of the patient and ILC describes the surgery made after an antibiotic therapy, in another hospital admission.

When speaking about the goals of the decision, the surgeons' main concern was about recovering the patient, as it is presented in table 2.

Table 2. Answers of the surgeons when questioned about the goals of the decision.

Interview	Goals of the treatment
1	Maximize the disease control and the recuperation of the patient, putting him back in his familiar, social and professional environment.
2	Maximize patient recovery and satisfaction, minimizing future complications and costs.
3	Re-establish, as much as possible, the physiologic functions of the patient (as they were before of the cholecystitis episode), maximizing patient satisfaction with less costs.
4	Maximize patient recovery, controlling as much as possible the infection, improving his satisfaction with less costs.
5	Maximize the septic focus control to improve survival, reducing future complications and costs.
6	Maximize patient recovery and satisfaction, with less costs.
7	Maximize patient recovery, with less costs.
8	Maximize patient recovery and satisfaction, minimizing morbidity, hospitalization time and costs.
9	Maximize patient recovery, with less costs.

The information collected in the questions whose objective was the exploration of the criteria was discussed with Professor Mendes de Almeida and the factors mentioned by the surgeons as important to evaluate the result of the treatment were clustered in criteria. The mentioned factors and

the clustering are presented in table 3. Pain and regularization of the inflammatory parameters were also mentioned in the interviews but they were suppressed because it was considered as being less applicable in this condition than the other factors.

Table 3. Clustering of the evaluating factors mentioned in the interviews in criteria. The criteria were defined at the same time, after analysing the factors and the way of clustering them.

Factors considered important by the surgeons to evaluate the success of the intervention	**Criteria to evaluate the decision in the model**				**Hospital costs**
	Morbidity	Functional recovery	Satisfaction	Patient costs	
Hospitalisation time					X
Antibiotic therapy time					X
Absenteeism from work				X	
Functional state recovery (previous to the cholecystitis episode)		X			
Surgery time					X
Conversion rate					X
Gastrointestinal functions recovery		X			
Hospital costs					X
Patient costs				X	
Patient satisfaction (aesthetic)			X		
Medical/surgical complications					X
Mortality	X				
Morbidity	X				

The organization of the criteria in a value tree is presented in the figure 12 (below). The hospital costs will not be considered because the model is concerned with the impact at the patient level. Patient costs were divided in medication, extra visits to the hospital and absenteeism from work because it was considered that extra visits to the hospital brings more inconvenience to the patient than medication costs and absenteeism from work can change patient's incomes, bringing even a more negative impact.

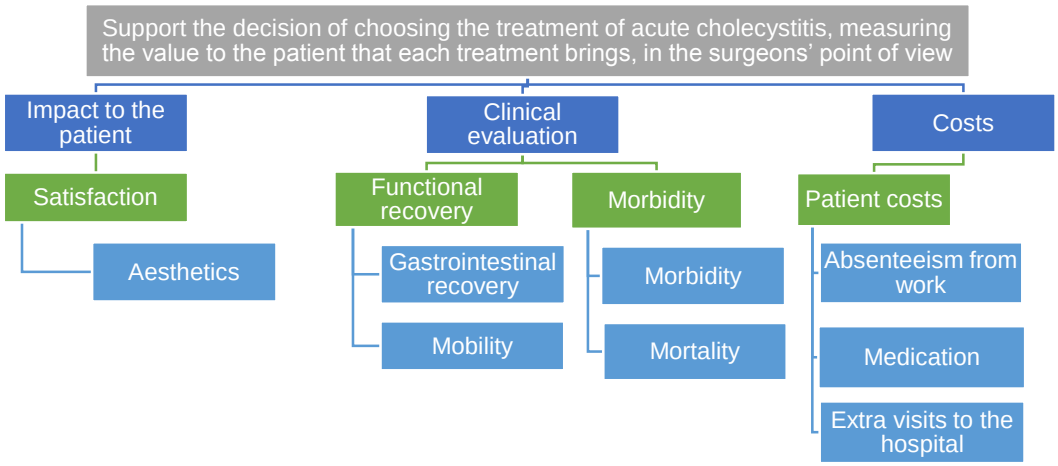


Figure 12. Organization of the criteria in a tree. The criteria are in the green boxes, below them (in light blue) there are factors mentioned in the interviews and above them (in dark blue) there are the areas of impact.

After the clustering, descriptors of performance were defined, as well as the anchors 'neutral' and 'good', and are presented in the table 4.

Table 4. Definition of the descriptors of performance and of the anchors 'neutral' and 'good'.

Criteria	Descriptors of Performance Levels
Morbidity	Long-term morbidities classified according to Clavien-Dindo scale [56]. ▪ No morbidity; ▪ Grade I (therapeutic necessity such: antiemetic, antipyretics, analgesics, diuretics and electrolytes) **- GOOD**; ▪ Grade II (other pharmacological therapeutic as antibiotics, parenteral nutrition) **– NEUTRAL**; ▪ Grade III (Requiring surgical, endoscopic or radiological intervention, with or without anesthesia); ▪ Grade IV (simple or multi organ dysfunction); ▪ Grade V (Death).
Functional Recovery	Symptoms presented by the patient. ▪ Asymptomatic; ▪ Reposition of the state previous to the acute episode **- GOOD**; ▪ Minimal symptoms **- NEUTRAL**; ▪ Limitative symptoms; ▪ Incapacitate symptoms.
Satisfaction of the patient	Satisfaction of the patient, considering the aesthetic results of the treatment. ▪ Very satisfied; ▪ Satisfied **- GOOD**; ▪ Not unsatisfied or satisfied **- NEUTRAL**; ▪ Unsatisfied; ▪ Very unsatisfied.
Patient Costs	Costs to the patient. ▪ Without costs and without alteration of the economic balance; ▪ With medication costs. Without extra hospital visits costs and without alteration of the economic balance **- GOOD**; ▪ With extra hospital visits costs. Without medication costs and without alteration of the economic balance; ▪ With medication costs and extra hospital visits costs. Without alteration of the economic balance **- NEUTRAL**; ▪ Without costs but with alteration of the economic balance; ▪ With medication costs and with alteration of the economic balance. Without extra hospital visits costs; ▪ With extra hospital visits costs and with alteration of the economic balance. Without medication costs; ▪ With medication costs, extra hospital visits costs and alteration of the economic balance;

Regarding the performance levels of patient costs criterion, the ‘alteration of the economic balance’ was defined as: ‘Despite many patients have retirements or other fixed incomes, this alteration refers to the people whose incomes are modified due to situations such as sick leave’. Additionally, but considering the functional recovery performance levels, it was defined the meaning of minimal, limitative and incapacitate symptoms as:

- Minimal symptoms: symptoms that don’t affect normal or pre-disease life;
- Limitative symptoms: symptoms that affect some normal pre-disease activities;
- Incapacitate symptoms: symptoms that stop activities or force to remain at home or even imply other people support to assure daily tasks.

These explanations have to be always associated with the levels, to not bring ambiguity to the descriptor. After establishing the criteria and descriptors of performance, the structuring phase was concluded, it was possible to enter in the next phase, the development of the individual multicriteria models, explained next.

4.3. Individual Multicriteria Models

Having now the multicriteria models structured, it is possible to start the development of the models. As said, it is important to develop first the individual models and only then reunite the surgeons to the model of the group, for the individual models not to be influenced.

The development of the individual models consists in building value scales and obtaining criteria weights, for each surgeon, which depends on collecting some specific judgments of the surgeons about differences of attractiveness between some of the performance levels obtained previously.

To collect these individual judgments, a web-based platform will be implemented. So, in this section, first it will be presented the planning of the web-based platform to understand how the needed judgments can be obtained. After explaining the planning, the protocol of the web-based platform using previous information will be presented. The section ends with the building of the value scales and the determination of the criteria weights of the individual models.

4.3.1. Web-Based Platform

The use of a web-based platform intends to be a quicker and simpler way of getting the individual judgments of the surgeons. It is more efficient than interviewing each surgeon again, allowing each person to answer whenever it is more convenient. The web-based platform was developed in Google Forms and the individual judgments collected are crucial for the building of the value scales and the determination of the criteria weights that define the individual multicriteria models. For that, the platform has to collect some judgments of the surgeons according to the criteria and the descriptors of performance defined in the previous phase.

The platform must have two parts: one that allows the building of the value scales and other that allows obtaining the criteria weights.

To build the value scales, the first part has a section for each criterion and each section should be intended to collect the qualitative judgments within the criterion. The descriptors of performance levels should be exposed as well as its definitions, when applicable, and surgeons must be asked to select the importance of the improvements (differences of attractiveness) between some pairs according to the categorical scale of MACBETH approach (no, very weak, weak, moderate, strong, very strong, extreme). All the questions of this part of the platform must have a common structure to all the criteria, to pass on simplicity and better understanding, thus, it will be always asked "To the quality of life of the patient, say the importance of each one of the following improvements in the [Criterion]". In this case, the improvements asked in the answer will be the comparison between each performance level and the least attractive one and between each consecutive pair of performance levels, which corresponds to the last column and the diagonal above the main diagonal of the matrix of judgments of the M-MACBETH software, respectively [50]. The other improvements within the criterion would be filled by transitivity. After having all the needed judgments, value scales are built to each criterion.

The second part should be intended to obtain qualitative judgments of overall attractiveness. Surgeons should rank the improvements of the 'neutral' to the 'good' level in all the criteria in terms of overall attractiveness and, as they choose a criterion, they should also classify its difference of attractiveness according to MACBETH scale. In the platform, it should be asked the ranking of the improvement they would choose comparing with all the criteria being in the 'neutral' level. The difference of attractiveness between having only one criterion, at a time, in the 'good' level and all the criteria being in the 'neutral' level will allow the insertion of the judgments corresponding to the last column of the weighting matrix of judgments in the software [50]; the other cells of this matrix will also be filled by transitivity. After these judgments, weights are assigned to the criteria.

The collection of the judgments according to each surgeon allows the modelling of ten individual models and the observation of the variability in their opinions. Now, it is presented in more detail the implementation of the platform using the information obtained in the structuring of the model and then the building of the value scales and the determination of the criteria weights will be exposed.

4.3.2. Web-Based Platform: Protocol

In the first part of the platform, there were a section for each criterion, as mentioned. The performance levels are clarified in the section, for not bringing ambiguity, and then there is the question that each surgeon should fill with the difference of attractiveness between some levels, the ones corresponding to the cells of the matrix of judgments wanted for the building of the value scales: the differences of attractiveness corresponding to the last column and to the diagonal above the main diagonal of the matrix of judgments. It is possible to see the case of 'Functional Recovery' criterion, as an example, in figure 13. Every criterion had a similar section.

Figure 13. Question regarding the Functional Recovery criterion in the first part of the web-based platform. First, the performance levels are presented and then it is asked, for the quality of life of the patient, to evaluate the difference of attractiveness between some levels – the levels that correspond to the last column (first four lines) and the diagonal above the main diagonal (last three lines) of the M-MACBETH matrixes, as it is possible to see in the matrix of judgments at left.

After a set of similar questions for all the criteria, the second part of the platform was implemented. To obtain the overall attractiveness, first, it was presented a set of all the criteria with the 'neutral' and 'good' levels, showed in figure 14, and the surgeon was asked to suppose that a patient, after a treatment, was in the state defined by all the yellow levels (corresponding to the 'neutral' levels) in the four criteria, i.e., in level II of Clavien-Dindo classification respecting to morbidity, with minimal symptoms respecting to functional recovery, not unsatisfied or satisfied respecting to satisfaction and with costs of medication and of extra visits to the hospital.

After this scheme, surgeons were asked: 'To improve the quality of life of the patient, if you could improve a level in one of the four factors (i.e. improve A, B, C or D) which one would you choose?'. After selecting an option, they were asked: 'To the quality of life of the patient, what is the attractiveness of the chosen improvement?' and in the answer they could select one of the MACBETH categories. Then it was asked to exclude the chosen factor and the same questions were asked. This process of excluding factors and repeat the questions was made until the end of the criteria.

In the end, a ranking of the improvements of the criteria was expected to be obtained and it would be possible to complete the information of the software respecting to the overall attractiveness: the weighting matrix of judgments, presented in figure 15. In the matrix, the criteria (which in the figure and by default presents the order Morbidity-Functional Recovery-Satisfaction-Costs) were ordered according to the ranking given by the surgeon and the judgments obtained by the questions were inserted in the last column.

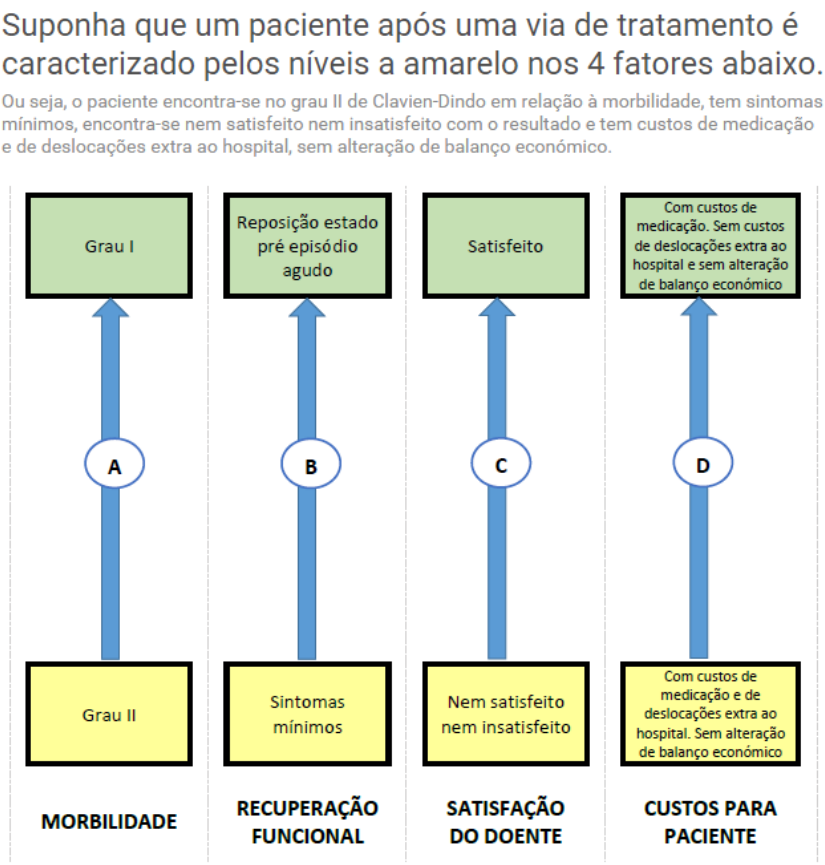


Figure 14. Ranking of the improvements. Here, surgeons were asked to suppose that a patient, after a treatment, is in the state defined by all the yellow levels in the four criteria, i.e., in level II of Clavien-Dindo classification respecting to morbidity, with minimal symptoms respecting to functional recovery, not unsatisfied or satisfied respecting to satisfaction and with costs of medication and of extra visits to the hospital.

