Continuous evaluation of health technologies: Development of instrument to evaluate medical devices in the context of invasive lung techniques

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Abstract: Faced with continuous technological evolution and diversity of technologies, the Health Technology Assessment (HTA) seeks to identify those that have the greatest value and help with the decisions of adoption and resource allocation. Many are the goals to be considered in the assessment and, within the same health organization, there are different perspectives. Recognized the complexity in this context of evaluation, there are few instruments that support the evaluation of medical devices (MDs) in hospital settings. Fundação Champalimaud (FC) intends to improve and structure its approach to the evaluation and procurement of medical devices in the context of invasive pulmonary techniques, with potential to be adapted and applied to other contexts. This thesis aims to develop a decision support system, based on multicriteria decision analysis, to support the FC in the evaluation of MD.
The decision support system has its grounds on a multi-criteria model developed based on the MACBETH method and follows a socio-technical approach, in which the evaluation follows several structuring steps (definition of criteria and performance descriptors) and building of the evaluation model (determination of value functions and weights) with a set of key actors of the FC, in order to ensure the various perspectives relevant to the evaluation. Once developed, the model is applied to a set of selected MDs, identifying which alternative has the highest value, proving its potential for the Hospital. In the end, the model is integrated in the proposed system, intended to enable the continuous evaluation of MD.

Keywords: Medical Devices, Multicriteria Analysis, Invasive Lung Techniques, Health Technology Assessment, MACBETH.

1. Introduction

The way health care is guaranteed has been greatly influenced by the rapid evolution and innovation in health technologies (HT), with medical devices (MDs) standing out as crucial resources for health care and without them many medical procedures would not be possible to accomplish, thus contributing to better health results for individuals [1] [2] [3] [4]. However, due to the growing demand for more advanced, efficient, and therefore more expensive technologies, there is an increasing pressure on decision making to ensure that the technologies developed and introduced in the health systems add value to the patients, health professionals and organizations [5] [6].

In healthcare, many decision makers base their decisions on intuitive approaches, historical and political patterns, or in an ad hoc basis, which raises questions about transparency, structure, and extent of their evaluations [7]. Therefore, the need to evaluate health technologies arises to identify those that have value and assist decision makers regarding the allocation of resources[8] [9]. Thus, health technology assessment (HTA) emerges as a multidisciplinary process, to measure and evaluate more accurately the alternatives and their impacts. HTA plays a critical role in promoting cost-effectiveness in health systems, as well as helping decision-makers to understand the added value to support decisions by using a variety of methods [10] [11] [12] [9].

Fundação Champalimaud (FC) is a medical, scientific, and technological centre that has as priority the innovation, research, and discovery of solutions to benefit people, promote the health and well-being. Moreover, it is an organization that is concerned with constantly adopting and implementing the latest technologies and medical devices, in an economically sustainable way, that add value to the patient and that provides visibility to its work. [13] .

In this way, in pulmonology, specifically in the context of invasive pulmonary techniques for patients with the main indication of oncologic lung disease with endoluminal involvement of the trachea and bronchi, FC considers to evaluate the procurement and implementation of a new MD. In the context of decision making, the FC has a commission to evaluate the viability of the procurement of MDs in financial terms and to consider the benefits and risks of their implementation. However, the FC recognizes the opportunity to improve and structure its approach to the evaluation and procurement of MDs in the context of invasive pulmonary techniques, with potential to be adapted and applied to other contexts.

The use of support techniques is increasingly relevant. Several organizations and entities use HTA to inform, contribute and assess the value of procedures as a decision-making support method [14] [7] [15] [16]. However, most of the HTA focus on the clinical efficacy and cost-effectiveness of the technologies, which is a paradigm with several limitations since there are other important criteria to consider [17] [18] [14].

Multicriteria decision analysis (MCDA) is been widely used in several areas, such as support for financial decisions, geographic information systems, environmental impact studies and healthcare, where so far there is little evidence on how to apply it [14] [19]. MCDA has gained special attention in HTA, so it has been gradually introduced in several agencies across Europe in their HTA practices, drug regulation and as a decision support tool [14] [16] [7] [9]. Several studies have discussed the potential of the implementation of MCDA. In

healthcare, however, it is observed that sometimes the methods are used inappropriately or without solid grounds, so there is the need to develop methodological and practical guidelines for the use of MCDA [20] [9].

It is acknowledged that HTA practices, initially developed to evaluate drugs, require various adjustments to be used for MDs. Several projects identify a set of limitations and challenges that need to be overcome to develop, implement tools and methodologies to assess MDs. Therefore, the scarcity of literature and methodologies for the continuous evaluation of MDs in hospital context is recognized, concluding that this is a growing and poorly explored area [21] [22].

This work aims to develop a decision support system, based on MCDA, to support the FC in the evaluation of MDs in order to promote a structured and transparent process that contributes to support decision-making and that is innovative in order to contribute to the literature.

In this study, a decision support system was developed applying a MCDA approach: the MACBETH method, which is an interactive approach based on the value-added principles, enabling the construction of a quantitative model of values through qualitative judgements [23] [24]. This technique has the potential to, through a socio-technical approach, determine the performance of the options giving an overall score, considering the various points of view of the actors and the multiple criteria aligned with the objectives of the organization [25]. In the specific case of this study, it was possible to develop a decision support system to structure and optimize some parts of the current process through the implementation of the developed multicriteria model, which enables the continuous evaluation of MDs.

2. Literature review

The healthcare provision depends daily on an extensive set of MDs, that play an essential role in both results and diagnosis [26] [27]. WHO [2] estimates that there are approximately 2 million different models of MDs, grouped into over 22 000 generic groups. The increase in the amount and variety of devices, simultaneously with the growing expenses of health systems, becomes a challenge to the sustainable and innovative development of health technologies [28]. The continuous development of new health technologies and the budget restrictions becomes a challenge, so that it is necessary to optimize the adoption and diffusion of technologies [29].

In this context of decision making, the use of support techniques is increasingly relevant. This section presents the methods that have been used to evaluate health technologies, some limitations and challenges imposed to the evaluation of medical devices. It appears that most of the methods used have been developed to evaluate drugs, so that it is evident that evaluating MDs generically based on the guidelines created and applied to drugs, leads to a situation where certain characteristics and particularities are not included [30].

2.1. Health technology assessment

The use of assistive techniques is increasingly relevant. From the rising need to select and introduce health technologies more rigorously emerges HTA [31]. Several organizations and entities use HTA as a multidisciplinary process to inform, contribute and assess the value of procedures as a decision support method [14] [7] [15] [16]. There is varied evidence of HTA practices by agencies around the world, used in the evaluation of drugs, however regarding the evaluation of MDs there are still several challenges [9] [32].

It is noted that most health technology assessment literature focuses on the five traditional techniques of economic evaluation [9] [33]. However, there are other relevant aspects to consider. In this way, HTA becomes a challenging process in a multidisciplinary field as such it is necessary to ensure evidence with good quality and adapt the methods used [34] [9]. Hence, there is a need for various evidence at the socio-cultural, legal, ethical, and organizational levels, although there is a recurrent shortage of methodologies to support assessments in a multidisciplinary field [35] [30].

2.2. Medical device assessment

The evaluation of MDs raises several challenges, for these reasons the appropriateness of the methods used is questioned [22]. Most decision-making structures incorporating the taxonomy of MDs have been designed to assess drugs, and therefore they need to be adapted to assess health technologies [35].

MDs differ from other health technologies in specific characteristics, such as: i) rapid modifications and innovations; ii) the efficiency of the results depends on the user's learning curve, i.e., training and experience; iii) cost of procurement and maintenance; iv) impact on the organization in terms of training and infrastructure, which means that all these variables must be considered when evaluating and comparing devices [22].

There is a growth in the number of approved technologies based on scarce evidence. This is due to the complexity of conducting randomized controlled clinical trials of MD, as the results depend on how it is used and the changes that can occur over time of use. Therefore, MD should be evaluated based on an interactive approach to draw conclusions about actual effectiveness [21] [35] [30] [9] [22].

As an emerging area, several projects identify a set of limitations and challenges that need to be overcome to develop and apply tools and methodologies to assess MDs [22] [21].

2.3. Economic evaluation of health technologies

Economic assessments are an important part of the methods used in health technology assessment to compare the various alternatives to support the decisions of which technologies to adopt [36] [11].

Much of the literature on health technology economic evaluation focuses on the five traditional techniques: cost-effectiveness analysis (CEA), cost-utility analysis (CUA), cost-benefit analysis (CBA), cost minimization analysis (CMA) and cost-consequence analysis (CCA). [36] In this manner, to consider the different criteria and obtain the value of the technology, the literature has explored a more comprehensive alternative method to measure the value of health technology introducing multi-criteria decision analysis, which is an emergent

area to help decision making [9] [33]. It is recognized that economically evaluating a MD is different from economically evaluating a drug, there are some challenges in the process of evaluating a MD due to a set of factors, characteristics and applications that characterize each [37] [26]. There is a great variety of MDs in such a way that, it is necessary to consider the particularities of each one when they are evaluated [37].