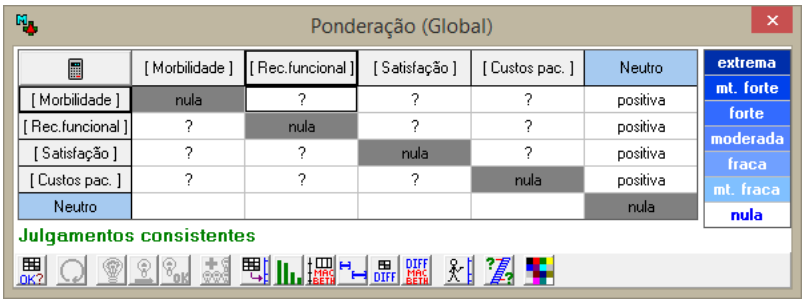


Figure 15. Weighting matrix of judgments given by default by the software.

After the implementation of the web-based platform it was possible to collect the judgments of the ten surgeons and, consequently, insert them into M-MACBETH and obtain the value scales and the weights for the criteria, according to each surgeon.

4.3.3. Building Value Scales for the Criteria

As mentioned, all the questions of the first part had a common structure and in all the answers the surgeons were asked to compare each performance level to the least attractive one and each consecutive pair of performance levels according to only one category of the MACBETH scale. The value scales were built inserting these judgments in M-MACBETH software.

When inconsistencies occurred, suggestions of the software were accepted, because in this phase there was not physical contact with the decision makers to discuss these events. Furthermore and for the same reason, the value scales were not adjusted or validated by the decision makers. Next tables present the value scales proposed by the software for the ten surgeons, after the insertion of the judgments. Each table presents the value scales of a criterion.

Table 5. Value scales obtained by the individual judgments to the 'Morbidity' criterion.

Interviewed Doctors (D)	Morbidity Value Scales					
	No morbidity	Grade I	Grade II	Grade III	Grade IV	Grade V
D1	175	100	0	-100	-200	-350
D2	180	100	0	-100	-200	-280
D3	200	100	0	-100	-200	-320
D4	200	100	0	-133	-266	-366
D5	450	100	0	-75	-150	-225
D6	175	100	0	-125	-225	-375
D7	133	100	0	-133	-266	-433
D8	200	100	0	-400	-800	-1400
D9	200	100	0	-133	-266	-433
D10	200	100	0	-133	-300	-500

Table 6. Value scales obtained by the individual judgments to the 'Functional Recovery' criterion.

Interviewed Doctors (D)	Functional Recovery Value Scales				
	Level 1	Level 2	Level 3	Level 4	Level 5
D1	267	100	0	-133	-266
D2	267	100	0	-166	-266
D3	200	100	0	-100	-220
D4	300	100	0	-400	-700
D5	167	100	0	-133	-266
D6	500	100	0	-133	-266
D7	133	100	0	-166	-300
D8	150	100	0	-200	-400
D9	200	100	0	-166	-300
D10	200	100	0	-100	-233

Table 7. Value scales obtained by the individual judgments to the 'Patient Satisfaction' criterion.

Interviewed Doctors (D)	Patient Satisfaction Value Scales				
	Level 1	Level 2	Level 3	Level 4	Level 5
D1	267	100	0	-16	-50
D2	214	100	0	-42	-85
D3	180	100	0	-100	-200
D4	167	100	0	-66	-100
D5	167	100	0	-100	-200
D6	183	100	0	-33	-50
D7	133	100	0	-133	-233
D8	117	100	0	-50	-66
D9	200	100	0	-75	-125
D10	175	100	0	-75	-150

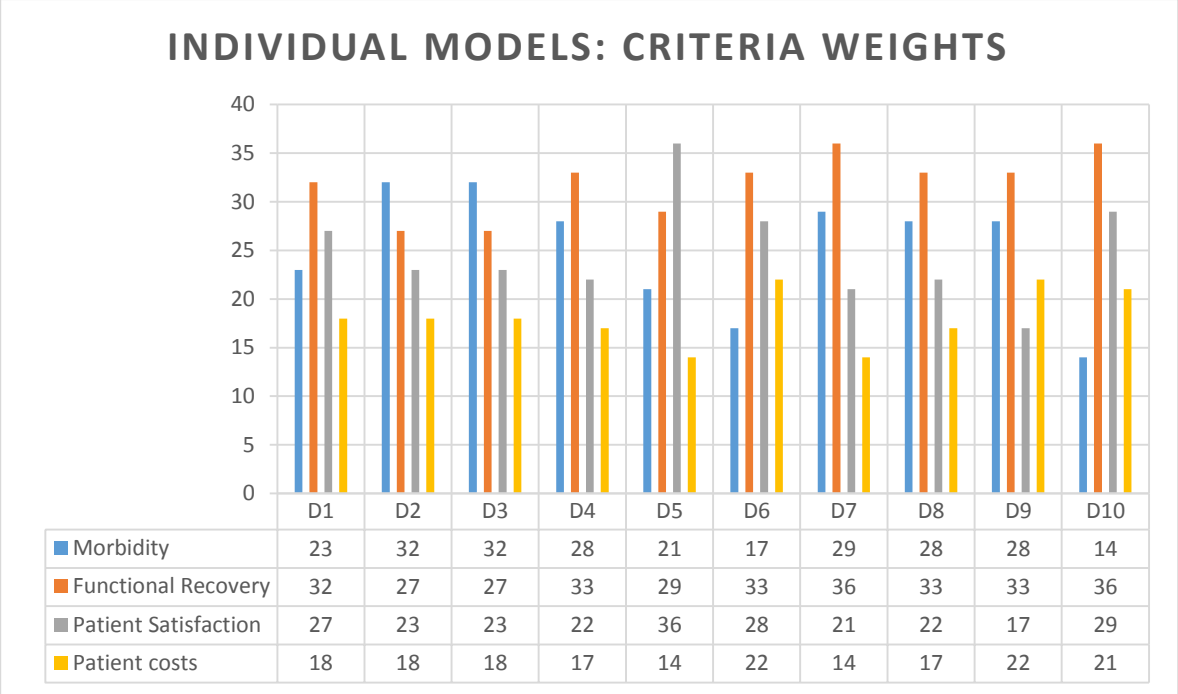
Table 8. Value scales obtained by the individual judgments to the 'Patient Costs' criterion.

Interviewed Doctors (D)	Patient Costs Value Scales							
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
D1	162	100	50	0	-62	-125	-162	-212
D2	200	100	50	0	-50	-65	-80	-95
D3	267	100	78	0	-88	-111	-133	-155
D4	140	100	40	0	-120	-180	-240	-280
D5	164	100	45	0	-54	-81	-100	-118
D6	133	100	67	0	-233	-300	-366	-433
D7	125	100	50	0	-75	-225	-300	-350
D8	150	100	50	0	-116	-166	-216	-266
D9	160	100	60	0	-140	-280	-340	-400
D10	120	100	60	0	-100	-160	-180	-280

4.3.4. Obtaining Criteria Weights

The answers to the second part of the platform allowed to obtain the ranking of the improvements and the criteria weights. As happened in the first part, inconsistencies here were also solved with the suggestions of the software and the criteria weights are the ones given by default because there was not validation by the decision makers.

Figure 16, below, presents a graph where it can be seen the ranking and the weights assigned to each criteria, for the ten surgeons.



	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Morbidity	23	32	32	28	21	17	29	28	28	14
Functional Recovery	32	27	27	33	29	33	36	33	33	36
Patient Satisfaction	27	23	23	22	36	28	21	22	17	29
Patient costs	18	18	18	17	14	22	14	17	22	21

Figure 16. Criteria weights according to the individual answers of the surgeons.

4.4. Compromise Multicriteria Model

After obtaining the individual models, it is time to develop the compromise model for the group. This compromise model will be the decision support tool for the hospital and, at the same time, it is useful to observe the variability between the opinions of the individual surgeons and the group.

In this section, for the development of the compromise model, the value scales must be built and the criteria weights must be determined, this time according to the group. As in the individual models phase, reaching this objectives involves acquiring some specific judgments of the surgeons about differences of attractiveness between performance levels obtained in the structuring phase. To collect the needed group judgments, all of the ten surgeons involved in the previous phases should be brought together. For that, a decision conference will be made.

This section presents first the decision conference planning to understand how the needed judgments will be obtained. After explaining the planning, the protocol will be presented, as well as the building of the value scales and the determination of the criteria weights for the group model.

4.4.1. Decision Conference

A decision conference is a gathering of people who want to solve an important matter. It is assisted by a facilitator, who has to be impartial in the content discussed and uses a model, created on-

the-spot, to guide the group in thinking more clearly about the matter. The created model won't give the solution but it will guide the group learning process and it is hoped to be, according to L. Philips and C. Bana e Costa, a 'requisite' model, i.e., it is hoped to be "sufficient in form and content to resolve the issues at hand". A decision conference will also allow different opinions and views, creativity, shared understanding, sense of common purpose and a quicker way of reaching agreement. Thus, the created model is a compromise of all participants' views and, since everyone participates and watches it being created, they will, more likely, have trust in the results [37].

Usually, there are four stages in a decision conference: (1) the issues are explored, (2) the model is built according to the judgments given by the participants, (3) the model is explored to see if there are discrepancies to solve and, finally, (4) an action plan is settled to follow in the future [37] [57].

In the decision conference, it should be asked the same judgments of the web-based platform, to obtain comparable information with the individual judgments. Thus, the decision conference will also have two parts: one with the questions about the differences of attractiveness within each criterion, to build the value scales; and another with the questions about the overall attractiveness, to obtain the criteria weights. Nevertheless, there are three fundamental differences in relation to the development of the individual models: first, here it will be accepted more than one category of the MACBETH scale if the decision makers are in doubt between sequential categories; second, if inconsistencies occur, than can be discussed with the decision makers and they can choose what suggestion to adopt; and third, the value scales and the criteria weights can be adjusted, in intervals consistent with the judgments, and validated by the decision makers.

A presentation must be prepared with the questions of the needed judgments but it can be in a more eye-catching way than it was in the platform, since there is less restrictions in the layout. Nevertheless, the questions of each part should also have a common structure, also for the simplicity and easier understanding.

In the first part, every question will have the following structure: 'For the quality of life of the patient, going from [Level A] to [Level B] is of [*category selected by the surgeons*] importance'. The MACBETH scale should be always presented for the surgeons to choose the category or categories. Once again, the judgments asked will be the comparison between each performance level and the least attractive one and between each consecutive pair of performance levels (the last column and the diagonal above the main diagonal of the matrix of judgments of the M-MACBETH software, respectively [50]). The other improvements within the criterion would be filled by transitivity. After having all the needed judgments, value scales are built to each criterion. Then, when building each value scale, it must be presented to the decision makers and they must validate it, adjusting first in the allowed intervals if they want.

In the second part it should be ranked the improvements of the 'neutral' to the 'good' level in all the criteria in terms of overall attractiveness and, then, they should also classify its difference of attractiveness according to MACBETH scale. It should be asked the ranking of the improvement they would choose comparing with all the criteria being in the 'neutral' level. The difference of attractiveness between having only one criterion, at a time, in the 'good' level and all the criteria being in the 'neutral' level will be inserted in the last column of the weighting matrix of judgments in the software [50]; the

other cells of this matrix will also be filled by transitivity. After these judgments, weights are assigned to the criteria. Then, the decision makers must validate the weights, adjusting them in the allowed intervals if they want, too.

After the confirmation of the value scales and the criteria weights with the surgeons, it is possible to observe how the model evaluates patient cases, according to each treatment's way, and to compare it with the information obtained with the individual models.

4.4.2. Decision Conference: Protocol

In the first part of the decision conference, the one dedicated to build the value scales, it was supposed to ask the surgeons the same judgments of the first part of the web-based platform. As happened in the protocol of the platform, in this section it will be possible to see examples of the type of questions of the decision conference and how it contributes to achieve the objectives (value scales and criteria weights). Figure 17 shows an example of a question of the 'Functional Recovery' criterion.

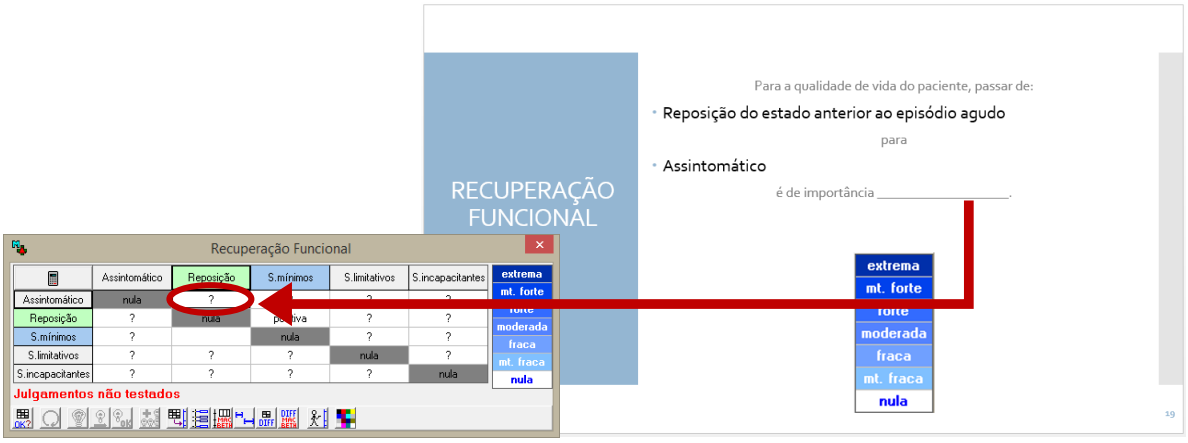


Figure 17. Example of a question of the decision conference. This question of the slide asks 'For the quality of life of the patient, going from: Reposition of the state previous to the acute episode to Asymptomatic is of [surgeons much choose a category] importance.' The answer given in this question is inserted in the indicated cell of the matrix.

All the questions regarding the value scales were made with a similar structure, excepting the questions of the 'Patient Costs' criterion. These questions tried to be more intuitive because all the possible combinations of the three types of costs (medication, extra visits and alteration of the economic balance) could be confusing. Figure 18 shows an example of the structure of these questions: it is asked the importance (difference of attractiveness) of going from A to B and states A and B present each one three boxes, according to the type of cost: medication, extra visits to the hospital and alteration of the economic balance, and each cost may or not exist in the state; in the figure, the state A has all the costs and the B has only the costs associated with the first box, that is, medication costs.

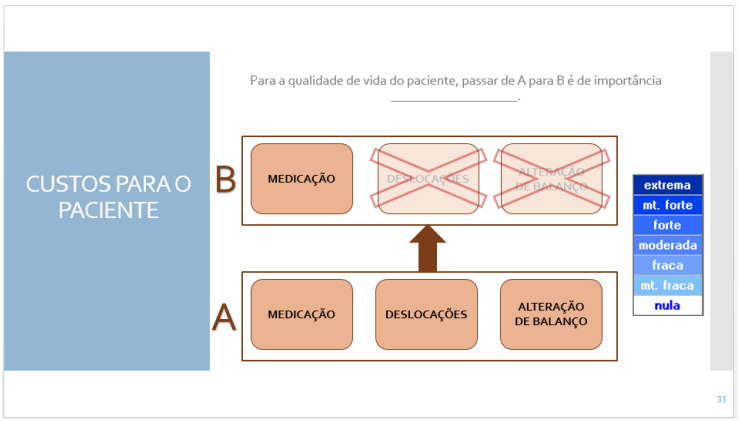


Figure 18. Example of question for the 'Patient Costs' criterion. It is asked 'For the quality of life of the patient, the importance of going from: A (having costs of medication, of extra visits to the hospital and alteration of the economic balance) to B (having only medication costs) is [surgeons much choose a category]'.

The questions regarding the definition of the criteria weights take place after all the questions regarding the judgments within each criterion and the validation of the value scales by the surgeons. To obtain the overall attractiveness, first, it was presented a set of all the criteria with the 'neutral' and 'good' levels, the same scheme presented in the web-based platform, figure 19 at left, and the surgeons were asked to suppose that a patient, after a treatment, was in the state defined by the 'neutral' levels in all the criteria. The surgeons must say in what order they would do the improvements to the 'good' level. Then, they must evaluate the improvements for all the criteria according to the MACBETH scale, which is asked as presented in the example of figure 19 at right using 'Functional Recovery' improvement.

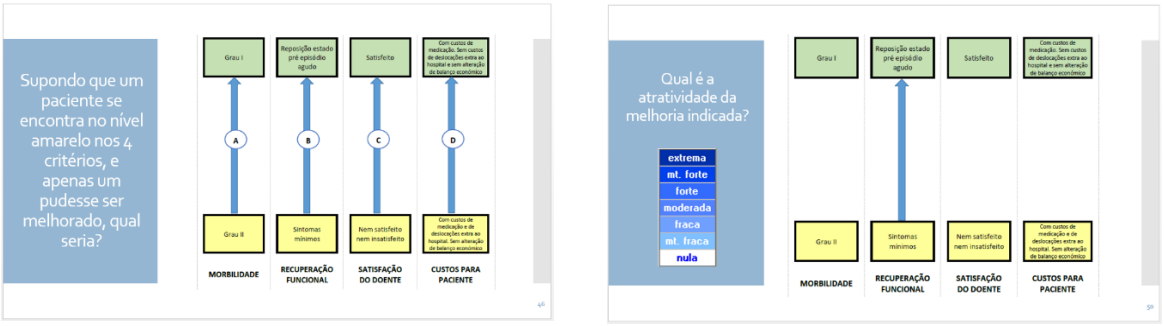


Figure 19. At left it is the question where the surgeons chose the ranking of the improvements from the 'neutral' (yellow) to the 'good' (green) level. At right, it is an example of how the difference of attractiveness was asked, in this example for the 'Functional Recovery' criterion.

4.4.3. Building Value Scales for the Criteria

In this phase, there were no inconsistencies in the given judgments. After collecting and inserting them in the matrix of judgments in M-MACBETH software, the value scales were presented to the decision makers for being adjusted, if needed, according to the consistent limits of the judgments, and to be validated.

The ‘Morbidity’ criterion was the first to collect the judgments. There were inconsistencies, so, the value scale was built after collecting the data. After building the value scale, it was adjusted by the surgeons. The interval between the ‘0’ that correspond to the ‘No morbidity’ performance level and the ‘Grade I’ was decreased, when adjusting the scale because it was not considered so different in terms of attractiveness. In the contrary, the intervals ‘Grade III’-‘Grade IV’ and ‘Grade IV‘-‘Grade V’ were intensified. Then, the surgeons validate it and it is presented in figure 20.

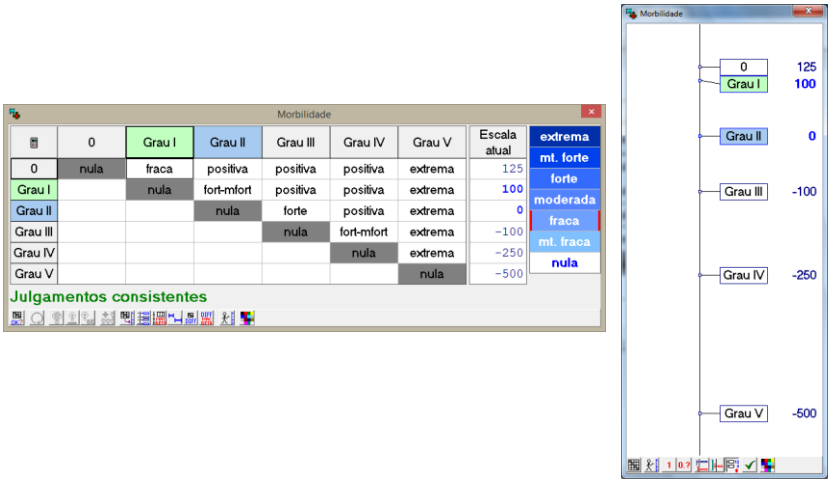


Figure 20. Matrix of judgments and value scale for the 'Morbidity' criterion.

The ‘Functional Recovery’ value scale was the second to be built (figure 21). It had also some adjustments. The intervals between the first and the second levels and between the fourth and the fifth levels were incremented before the validation by the surgeons.

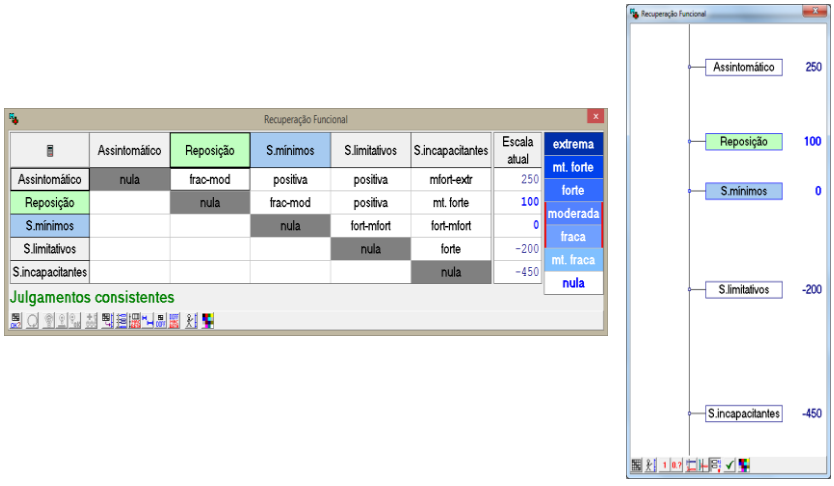


Figure 21. Matrix of judgments and value scale for the 'Functional Recovery' criterion.

The ‘Patient Satisfaction’ matrix didn’t need adjustment because it was in agreement with the surgeons, so it was immediately validated. Figure 22 presents the matrix of judgment and the value scale of this criterion.

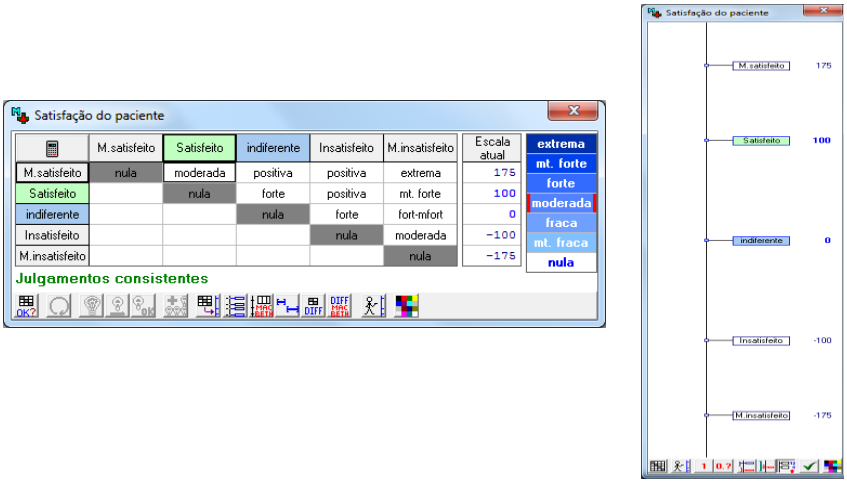


Figure 22. Matrix of judgments and value scale for the 'Patient Satisfaction' criterion.

The questions regarding the 'Patient Costs' criterion had the schemes with the boxes, as explained in the section of the protocol, due to the different dimensions of costs (medication, extra visits to the hospital and alteration of the economic balance) that could combine in several ways. These questions were of easy understanding, as intended. The judgments given in the first place were consistent, however when looking at the value scale, surgeons wanted to adjust the score of only having medication costs in a way not compatible with the judgments. Thus, the judgments given to the difference of attractiveness between the medication costs and extra hospital visits costs and between this one and the medications more extra visits costs were changed to be possible the adjustment the way the surgeons wanted. Then, the value scale was in agreement with them and thy validate it. Figure 23 shows the matrix of judgments and the value scale of this criterion.

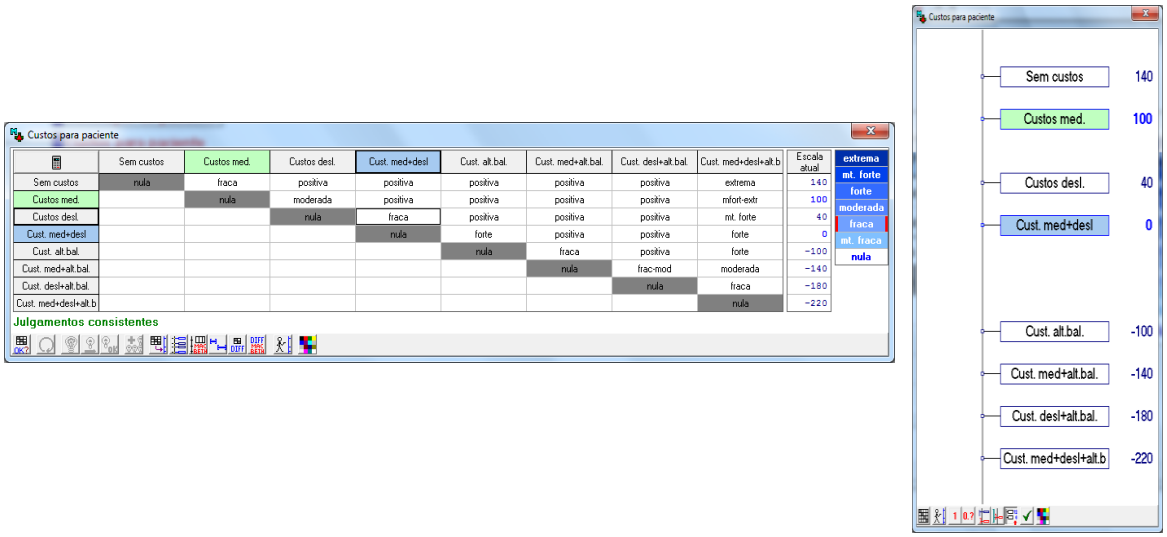


Figure 23. Matrix of judgments and value scale for the 'Patient Costs' criterion.

4.4.4. Obtaining Criteria Weights

After ranking the improvements, surgeons gave inconsistent judgements with the ranking. It was solved by explaining that they must look to the attractiveness of the improvement and not to the criterion per se. After that, they changed their ranking, being the judgements consistent with the new ranking. They agreed with the given weights, so the adjustments at this point were not needed, being the weights validated by the surgeons. The weights assigned to the criteria are presented in figure 24.