2.4. MCDA in healthcare systems

The decision-making process can involve different objectives, with different degrees of relevance and even contradictions, so in any organization this process tends to be multidimensional and complex. The critical role of budget constraints in activities, services provided and decisions such as investment, disinvestment, reimbursement, resource allocation, among others, is also highlighted [37] [19] [17].

A careful assessment of the various alternatives is therefore necessary to determine their value and understand their implications so that the necessary conditions are met for taking a coherent decision with confidence and transparency [19] [15].

For a decision-making process to be transparent, tools must be used that can structure, analyse, and evaluate the alternatives, making the process systematic and methodical [15]. Multicriteria decision analysis instruments have proven to be very useful in projects with multiple criteria and limited resources [38]. Thus, MCDA has gained special attention in HTA, so that it has been gradually introduced in several agencies across Europe in their practices of HTA, drug regulation and as a decision support tool [14] [16] [7] [9].

It is also noted that most studies integrating MCDA into HTA are in the field of pharmaceuticals, followed by health technologies, with a much lower percentage of studies applied to MDs [9]. MCDA is a support to the decision-maker through the structuring of high amounts of information, to overcome intuitive processes and human difficulties to analyse and solve complex and multidisciplinary problems [18] [37] [14]. It is an approach used to analyse complex problems with various objectives and alternatives, thus it is a set of tools that allows classifying, selecting and comparing different alternatives, taking into consideration the various criteria of each alternative, allowing individual comparison of each criteria to develop an overall assessment of value [14] [19].

In the methods based on value theory, reference is made in the literature to various approaches to aid multi-criteria decision analysis such as Multi-Attribute Utility Theory (MAUT), Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH), Simple Multi-Attribute Rating Technique (SMART) [39] [40].

In healthcare, the MACBETH has been used in different contexts. This method allows an evaluation of each criterion of each alternative to establish an overall assessment through an additive model. With this approach, it is highlighted that since there is no need for direct attribution of quantitative values by decision-makers, it is possible to avoid some types of errors which tend to occur throughout the decision-making processes [41] [23] [24].

3. Methodological approach

This section presents the methodological approach developed to complete the objectives of this article. Fig. 1 illustrates the main four steps that constitute this methodology.

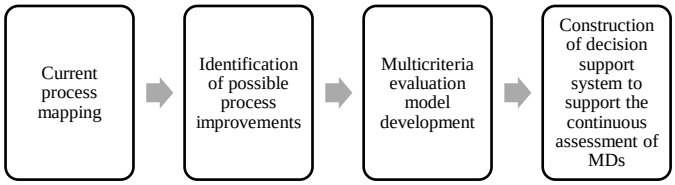

Fig. 1 - Methodological approach steps

3.1. Current process mapping and identification of possible process improvements

Once the objective of this study is to develop a decision support system, based on MCDA, to support the FC in the evaluation of MDs, it is necessary to study the current process of evaluation and procurement of MDs.

The first stage, through unstructured interviews with decision makers aimed to simplify the problem and clarify the practices and methodologies used in the current process of evaluation and procurement of medical devices.

Although it has been verified that the MD procurement and evaluation process implemented has the practice of exploring the benefits and risks of the equipment, as well as performing economic analysis, there are opportunities for improvement, where the second stage fits. In this stage, the actors identified the main challenges and considerations they have about possible improvements.

3.2. Multicriteria evaluation model development

The multi-criteria model developed based on MACBETH, an interactive approach based on value-added principles, enabling the construction of a quantitative model of values through qualitative judgements, i.e., developed without decision-makers having to express quantitative judgements and direct numerical representations of their preferences [23] [24]. This method allows an evaluation of each criterion of each alternative, to establish an overall assessment through an additive model [41].

It is developed through a socio-technical approach, involving a process of interaction with the various decision makers to support the technical component [25]. For the development of the multi-criteria model of evaluation three main phases are recognized: model structuring, model construction and results analysis.

The first stage in the development of the multi-criteria evaluation model is the structuring, in which it is intended to obtain judgments and, the necessary perspectives and information through a social process with the decision makers [42] [43]. In this work, the structuring of the model followed the value-focused thinking strategy, having as focus the goals that are intended to achieve [44] [45]. Once the decision problem is simplified and contextualized, it is possible to define the criteria and build a value tree. Afterwards, it is necessary to proceed to the operationalization of the criteria through the definition and construction of performance descriptors [42] [46] [37]. Performance descriptors help to better understand the

problem, they must be intelligible and operational to have a clear meaning. Thus, all plausible performance levels should be defined for each criterion. As impact levels are defined for the performance descriptors of each criterion, two reference levels are assigned, i.e., one for upper and one for lower reference, called "Good" and "Neutral" [45] [47] [44].