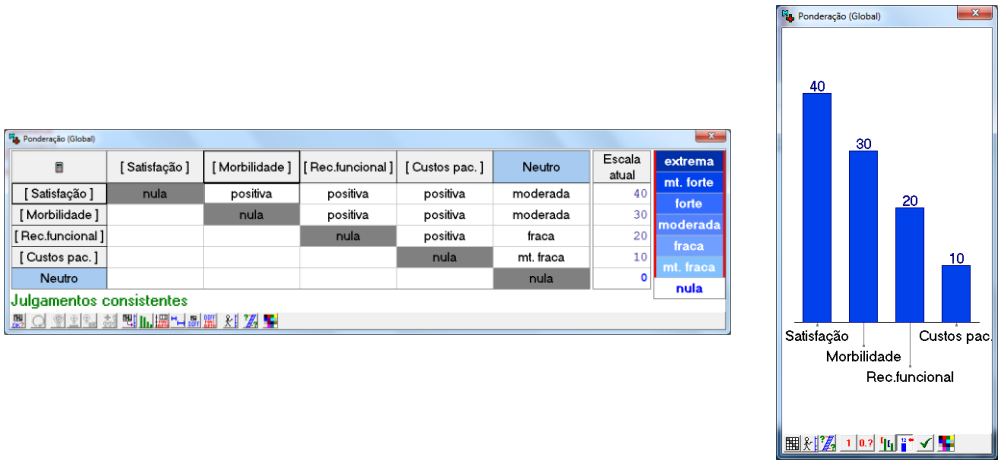


Figure 24. Weighting matrix of judgments and weights for the criteria. The ranking is in the following order: 'Patient Satisfaction', 'Morbidity', 'Functional Recovery' and 'Patient Costs'.

In this chapter it was observed how the steps of the multimethodology were planned and applied to 10 surgeons of Hospital de Santa Maria in Lisbon. After the structuring of the multicriteria models using exploratory interviews, a web-based platform collected individual opinions to understand how surgeons make decisions concerning the treatment of acute cholecystitis, developing individual multicriteria models, and then a decision conference allowed to do the same for the group. After obtaining the group model it could be adapted to a decision support model for the treatment choice of acute cholecystitis. So, the hospital database could be accessed to see how the model would evaluate patients and if possible be improved, resulting in a final model.

Now, the next chapter presents the results about the variability in surgeons' opinions concerning the treatment of acute cholecystitis and the way of supporting that decision making use of the compromise model.

5. Results

In this chapter the results of the multimethodology will be presented. Comparisons will be made between the individual and group models to explore the variability in their opinions. Then, using patient cases, the use of the models will be illustrated, which allows the observation of the influence of the opinions in a final result for the patient and the elucidation of how the group model can be a useful tool, assisting the doctors in their decision.

5.1. Comparing the Individual and Group Models

In this section, individual and group opinions are compared for each criterion, presenting the preference judgments given and the associated value scales. After presenting the qualitative judgments and the value scales for all the criteria, the standard deviation of each level of each criterion is presented in a graph to observe in a general way the extent to which the individual surgeons analyse patients in the same way. When presenting the individual opinions, the detected inconsistencies are mentioned as well as the suggestions adopted to fix them. After the value scales, the criteria weights will be compared, also presenting the inconsistencies noticed in the individual phase.

The value scales and criteria weights presented for each surgeon in the individual models could be a little different if the inconsistencies and validation were confirmed by the surgeons, and here the quantitative comparisons are made with those not confirmed values. Including a way to detect this cases and to validate the procedures in the web-based platform could solve this problem. In the group model this problem does not exist because the decision conference allowed surgeons to participate in every step of the model development, solving inconsistencies and validating always when necessary.

5.1.1. Morbidity

Morbidity criterion presented six levels of performance, since a state of no morbidity to death. The judgments of differences of attractiveness given by the surgeons were made regarding the comparison of the death state (the least attractive level) with all the others and the comparison of all the consecutive pairs of levels of performance. Table 9 presents the classification according to the MACBETH scale given by each surgeon and by the group.

In the given judgments, the comparisons made with the death state were all classified as ‘Extreme’ by 50% of the surgeons and by the group. The comparisons which classification was more divergent in the individual opinions were the ones between Grade I and 0 (no morbidity) and between Grade II and Grade I, since they had classifications in a range from ‘Very Weak’ to ‘Very Strong’.

In the opinion of the group, the comparisons that brought hesitations to the group were classified with two categories, since it is allowed by the MACBETH approach.

After presenting the qualitative judgments according to each surgeon and to the group in table 9, figure 25 presents the number of surgeons that attributed each MACBETH category to each performance level and compares it, side by side, to the group answer, in a more straightforward way. When there are two categories in the group answer, it means that both were considered due to the hesitations of the surgeons.

Table 9. Qualitative judgments attributed to the comparisons of Morbidity criterion by every surgeon and the group. The initials are according to MACBETH scale: N – No; VW – Very Weak; W – Weak; M – Moderate; S – Strong; VS – Very Strong; E – Extreme. The hyphen represents that more than one categories were attributed and the strikethrough represents an inconsistent judgment, being the correction adopted presented after the arrow.

Interviewed Doctors (D)	Morbidity: Differences of Attractiveness								
	Grade V - 0	Grade V - I	Grade V - II	Grade V - III	Grade V - IV	Grade I - 0	Grade II - I	Grade III – II	Grade IV - III
D1	E	E	E	E	E	M	S	S	S
D2	E	E	VS	VS	S	S	VS	VS	VS
D3	E	E	E	E	E	VS	VS	VS	VS
D4	E	VS	S	S	M	M	M	S	~~VS~~ → S
D5	E	~~M~~ → S	S	~~VS~~ → S	M	VS	S	M	M
D6	E	E	E	E	E	M	S	VS	S
D7	E	E	E	VS	VS	VW	M	S	S
D8	E	E	E	E	E	VW	VW	S	S
D9	E	E	E	VS	VS	M	M	S	S
D10	E	E	E	E	E	M	M	S	VS
GROUP	E	E	E	E	E	W	S - VS	S	S - VS

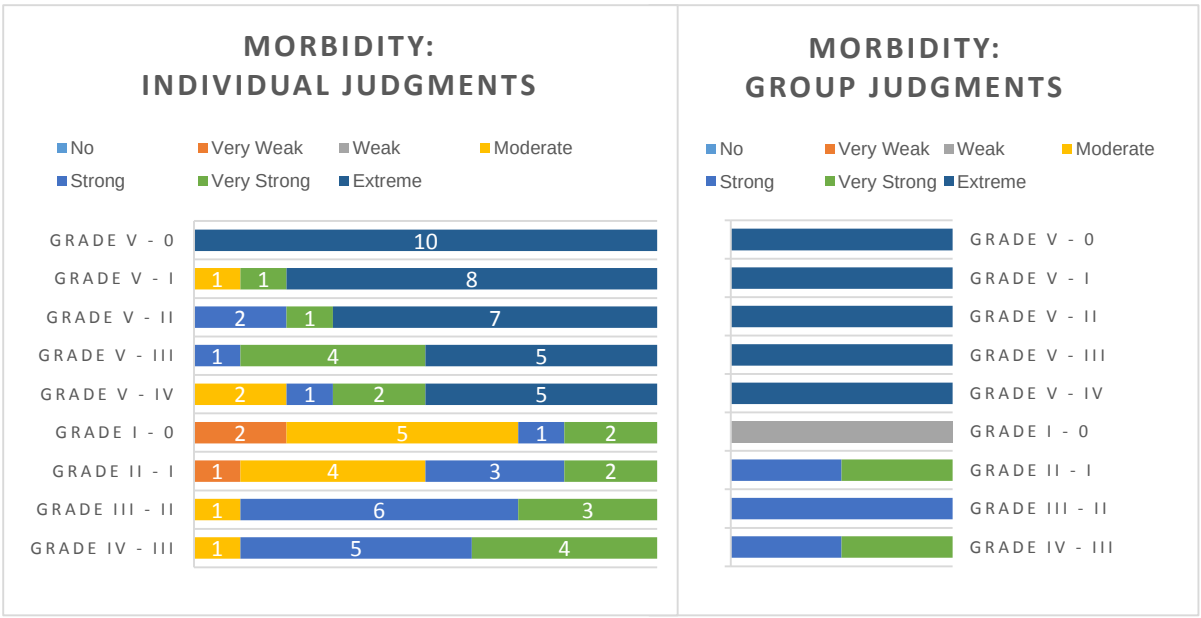


Figure 25. Quantification of MACBETH categories by performance levels. At left there are the individual opinions, considering the inconsistent judgments and not its corrections and at right it is the category or categories selected by the group.

After looking at the graphs of figure 25 it is possible to say in seven of nine comparisons the group opinion translates the majority of individual opinions, being one of them together with the second most chosen (Grade IV-III). Grade I-0 was classified as 'Weak' by the group, which is a category that was not chosen in the individual opinions and it translates less impact than the categories chosen by eight of ten surgeons when asked individually. Grade II-I was classified by two categories, the ones that were chosen in second and third place in the individual opinions by a total of five surgeons. Looking at the individual judgements, the first four comparisons together with the last two present more similar answers than the other comparisons. So, we can say that respecting Morbidity, surgeons analyse more differently comparisons of attractiveness between consecutive performance levels than between the least attractive level and the other levels. Nevertheless, in the group answer, they could easily choose an evaluation together.

Table 10 presents the value scales of the individual and group models obtained by the given qualitative judgments.

Table 10. Value Scales built according to the consistent qualitative judgments for the individual and group opinions.

Interviewed Doctors (D)	**Morbidity Value Scales**					
	No morbidity	**Grade I**	**Grade II**	**Grade III**	**Grade IV**	**Grade V**
D1	175	100	0	-100	-200	-350
D2	180	100	0	-100	-200	-280
D3	200	100	0	-100	-200	-320
D4	200	100	0	-133	-266	-366
D5	450	100	0	-75	-150	-225
D6	175	100	0	-125	-225	-375
D7	133	100	0	-133	-266	-433
D8	200	100	0	-400	-800	-1400
D9	200	100	0	-133	-266	-433
D10	200	100	0	-133	-300	-500
Average	211,3	100	0	-143,2	-287,3	-468,2
Standard Deviation	86,5	0	0	92,5	185,6	336,9
GROUP	125	100	0	-100	-250	-500

Grade I and grade II are the anchors of the value scale, the good and the neutral levels, so their values are 100 and 0 in all situations, not having variation.

Value scales are interval scales thus the length of the interval between performance levels translates the attractiveness of the improvement given by surgeons. So, when the validation was made, in group model, questions such "do you agree that the difference of attractiveness of the improvement between Grade III and Grade II is the same of the improvement between Grade II and Grade I?" were asked.

For a better understanding of the interval scales presented in this chapter, looking at the first three levels it is possible to say that the individual value scales translate that five (D3, D4, D8, D9, D10)

of ten surgeons considered the improvement from Grade I to No morbidity equally attractive to the improvement from Grade II to Grade I, since both intervals have 100 points. The other surgeons considered it as less attractive, with the exception of D5 that considered it as three and a half times more attractive and which contributed to an average of more than 200 to the value attributed to No morbidity level. In group, and explaining these comparisons of attractiveness, surgeons defended that Grade II to Grade I is a more attractive improvement than Grade I to No morbidity so this latter level was validated at 125, which means that the improvement Grade II to Grade I is four times more attractive than Grade I to No morbidity (first interval has 100-0=100 points and the other 125-100=25).

Regarding the level Grade III, there is two values that capture the attention: -75 and -400, the other values are closer to the group value that was -100. According to the group, the improvement between Grade III and Grade II is equally attractive to the neutral-good improvement (between Grade II and Grade I). The -75 case considered the first improvement (Grade III-Grade II) less attractive while the -400 case considered it four times more attractive, both compared to the neutral-good improvement.

In the level Grade IV, the values that diverge more are -150 and -800. The group obtained a value of -250 so for the group the improvement between Grade IV and Grade III was considered one and a half time more attractive than the improvement between Grade III and Grade II. In the individual opinions, for eight surgeons (D1-D5, D7-D9) these improvements were considered as equally attractive, despite the intervals have different between the surgeons, and for the other two surgeons, D6 considered Grade IV to Grade III a less attractive improvement than Grade III to Grade II and D10 considered the opposite.

Finally and respecting the level Grade V, its more discrepant value is -1400, however if the improvements Grade V to Grade IV and Grade IV to Grade II (neutral level) are compared the latter ones are always more attractive, two times in the D5 case and less than that in the others. If Grade V to Grade II (neutral level) is compared with the neutral-good (Grade II-Grade I) improvement, it is always more than two times more attractive, being 14 times in the -1400 case (D8); for the group it is five times more attractive.

In the individual value scales obtained, it was observed that:

- All surgeons agree that the Grade IV to Grade II improvement has more impact for the patient quality of life than the Grade V to Grade IV improvement;
- All surgeons agree that the Grade V to Grade II improvement has more impact for the patient quality of life than the Grade II to Grade I improvement.
- The majority of surgeons (80%) consider that the Grade IV to Grade III and Grade III to Grade II improvements are equally attractive.
- 60% of the surgeons considered that Grade III to Grade II improvement has more impact for the patient quality of life than the Grade II to Grade I improvement.

These assumptions are important for the multicriteria models attribute more or less length in the intermediate intervals (the intervals between the levels of performance).

Now that the interval scales are explained as well as its meaning in the performance levels, the different opinions will be analysed in the other criteria in a briefer way.

5.1.2. Functional Recovery

Following the same structure of Morbidity criterion, the qualitative judgements according Functional Recovery criterion are presented below in table 11 and figure 26 presents the number of surgeons that attributed each MACBETH category to each performance level comparing it to the group answer.

Table 11. Qualitative judgments attributed to the comparisons of Functional Recovery criterion by every surgeon and the group. The initials are according to MACBETH scale: N – No; VW – Very Weak; W – Weak; M – Moderate; S – Strong; VS – Very Strong; E – Extreme. The hyphen represents that more than one categories were attributed and the strikethrough represents an inconsistent judgment, being the correction adopted presented after the arrow.

Interviewed Doctors (D)	Functional Recovery: Differences of Attractiveness						
	Level 5 to Level 1	Level 5 to Level 2	Level 5 to Level 3	Level 5 to Level 4	Level 2 to Level 1	Level 3 to Level 2	Level 4 to Level 3
D1	E	E	E	S	VS	M	S
D2	E	VS	VS	M	VS	M	VS
D3	E	E	E	E	VS	VS	VS
D4	E	~~S~~ → VS	VS	M	W	VW	S
D5	E	VS	~~M~~ → S	S	W	M	S
D6	E	~~N~~ → S	~~VW~~ → S	S	VS	~~N~~ → M	S
D7	E	E	VS	S	VW	M	VS
D8	E	E	E	S	VW	W	S
D9	E	VS	VS	S	M	M	VS
D10	E	E	E	S	M	M	~~S~~ → M
GROUP	VS-E	VS	S-VS	S	W-M	W-M	S-VS

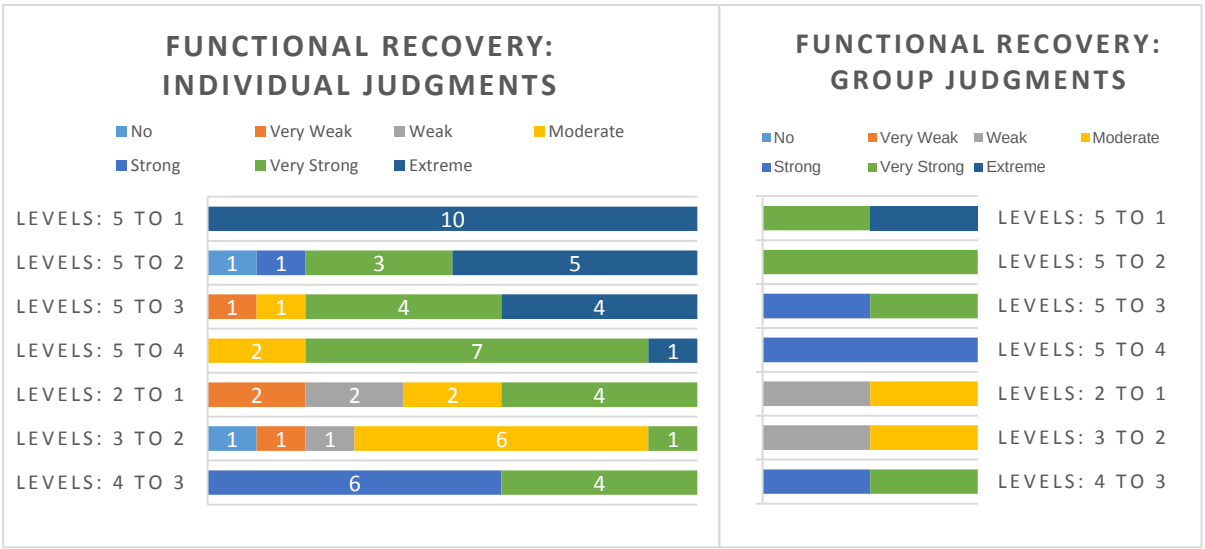


Figure 26. Quantification of MACBETH categories by performance levels. At left there are the individual opinions, considering the inconsistent judgments and not its corrections and at right it is the category or categories selected by the group.

In the given judgments, the comparisons which classification was more divergent in the individual opinions were the ones from Level 2 to Level 1 and from Level 3 to Level 2 with a range of classifications from 'Very Weak' to 'Very Strong'. There is complete agreement in the attractiveness of the improvement from Level 5 (Incapacitate symptoms) to Level 1 (Asymptomatic), being 'Extreme' the MACBETH category attributed in the individual opinions and 'Extreme-Very Strong' by the group.

D6 presented inconsistencies involving Level 2 (Reposition of the state previous to the acute episode) that must be a misunderstanding by the surgeon about the Level 2 because he considered Level 2 with no difference of attractiveness related to Level 5 (Incapacitate symptoms).

After looking at the figure it is easier to see that the group discussion led to choosing categories that not always were selected by the majority of surgeons and for example the improvement from Level 5 to Level 4 was classified as 'Strong' despite this category not have been selected in the individual phase.

Table 12 presents the value scales that translate the individual and group opinions, obtained by the given qualitative judgments or its adopted suggestions when inconsistencies occurred.

Table 12. Value Scales built according to the consistent qualitative judgments for the individual and group opinions.

Interviewed Doctors (D)	**Functional Recovery Value Scales**				
	Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
D1	267	100	0	-133	-266
D2	267	100	0	-166	-266
D3	200	100	0	-100	-220
D4	300	100	0	-400	-700
D5	167	100	0	-133	-266
D6	500	100	0	-133	-266
D7	133	100	0	-166	-300
D8	150	100	0	-200	-400
D9	200	100	0	-166	-300
D10	200	100	0	-100	-233
Average	238,4	100	0	-169,7	-321,7
Standard Deviation	106,6	0	0	86,8	141,7
GROUP	250	100	0	-200	-450

In the table it is possible to see that:

- The Level 2 to Level 1 improvement was considered as more attractive than the neutral-good (Level 3 to Level 2) improvement by four surgeons (D1, D2, D4, D6), less attractive by three surgeons (D5, D7, D8) and equally attractive by the others. The group opinion classifies that improvement as one and a half times more attractive than the neutral-good one;
- 80% of the surgeons consider the Level 4 to Level 3 improvement as more attractive to the patient quality of life than the neutral-good improvement and the other two surgeons

(D3, D10) consider both improvements equally attractive. In the group value scale it is classified as two times more attractive than the neutral-good improvement;

- The Level 5 to Level 4 improvement is considered equally attractive to the Level 4 to Level 3 improvement by four surgeons (D1, D5, D6, D8), two surgeons (D3, D10) considered it more attractive and the other four considered it less attractive. The group considered it as more attractive.
- All surgeons agree that the Level 5 to neutral level (Level 3) improvement has more impact to the patient quality of life than the neutral-good improvement, being four and a half times more attractive in the group judgment.

5.1.3. Patient Satisfaction

The qualitative judgments that translate the individual and group opinions are in table 13. Patient Satisfaction is the criterion with less inconsistencies and they occur in D6: the Level 4-Level 3 improvement is classified as 'Moderate' which is not consistent because the Level 5-Level 4 and Level 5-Level 3 improvements were classified as 'Very Weak' and 'Weak' respectively; and in D7: the Level 5-Level 4 improvement is classified as 'Moderate' and the Level 4-Level 3 as 'Strong' and then the Level 5-Level 3 improvement cannot be classified as 'Moderate'.

Table 13. Qualitative judgments attributed to the comparisons of Patient Satisfaction criterion by every surgeon and the group. The initials are according to MACBETH scale: N – No; VW – Very Weak; W – Weak; M – Moderate; S – Strong; VS – Very Strong; E – Extreme. The hyphen represents that more than one categories were attributed and the strikethrough represents an inconsistent judgment, being the correction adopted presented after the arrow.

Interviewed Doctors (D)	Patient Satisfaction: Differences of Attractiveness						
	Level 5 to Level 1	Level 5 to Level 2	Level 5 to Level 3	Level 5 to Level 4	Level 2 to Level 1	Level 3 to Level 2	Level 4 to Level 3
D1	E	VS	W	W	E	VS	VW
D2	E	E	M	M	VS	S	M
D3	E	E	E	VS	S	VS	VS
D4	E	VS	M	VW	W	M	W
D5	E	S	M	W	VW	W	W
D6	E	VS	W	VW	S	VS	~~M~~ → W
D7	E	VS	~~M~~ → S	M	VW	M	S
D8	VS	VS	M	VW	VW	VS	M
D9	E	VS	S	W	S	S	M
D10	VS	VS	S	M	M	S	M
GROUP	E	VS	S-VS	M	M	S	S

The first two improvements have 80% and 70% of agreement in 'Extreme' and 'Very Strong' categories, respectively, being the group judgment in concordance with the majority. Level 5 to Level 4, that is Very Unsatisfied to Unsatisfied, has a range from 'Very Weak' to 'Very Strong' in the answers, which also occurs with Level 2-Level 1 (Satisfied to Very Satisfied) and with Level 4-Level 3 (Unsatisfied

to Not Unsatisfied or Satisfied). The group attributes 'Moderate' category to the first two cases and 'Strong' to the last one because they consider that a patient who is no longer unsatisfied and starts to be not unsatisfied or satisfied is a more attractive improvement than a patient who starts to be even more satisfied or even less unsatisfied.

Figure 27 shows the quantification of the judgments by improvements according to each surgeon and compares it with the group answer.

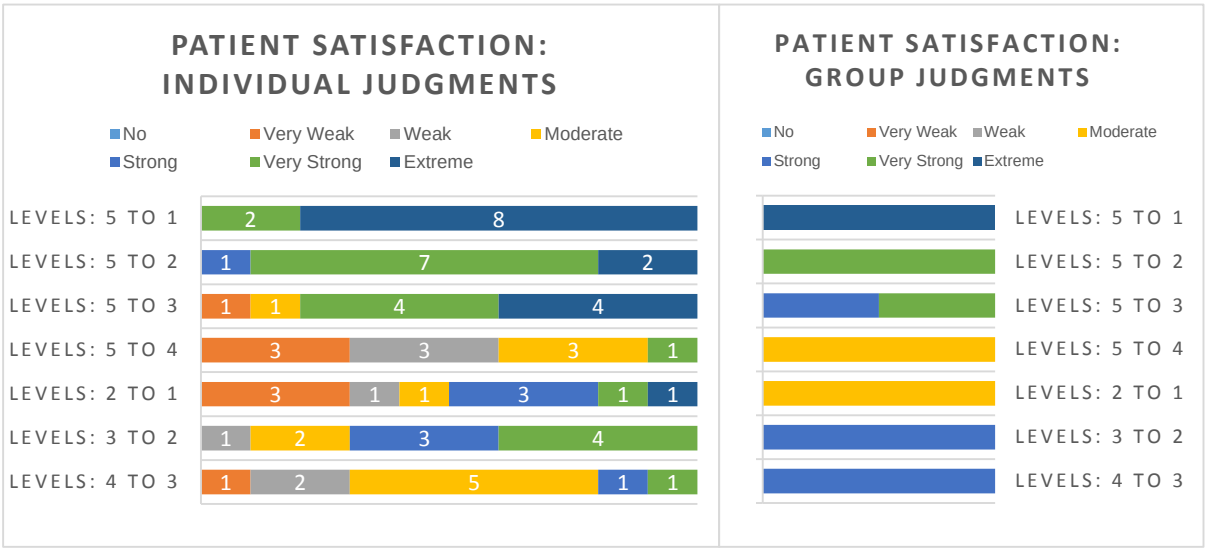


Figure 27. Quantification of MACBETH categories by performance levels. At left there are the individual opinions, considering the inconsistent judgments and not its corrections and at right it is the category or categories selected by the group.

In the group opinion, the first two categories are in agreement with the majority of the individual opinions, as said before. For the other improvements, it is demonstrated once again that discussing the subjects in a group, with everyone exposing their opinions, can lead to an agreement in a way not thought before, or thought by few people.

Table 14 presents the value scales obtained by the qualitative judgments attributed in the Patient Satisfaction criterion and it can be seen that:

- 70 % of the surgeons consider the Level 2 to Level 1 improvement as less attractive than the neutral-good improvement (Level 3 to Level 2). It is considered more attractive by two surgeons (D1, D2) and equally attractive by one surgeon (D9).
- 70 % of the surgeons consider that the Level 4 to Level 3 improvement is less attractive than the neutral-good improvement. It is considered more attractive by surgeon D7, equally attractive by surgeons D3 and D5.
- 50% of the surgeons consider the Level 5 to Level 4 improvement less attractive than the Level 4 to Level 3 one. It is considered more attractive by two surgeons (D1, D2) and equally attractive by three surgeons (D3, D5, D10).
- The group considered that the neutral-good improvement is equally attractive to the Level 4 to Level 3 improvement and these improvements are more attractive than the ones between Level 2 and Level 1 (Satisfied-Very Satisfied) and between Level 5 and Level 4 (Very Unsatisfied-Unsatisfied), which are equally attractive between each other.

Table 14. Value Scales built according to the consistent qualitative judgments for the individual and group opinions.

Interviewed Doctors (D)	Patient Satisfaction Value Scales				
	Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
D1	267	100	0	-16	-50
D2	214	100	0	-42	-85
D3	180	100	0	-100	-200
D4	167	100	0	-66	-100
D5	167	100	0	-100	-200
D6	183	100	0	-33	-50
D7	133	100	0	-133	-233
D8	117	100	0	-50	-66
D9	200	100	0	-75	-125
D10	175	100	0	-75	-150
Average	180,3	100	0	-69	-125,9
Standard Deviation	41,7	0	0	35,4	67,1
GROUP	175	100	0	-100	-175

5.1.4. Patient Costs

Table 5 presents the qualitative judgments given, individually and in group, considering the Patient Costs criterion. This criterion presents more inconsistencies but it has also more comparisons asked to the surgeons. Questions regarding this criterion were considered easier to answer discussing them in group, in the decision conference, than when they were asked in the web-based platform, which happened due to all the possible combinations in the type of costs.

The comparisons with more inconsistencies are from Level 8 to 4 (from costs of medication and extra visits to the hospital plus alteration of the economic balance to the same costs but without alteration of the economic balance) and from Level 7 to 6 (from costs of medication plus alteration of the economic balance to costs of extra visits to the hospital plus alteration of the economic balance).

The first comparison between the least and the most attractive levels almost had total agreement in the classification, having nine surgeons and the group classifying it as ‘Extreme’ and only one surgeon (D8) classifying it as ‘Very Strong, which makes sense since they are the levels associated with more and less attractiveness in the descriptor. Between Levels 2 and 1 the given classifications were from ‘Very Weak’ to ‘Very Strong’, being in the group opinion classified as ‘Weak’.

Figure 28 is presented after table 5 and it shows the number of answers classifying each category and compares it, once again, to the group opinion.

Table 15. Qualitative judgments attributed to the comparisons of Patient Costs criterion by every surgeon and the group. The initials are according to MACBETH scale: N – No; VW – Very Weak; W – Weak; M – Moderate; S – Strong; VS – Very Strong; E – Extreme. The hyphen represents that more than one categories were attributed and the strikethrough represents an inconsistent judgment, being the correction adopted presented after the arrow.

Interviewed Doctors (D)	Patient Costs: Differences of Attractiveness between Levels												
	8 to 1	8 to 2	8 to 3	8 to 4	8 to 5	8 to 6	8 to 7	2 to 1	3 to 2	4 to 3	5 to 4	6 to 5	7 to 6
D1	E	VS	VS	VS	VS	VS	S	VS	S	S	VS	VS	M
D2	E	VS	VS	S	M	M	M	VS	S	S	S	~~S~~ → M	~~S~~ → M
D3	E	~~S~~→VS	VS	~~M~~→S	W	W	W	VS	W	M	S	~~M~~ → W	W
D4	E	VS	S	~~M~~→S	S	M	W	W	M	W	S	M	M
D5	E	E	VS	~~S~~→VS	VS	W	~~M~~→W	VS	S	M	S	W	W
D6	E	VS	VS	M	W	W	W	VW	VW	W	M	~~M~~ → W	~~M~~ → W
D7	E	E	VS	S	S	M	W	VW	W	W	M	S	~~S~~ → M
D8	VS	VS	S	S	S	M	M	M	M	M	S	M	M
D9	E	VS	S	S	S	M	M	M	W	M	S	S	~~S~~ → M
D10	E	VS	~~S~~ → VS	~~S~~ → VS	VS	VS	VS	VW	W	M	VS	M	VW
GROUP	E	VS-E	VS	S	S	M	W	W	M	W	S	W	W-M

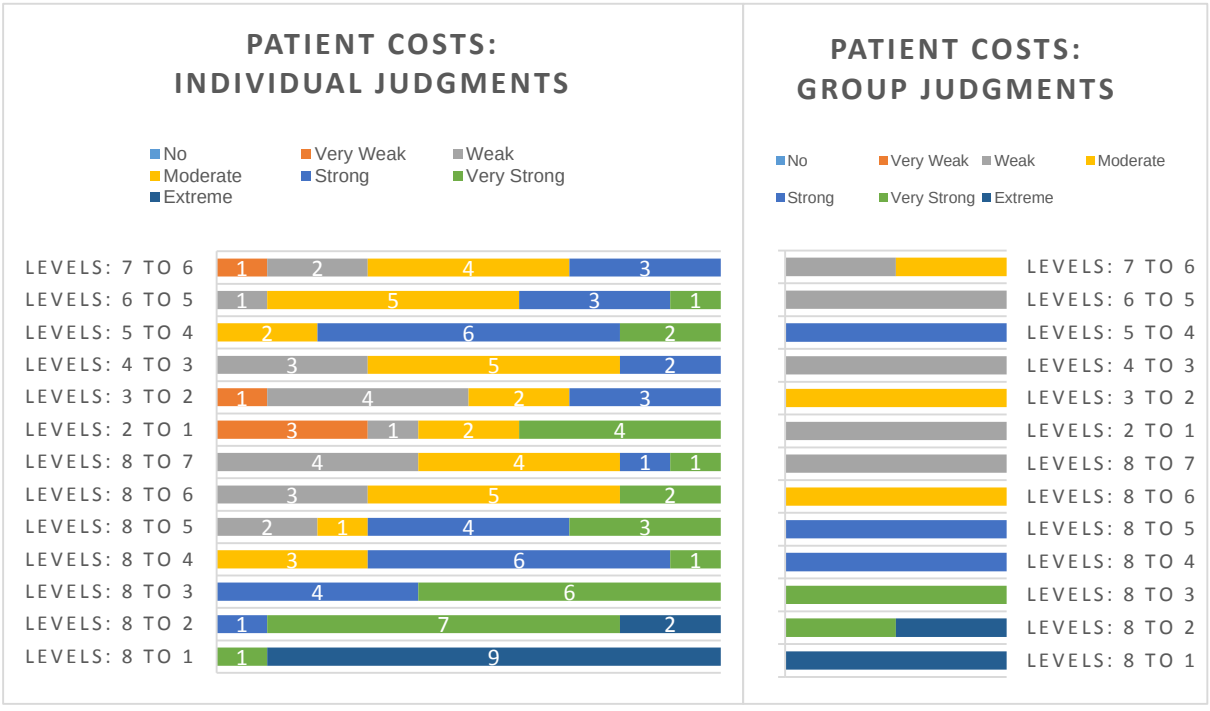


Figure 28. Quantification of MACBETH categories by performance levels. At left there are the individual opinions, considering the inconsistent judgments and not its corrections and at right it is the category or categories selected by the group.

Some judgments of the group opinion translate the individual opinion of the majority of the surgeons however it does not occur always like that, the agreement was reached sometimes according to different judgments.

Table 16 shows the value scales obtained after the qualitative judgments for the individual and group opinions.

Table 16. Value Scales built according to the consistent qualitative judgments for the individual and group opinions.

Interviewed Doctors (D)	**Patient Costs Value Scales**							
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
D1	162	100	50	0	-62	-125	-162	-212
D2	200	100	50	0	-50	-65	-80	-95
D3	267	100	78	0	-88	-111	-133	-155
D4	140	100	40	0	-120	-180	-240	-280
D5	164	100	45	0	-54	-81	-100	-118
D6	133	100	67	0	-233	-300	-366	-433
D7	125	100	50	0	-75	-225	-300	-350
D8	150	100	50	0	-116	-166	-216	-266
D9	160	100	60	0	-140	-280	-340	-400
D10	120	100	60	0	-100	-160	-180	-280
Average	162,1	100	55	0	-103,8	-169,3	-211,7	-258,9
Standard Deviation	43,6	0	11,3	0	54,4	79,4	99,1	115,1
GROUP	140	100	40	0	-100	-140	-180	-220

According to these value scales:

- 80% of the surgeons considered the first improvement (Level 2 to Level 1) less attractive than the neutral-good improvement (Level 4 to Level 2). Only D2 considered it as equally attractive and D3 as more attractive.
- Only two surgeons (D4, D5) considered the Level 4 to Level 3 improvement as less attractive than Level 3 to Level 2, which was also the group opinion. The other surgeons were divided between equally and more attractive.
- In the consecutive comparisons of levels since Level 5 to 8, the group considered that all the intervals should have the same length (in this case 40 points), which translates that they consider these three pairs of improvements equally attractive between each other. This situation also occurred in surgeon D8 but with intervals of 50 points. As mentioned, the length of the interval translates the impact of the improvement, i.e., the difference of attractiveness of that change, according to the surgeon, so according to D8, despite all those improvements being equally attractive, they are considered more attractive than in the group opinion.
- 70% of the surgeons consider the Level 8 to neutral level improvement less than four and a half times more attractive than the neutral-good improvement.

5.1.5. Comparisons of Standard Deviations

The standard deviations of the individual opinions were presented in the tables of the value scales obtained, however, here the standard deviations respecting all the criteria levels are together.

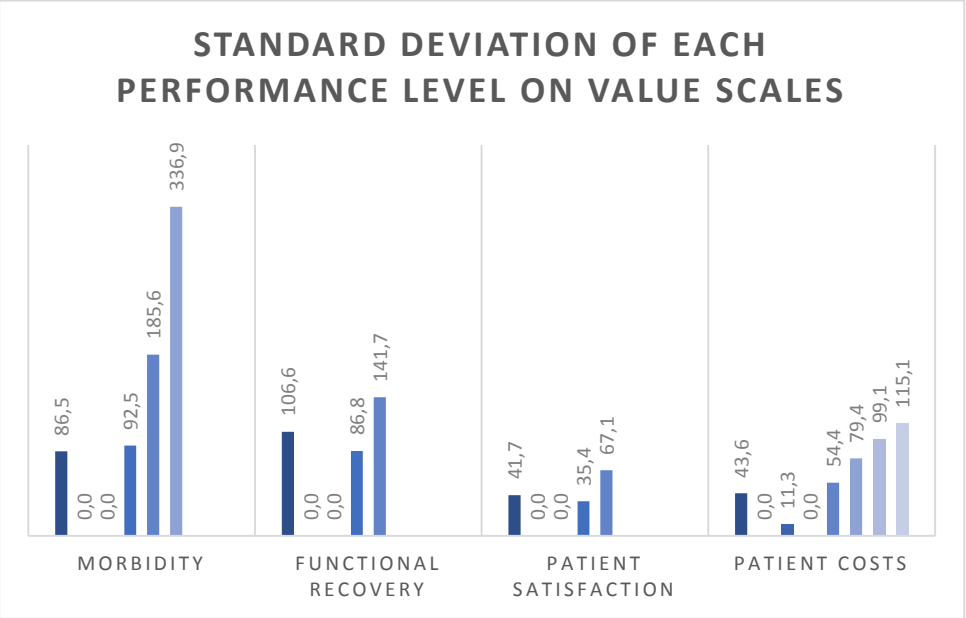


Figure 29. Standard deviation of the performance levels of each criterion in the individual opinions. The zeros are the anchors (neutral and good levels), they have not deviation from their values because the anchors are fixed values in the value scales, which are always 0 for the neutral level and 100 for the good level.

Patient Satisfaction criterion is the one with more agreement, having lower standard deviation values, and Morbidity the one with less. Morbidity criterion presents the higher standard deviation in the last performance level (death state) because the value of death in the value scale goes from -225 to -1400 in the individual models, having an average of -468.

Considering the averages of the values of each level, the group judgments are always in the interval given by the standard deviation added and subtracted in the average, except in the case that the standard deviation is 11.3 in the Patient Costs criterion. Here, the group judgment is outside of the interval however it is by less than four units. Thus, there are not values in group value scales that diverge a lot from the individual ones. Most of the times, in the individual value scales, it was observed similarity in the opinions comparing the attractiveness of improvements.

5.1.6. Criteria Weighting

Table 17 presents the ranking given by the surgeons and the group when they were confronted with all the criteria in the neutral level and they had to choose the order in which they would do the improvements.

Table 17. Ranking of the criteria according to the attractiveness of the neutral-good improvement and its classification using MACBETH scale: N – No; VW – Very Weak; W – Weak; M – Moderate; S – Strong; VS – Very Strong; E – Extreme. In the cells in boxes (D5) the ranking was inconsistent with the judgments and the order was swapped.

Interviewed Doctors (D)	**Criteria weighting: Ranking**			
	Ranked 1st (qualitative judgment)	**Ranked 2nd (qualitative judgment)**	**Ranked 3rd (qualitative judgment)**	**Ranked 4th (qualitative judgment)**
D1	Functional Recovery (VS)	Patient Satisfaction (VS)	Morbidity (VS)	Patient Costs (S)
D2	Morbidity (S)	Functional Recovery (S)	Patient Satisfaction (S)	Patient Costs (S)
D3	Morbidity (E)	Functional Recovery (E)	Patient Satisfaction (VS)	Patient Costs (S)
D4	Functional Recovery (VS)	Morbidity (S)	Patient Satisfaction (S)	Patient Costs (M)
D5	Patient Satisfaction (S)	Morbidity (M)	Functional Recovery (S)	Patient Costs (W)
D6	Functional Recovery (VS)	Patient Satisfaction (S)	Patient Costs (M)	Morbidity (M)
D7	Functional Recovery (M)	Morbidity (M)	Patient Satisfaction (W)	Patient Costs (W)
D8	Functional Recovery (S)	Morbidity (S)	Patient Satisfaction (M)	Patient Costs (M)
D9	Functional Recovery (VS)	Morbidity (S)	Patient Costs (S)	Patient Satisfaction (M)
D10	Functional Recovery (VS)	Patient Satisfaction (S)	Patient Costs (M)	Morbidity (W)
GROUP	Patient Satisfaction (M)	Morbidity (M)	Functional Recovery (W)	Patient Costs (VW)

In the decision conference it was perceptible that the surgeons were ranking the options not considering the neutral-good improvement but they were looking just at the criterion, thinking about what is the more important instead of the improvement they wanted to do first. This reveals how important is involving the decision makers in the development of the multicriteria model and how the on-the-spot development brought advantages. This fact explains why the group ranking has a first option so different of the individual models.

Patient costs criterion, however, reveals itself 70% of the times in the 4th placed in the individual opinions and in the group opinion. In the individual models Morbidity criterion is placed in 2nd by 5 of 10 surgeons but in the other 5 it goes from the 1st to the 4th place and Functional Recovery criterion is placed 1st by 7 of 10 surgeons. This information is more perceptible in the graph of figure 30 that presents the ranking according to individual opinions and then figure 31 presents the quantitative values that is the criteria weights according to all the surgeons.

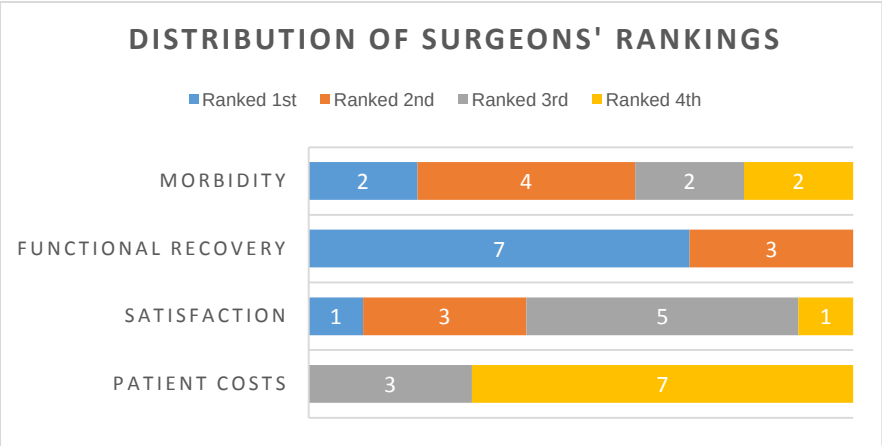
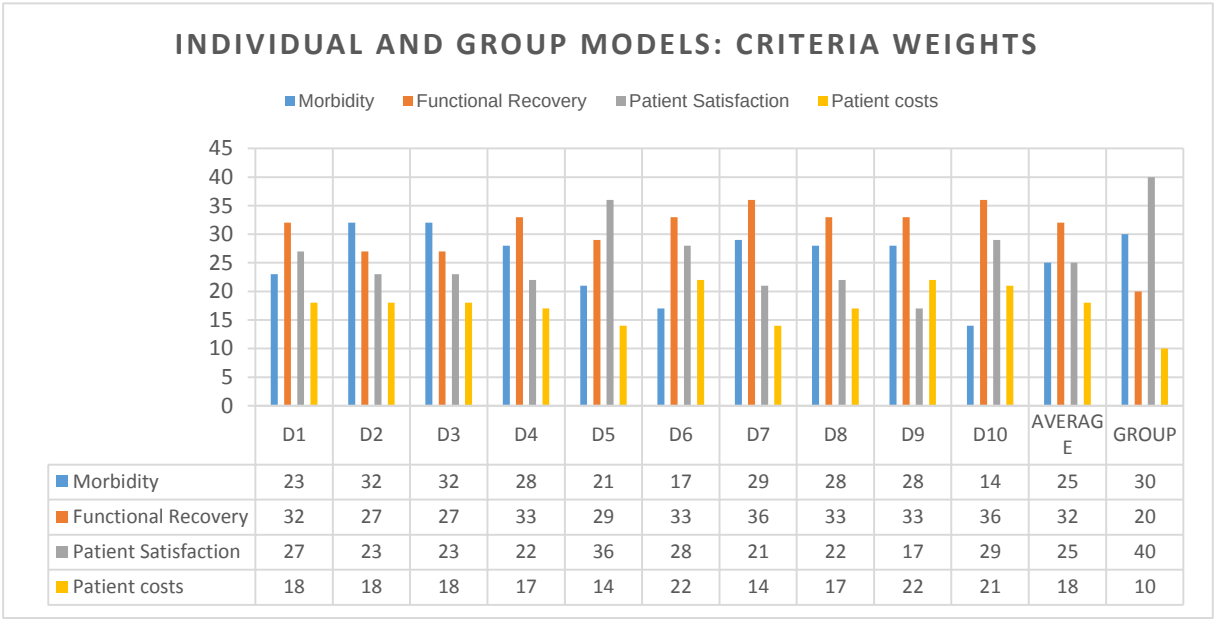


Figure 30. Distribution of criteria by the ranking according individual opinions.



	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	AVERAGE	GROUP
Morbidity	23	32	32	28	21	17	29	28	28	14	25	30
Functional Recovery	32	27	27	33	29	33	36	33	33	36	32	20
Patient Satisfaction	27	23	23	22	36	28	21	22	17	29	25	40
Patient costs	18	18	18	17	14	22	14	17	22	21	18	10

Figure 31. Criteria weights and ranking according to individual opinions and to the group opinion.

In the graphs it is possible to see the impact of the decision conference in the ranking and in the weights. Patient Satisfaction was treated very differently by the group, after understanding that the rank should be based on the attractiveness of the improvements.

5.2. The Models Illustrated by Patient Cases

Each multicriteria model developed evaluates the benefit that each treatment brings to the patient quality of life, in the surgeons' point of view. It can be a useful tool because evaluating all the possibilities allows the observation of what is associated with a higher overall value. However, to measure the benefit of each possibility, it is needed to know the impact of all the possibilities in the

patient, according to the criteria of interest (Morbidity, Functional Recovery, Patient Satisfaction and Patient Costs).

Patient cases were constructed with the impacts on the criteria to see how the models evaluate each case. Next section presents how the cases were constructed and their performances. Then, it is made the comparison between models to observe the impact of the opinions in the answer of the model. Finally, it is explained how the compromise model of the group can be a useful tool for the hospital, aiding in the decision making process.

5.2.1. Patient Cases

Patient cases were constructed accessing the hospital database. However, the information about the impact of both ways of treatment, ELC and ILC, according to the criteria of the model was not available. First, because if a patient undergoes an ELC, the impact about an ILC could not be documented and second because, even for the chosen approach, the needed information was not documented in the database.

To overcome this difficulty, patients with similar medical history were grouped and two groups were chosen to be surveyed by telephone about the needed information: the patients with no clinical history and the patients with diabetes mellitus type II (DMII). DMII cases were chosen for having an increased risk of complications [58]. In these groups there were patients that underwent both ways of treatment. Questioning the patients about the criteria of interest allowed to overcome the second difficulty pointed out about not having the information about the impacts on the criteria. To overcome the first difficulty (about just having the impacts on a way of treatment for a patient), the information of the groups was brought together and two generic patients were constructed, one for each group: patient A – a generic patient without clinical history; and patient B – a generic patient with DMII. The generic patients A and B used the data of all the patients of the groups, the impacts of all the patients with no clinical history and the impacts of all the patients with DMII respectively, allowing to know the impacts on the criteria according to both ways of treatment, since there were patients of ELC and of ILC in both groups. For each generic patient, a best and a worst cases were made with the best and the worst impacts obtained.

First, the impacts on the criteria were assembled considering the more obtained answers of the patients. However, the groups with the wanted specifications about clinical history and with more than 72 hours since the onset of the symptoms that answered by telephone were composed by a really small number of people: eight people to build patient A and nine to build patient B so the cases were built using the data of very few people just to show how the models evaluation process works.

Table 18 is presented next with the general cases made with the more obtained values. After that, two more tables are presented, one for patient A best and worst impacts obtained and another for patient B best and worst impacts obtained.

Table 18. Patient A and B performances in ELC and ILC according to the answers obtained by the patients.

Criteria		Patient A	Patient B
ELC	**Morbidity**	No morbidity	No morbidity
	Functional Recovery	Asymptomatic	Asymptomatic
	Satisfaction	Satisfied	Satisfied
	Costs	With extra hospital visits costs and with alteration of the economic balance. Without medication costs.	With medication costs, extra hospital visits costs and alteration of the economic balance.
ILC	**Morbidity**	No morbidity	No morbidity
	Functional Recovery	Limitative Symptoms	Minimal Symptoms
	Satisfaction	Very Satisfied	Very Satisfied
	Costs	With extra hospital visits costs. Without medication costs and without alteration of the economic balance.	Without costs but with alteration of the economic balance.

Table 19 and 20, below, are the ones that present the best and worst cases for patient A and B, respectively.

Table 19. Patient A best and worst cases reported by the patients of the two treatment options.

Patient		Criteria	Best Case	Worst Case
A	ELC	**Morbidity**	No morbidity	Grade III
		Functional Recovery	Asymptomatic	Limitative Symptoms
		Satisfaction	Very Satisfied	Satisfied
		Costs	With medication costs and extra hospital visits costs. Without alteration of the economic balance	With extra hospital visits costs and with alteration of the economic balance. Without medication costs
	ILC	**Morbidity**	No morbidity	Grade III
		Functional Recovery	Asymptomatic	Limitative Symptoms
		Satisfaction	Very Satisfied	Very Satisfied
		Costs	Without costs and without alteration of the economic balance	With medication costs, extra hospital visits costs and alteration of the economic balance

Table 20. Patient B best and worst cases reported by the patients of the two treatment options.

Patient		Criteria	Best Case	Worst Case
B	ELC	Morbidity	No morbidity	No morbidity
		Functional Recovery	Asymptomatic	Limitative Symptoms
		Satisfaction	Very Satisfied	Not unsatisfied or satisfied
		Costs	Without costs and without alteration of the economic balance	With medication costs, extra hospital visits costs and alteration of the economic balance
	ILC	Morbidity	No morbidity	No morbidity
		Functional Recovery	Asymptomatic	Minimal Symptoms
		Satisfaction	Very Satisfied	Satisfied
		Costs	With medication costs. Without extra hospital visits costs and without alteration of the economic balance	Without costs but with alteration of the economic balance

These cases allow to observe the answer of the models for those patients however the cases are very wide-ranging and they must be improved. Speaking only about the clinical history is scarce information. Besides, the patients with DMII can also have other co-morbidities and to investigate the effect of multiple co-morbidities on the outcomes of the patient is an important matter. Ideally, the patient cases would provide enough information for the doctors to imagine the patient itself. Thus, a lot of work can be posteriorly done here. Next section presents the evaluation of the models to the performances of these patients.

5.2.2. Comparing Results of the Multicriteria Models

The performances of patients A and B are presented in figure 32, below.

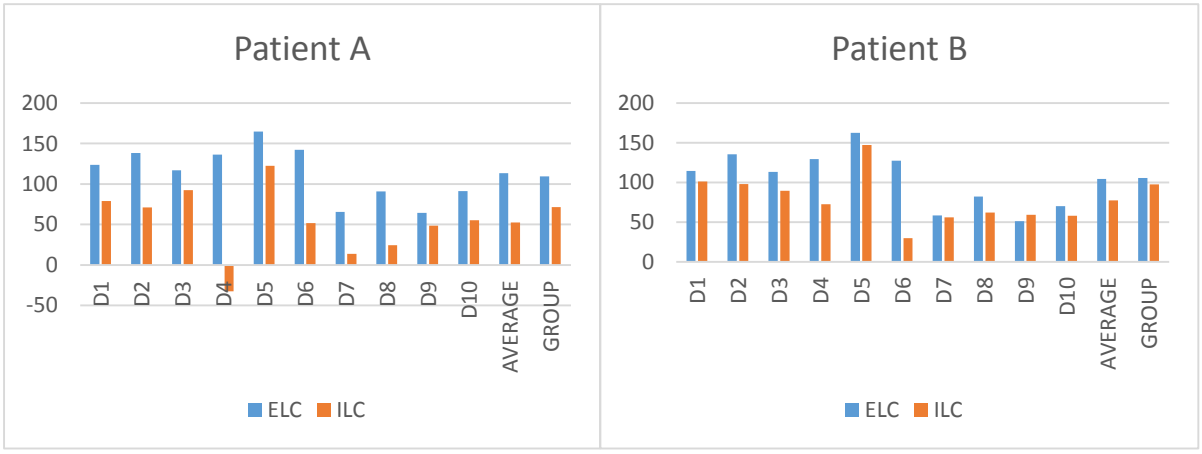


Figure 32. Evaluation of the multicriteria models for patient A at left and patient B at right.

Patients A and B have the same performance on Morbidity, the level with the highest score on the value scale, so, for the two approaches all the patients are evaluated with the maximum partial score on this criterion.

Regarding the other criteria, for patient A an ELC provides a better performance for Functional Recovery criterion but ILC does the same for the Patient Satisfaction and Patient Costs criteria. Looking at the graph, it is possible to see that ELC has always more value than ILC which happens due to the poor performance of ILC reported in Functional Recovery criterion which cannot be compensated by the satisfaction and the costs because, even for the cases that Patient Satisfaction has a higher weight than Functional Recovery, its performance on patient A is not considered so low in the value scale as the performance of Functional Recovery. The same happens with the costs. For example, the negative value associated with the ILC in D4 happens because this surgeon attributed the weight of 33 to this criterion and the performance level of this patient for ILC is associated with -400 in the value scale, so the partial score of Functional Recovery criterion is -400 x 33 = -13 200 while if we look at D5, Functional Recovery is associated with a weight of 29 and a value on the value scale of -133, contributing with -133 x 29 = -3 857 to the overall score, and this result is very different from the previous one. All this values can be consulted in the previous section, where the comparisons of the values are made.

For patient B, the values of both treatment options are similar, in general. The Functional Recovery for this patient varies between Minimal Symptoms or Asymptomatic which is not so much as in patient A. D6 differentiates itself for the major difference between the values of ELC and ILC and D9 differentiates itself because is the only one which model attributes more value to ILC. D6 attributes more value to the asymptomatic state on the Functional Recovery value scale than the other surgeons which contributes a lot to increase the value of ELC because in the ILC it is in the neutral level so the interval in this case is given by the value. D9 evaluates the cost levels with a higher impact than the other surgeons, comparing the interval between the level of ELC and ILC, so for this surgeon's model this partial score impact is sufficient for providing a different result.

Now, it is possible to see the results of the models for the best and the worst to both patients.

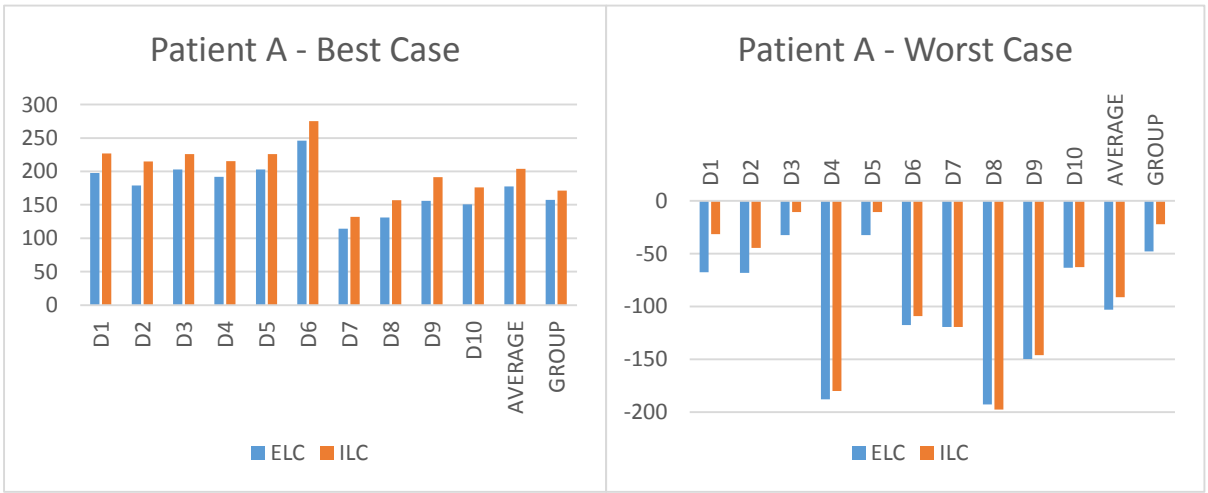


Figure 33. Evaluation of the multicriteria models for the patient A best and worst cases.

In patient A the best impacts obtained with the few patients questioned only differ in the Patient Costs criterion, which are worst in ELC so, obviously, it had to always give more value to the ILC treatment. In the worst case, the only differences are in Patient Satisfaction and Patient Costs. The first has a better performance in ILC and the second in ELC so in the graph at right of the previous figure (figure 33) we can see the results according to each model. In the majority of the evaluations, the values of ELC and ILC are not so different because the differences between the levels of ELC and ILC (for both criteria) are not so big. In the group model, Patient Satisfaction is the criterion with the highest weight and Patient Costs with the lowest so, even with a little difference between the levels on both approaches, the weights influence that difference of value. In D5 it happens the same with the weights of the criteria but in the other cases the differences are mainly attributed to the differences on value scales, once the majority of surgeons does not have weights so different for this criteria.

For patient B, the best and worst cases reported are presented below in figure 34. Once again, the best impacts obtained only differ in the Patient Costs criterion, which are worst in ILC so, obviously, it had to always give more value to the ELC treatment. All the patients of group B, ELC and ILC patients, presented no morbidity and the ones undergoing ILC presented better impacts in the three remaining criteria Patient Satisfaction, Patient Costs and Functional Recovery, so, in this case the treatment with more value was also obvious. The worst performance level reported by patients of ILC in group B were satisfied which together with the no morbidity contributes to a positive overall score of Patient B in ILC even in the worst case graph.

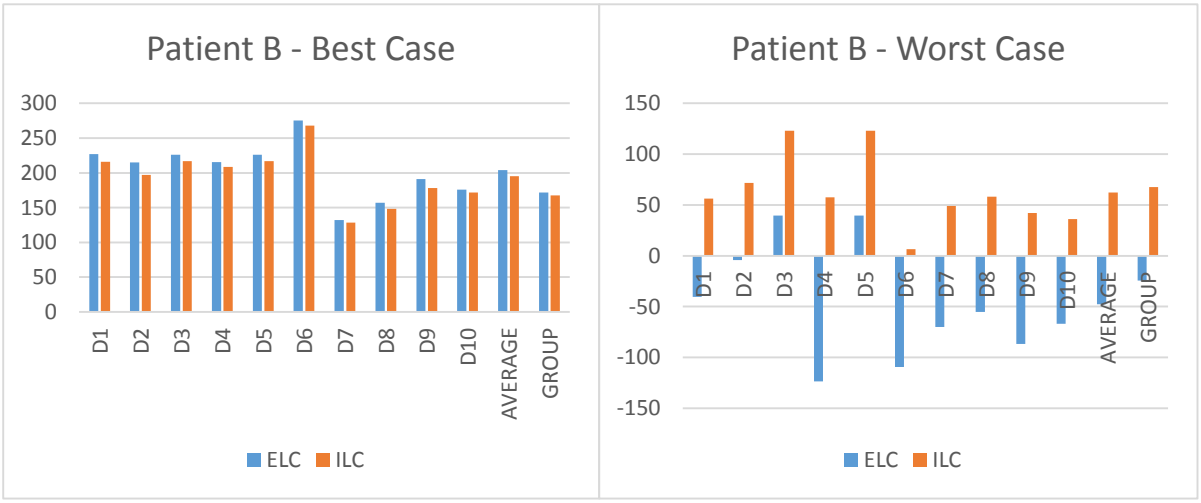


Figure 34. Evaluation of the multicriteria models for the patient B best and worst cases.

These cases of best and worst reported performances are sometimes obvious and they are not good examples to show the application of the model, they have to be refined to be possible a better observation of the results. Like they are now, they are very contrasting. However, the first cases presented contributed to give an idea of how, even with different performances, the multicriteria models result in a score because they had some different impacts in both approaches, pros and cons for each way of treatment, which usually happens in these matters. In those cases the Morbidity was constant

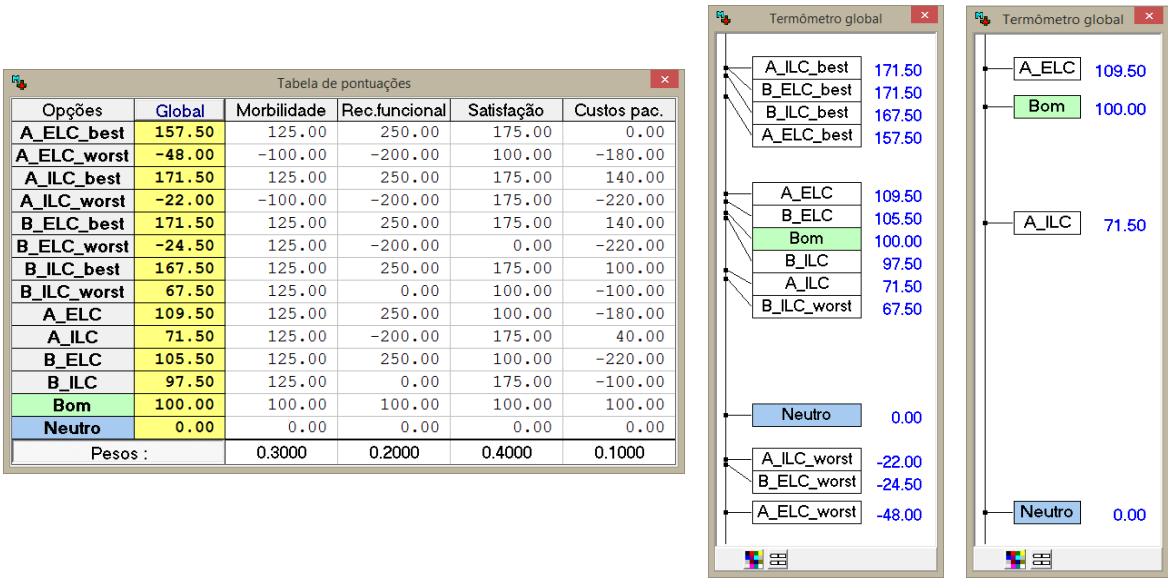
because the information obtained did not have some differences in this criterion, but it would be even more interesting observing the answers of the models to cases in which all the criteria have differences.

In general, despite the different opinions obtained in the qualitative judgments of the surgeons, the answers of the models are similar, converging to a same result for the patients. Next section explain how the compromise model can be used as a decision support model for the hospital.

5.2.3. The Compromise Model as a Decision Support Model

As mentioned, each multicriteria model developed can be a useful tool in evaluating the benefit that each treatment brings to the patient quality of life, in the surgeons' point of view, allowing to know which treatment is associated with a higher value. This way, surgeons could have a way not for obtain a solution but to acquire relevant information in a consistent and well-thought way.

Here in this section, the compromise model results are presented (figure 35) to the patient cases created before, however and because the evaluation of each possibility needs the information about the impact of all the possibilities in the patient according to the criteria of interest (Morbidity, Functional Recovery, Patient Satisfaction and Patient Costs) it would be interesting to add this kind of information in the hospital database. This way and in a long term, several cases could be compared and clustered according to much more specific characteristics of the patients, obtaining more specific patient cases to evaluate with the model. For now, patient cases must also be supported by the literature, trying to obtain information on how single and multiple co-morbidities influence the criteria of the model to specific patient profiles, which must be made more specifically than the cases obtained here.



Opções	Global	Morbilidade	Rec.funcional	Satisfação	Custos pac.
A_ELC_best	157.50	125.00	250.00	175.00	0.00
A_ELC_worst	-48.00	-100.00	-200.00	100.00	-180.00
A_ILC_best	171.50	125.00	250.00	175.00	140.00
A_ILC_worst	-22.00	-100.00	-200.00	175.00	-220.00
B_ELC_best	171.50	125.00	250.00	175.00	140.00
B_ELC_worst	-24.50	125.00	-200.00	0.00	-220.00
B_ILC_best	167.50	125.00	250.00	175.00	100.00
B_ILC_worst	67.50	125.00	0.00	100.00	-100.00
A_ELC	109.50	125.00	250.00	100.00	-180.00
A_ILC	71.50	125.00	-200.00	175.00	40.00
B_ELC	105.50	125.00	250.00	100.00	-220.00
B_ILC	97.50	125.00	0.00	175.00	-100.00
Bom	100.00	100.00	100.00	100.00	100.00
Neutro	0.00	0.00	0.00	0.00	0.00
Pesos :		0.3000	0.2000	0.4000	0.1000

Figure 35. Results of the compromise model for the patient cases presented before. At left there is the table of scores with all the values attributed to each option and the weights of the criteria. At the middle the overall thermometer and at right the overall thermometer without the best and worst cases. (Blue and green boxes are the neutral and good levels, respectively).

So here, if we look at the overall thermometer at right in figure 35 we can say that for patient A an ELC provides more benefit to the quality of life of the patient than an ILC, with an overall performance better than the good level. This is the way that this model intends to help the surgeons: informing them about what is considered better for each patient according to their given notions of importance, attractiveness and requirements. That is why it is so important the restriction of the patient cases because patients are different in several ways, each difference can induce a different outcome and the outcomes must be as much accurate as possible to have the expected performances to insert in the model and see the results.

6. Discussion

This section compares the multimethodology with what was known according to the literature review. Additionally, it is presented a section with the major pros and cons of the followed multimethodology.

6.1. Comparison of the Multimethodology with the Current Literature

In the literature review the problem of the timing in the treatment of acute cholecystitis patients was explored. Despite the existence of Tokyo Guidelines concerning the optimal timing and treatment for these cases, there is no agreement and, consequently, no optimal solution when patients present more than 72 hours since the onset of symptoms. Additionally, studies concerning variability found were based on interviews or surveys, only. Merging the interests, this thesis make use of MACBETH multicriteria approach to explore how surgeons make decisions regarding the choice of treatment of acute cholecystitis as well as to construct a decision support model to assist surgeons in that choice.

Multicriteria decision analysis (MCDA) technique and, particularly, the MACBETH approach was sometimes used in healthcare but cases for choosing the treatment in a set of options were not found to report. In this work, this approach allows to consider several dimensions of the problem because it incorporates multiple criteria which had their weights determined first making use of a web-based platform to access individual opinions and then in a decision conference, on-the-spot, with everyone exposing their opinions and concerns in a group and feeling part of the development of the model. Surgeons' different opinions are explored, to understand their impact on the variability, and a model to support the treatment choice is developed, giving an overall score to a patient state after all the ways of treatment and observing which way is associated with a higher value.

This multimethodology was applied to the acute cholecystitis cases due to the lack of information detected in these cases, however, it can be adapted to other diseases providing information on how surgeons think alone and, at the same time, preparing them with the type of questions for a more dynamic decision conference culminating in the development of a decision support model to assist them.

6.2. Multimethodology: Pros and Cons

The followed multimethodology involved a socio-technical approach that contributed to obtain the needed information together with the decision makers, surgeons in this case. It involved several steps: the structuring of the multicriteria models making use of exploratory interviews, the development of the individual models after obtaining the individual judgments in a web-based platform, and the development of the compromise model by a decision conference bringing all the surgeons involved in the individual models together.

The use of all the methodologies in each step could have been more intensely studied, however, the fact that the surgeons were always participating created a more acceptance in the decision support model and during the development of each phase they could be aware of what was happening and gain confidence and familiarization with the processes and questions' type. This familiarization is very important because guidelines and other tools are not followed by a lot of surgeons mainly because they do not think it is useful, as mentioned in the literature review. Additionally, involving surgeons in the development process was mentioned as a good strategy for them to use that information.

In the beginning it was noted a difficulty in having the surgeons thinking following a value-focused thinking, especially in providing information about what they expected to obtain when they are choosing the treatment without giving specific information about the patients, i.e., in a more general way to explore the criteria. But in the end, especially in the decision conference, it was noted adaptation to the process and willingness to discuss all the matters. So, an alternative way for looking at the problematics were presented and it ended up accepted.

The use of MACBETH approach was also valorised for asking for qualitative judgments instead of quantitative information. In the group they showed they were getting used to the scale and to think about differences of attractiveness, except when they were establishing the criteria weights that they showed misunderstanding in the individual web-based platform questions. Nevertheless, they were clarified during the decision conference. The possibility of inserting more than one category when they were evaluating differences of attractiveness was also very useful in hesitation cases.

The major limitation is the fact that the patient cases are much general and that way the results of the model are not accurately observed. The needed information to do it more precisely was not available in the hospital database and there was no available time to do it with an extensive literature search, however, this is a thrilling path to follow in the future. Additionally, and as mentioned in the results chapter, when inconsistencies occurred in the individual judgments, suggestions of M-MACBETH software were accepted without discussing it with the surgeons. This way, value scales and criteria weights can be a little different from surgeons' opinions, which biases the comparison of views. Ideally, solving inconsistencies and validating the procedures should be made by each surgeon, however, the web-based platform had not the capacity of detecting inconsistencies and asking for the validation of the steps, which is also an improving point for the future.

7. Conclusion

Decision making situations in surgery are something that a surgeon is always exposed to and in which using capabilities acquired by experience and training and the knowledge obtained in guidelines and norms is a constant. However, evidence reported in the literature points out for a large and inexplicable variability in surgical decision making, even in areas in which scientific data exist. Thus, this thesis tried to explore and understand how surgeons think when making the treatment choice for acute cholecystitis patients. This disease was selected because it has a lack of evidence and tools to assist doctors in their decisions about which treatment to choose in patients with more than 72 hours of symptoms, so, besides exploring how surgeons think, a decision support model for this choice is also developed.

To achieve the objectives of explore and understand how surgeons make decisions concerning the treatment of acute cholecystitis patients, as well as construct a decision support model to assist surgeons in the choice of treatment, this thesis built a multimethodology that develops and applies multicriteria methods. First, it uses exploratory interviews to recognise and structure the several issues that surgeons consider in the evaluation of the choice of treatments for a patient. Then, making use of MACBETH based questions in a web-based platform it is constructed an individual model that captures the views of surgeon, for each one of ten surgeons of Hospital de Santa Maria in Lisbon. Then all surgeons are brought together to take part of a decision conference, building then a MACBETH group model on-the-spot. The decision support model intends to evaluate the benefit that each treatment option brings to the patient quality of life, in the surgeons' point of view, for aiding in the choice of the treatment that brings more value to the patient.

This multimethodology was useful to accomplish the objectives, the variability between surgeons' opinions was explored, it was not found influence on a final decision for a patient for the observed patient cases even with some different opinions on the judgments, and the decision support model was built. The fact that the socio-technical approach allowed the familiarization of the surgeons with the process, gaining confidence in it, was a topic of much interest.

Nevertheless, there is a need for improving the web-based platform for the detection of inconsistencies and possibility of validation and for the development of patient cases more specified in a future work. Besides the improvement of patient cases with a more exhaustive literature research and inserting the needed information in the hospital database, an application can be developed for the surgeons just to insert the patients' characteristics in it and obtain the value of each option of treatment for that particular patient. The application could compare the characteristics with the improved patient cases, obtained by the literature and from more data of the hospital.

This multimethodology can also be applied to other diseases that need some guidance on the thinking process.

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8. References

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