After the model is structured and validated, it is determined the value functions for each criterion and their weighting coefficients, to obtain the global value of each alternative. The developed model uses a compensatory model of additive aggregation in its formulation, allowing the estimation of the overall value of each alternative, as it can be demonstrated through the following equation [47]:

$$V(a) = \sum_{j=1}^{n} p_j . v_j(a)$$

$$\sum_{j=1}^{n} p_j = 1 \ e \ p_j > 0 \qquad (1)$$

$$\begin{cases} v_j(a^+)=100 \\ v_j(a^0)=0 \end{cases} \quad \text{para } j = 1, \dots, n$$

Where V_a represents the global value of the alternative a, p_j represents the weighting coefficient assigned to criterion j and $v_j(a)$ represents the partial value of the alternative a in criterion j. Finally, a^+ corresponds to the "Good" impact level and a^0 to the "Neutral" impact level assigned to each performance descriptor. The additive model is a compensatory model in the sense that the contribution of the value attributed to an alternative in each criterion can be compensated, positively or negatively, by the scores obtained in another criterion [47].

The value functions are determined through qualitative judgements, in other words, without the decision makers having to express quantitative judgements and direct numerical representations of their preferences. The qualitative judgments of the decision makers are entered into the software in a judgment matrix, once their consistency is checked, value functions are obtained for each criterion [23] [24] [47] [38].

Then, each criterion's weights are determined to evaluate its importance for decision makers. To this end, first it is necessary to sort the criteria, asking the decision makers to identify the swing, that is, the transition from neutral to higher level, which they consider more relevant. The identified criterion is placed first in the matrix of weighting judgments, repeating the same process until the swings are sorted in descending order of attractiveness. Afterwards, according to the ordering established in the decision conferences, the criteria are sorted according to the order established in the judgment matrix for their weighting. Then, to fill in the cells of the judgment matrix, except for the last column, decision makers establish qualitative judgments to fill in the judgment matrix. in each cell the decision makers express their judgment about the intensity according to which they prefer an alternative with a "Good" level in each criterion, relative to another alternative with a "Good" level in another criterion. Finally, the completion of the last column is done by judging the attractiveness of going from the "Neutral" level to the "Good" level in each criterion [24] [47] [48].

After the model has been developed, to validate the model and analyses its potentialities, it is selected the alternatives to be evaluated. Using the features of M-MACBETH the consistency of the model is analyzed through the evaluation of the results obtained (overall score of each alternative is obtained and the profile of medical devices is evaluated), cost-benefit analysis and sensitivity and robustness analysis [45] [23].

4. Implementation of the methodological approach

This study aims to develop a model that assists FC in evaluating MD's in the context of invasive lung techniques. In this section, it will be presented the stages that have been completed to develop this model correctly, using the MACBETH method and the M-MACBETH software.

4.1 Model structuring

Through an interaction process with the various decision makers, it has been identified the criteria able to represent the various points of view. The model is structured according to sixteen general criteria, grouped into five areas of concern that allow grouping criteria with common characteristics.

After defining the criteria, they are integrated into the software, where it is possible through the value tree to visually represent the problem. Next, we proceed to the construction of performance descriptors. The decision makers decided that the performance descriptors of the present model should be qualitative and constructed to be easier to adapt to other hospital areas in the future and to avoid some subjectivity conflicts inherent to the matter.

4.2 Model construction

Once the structuring phase of the multicriteria model is completed, the value functions and weighting coefficients for each criterion are determined. Once again, this stage was carried out in decision conferences with the decision makers.

After the model structuring was validated, the value functions were determined for each criterion. In this way, decision makers have evaluated qualitatively the difference in attractiveness between performance levels for each criterion. Once the MACBETH judgment matrix is filled in, the software checks the consistency of the judgments and proposes a numerical scale that gives each performance level a score.

Subsequently, from the various judgements that are inherent to this phase, the matrix of judgements for the weighting of criteria was filled out.

4.3 Alternatives selection

Within the framework of invasive lung techniques, there are several MDs alternatives for patients with the main indication for lung cancer with endoluminal involvement trachea and bronchi. It is considered important to highlight that MDs are mostly used as resources for palliative therapy to reduce obstructions and for symptomatic relief.

Regarding the set of selected alternatives, the decision makers opted for the following set of MDs: argon-plasma coagulation, diode laser, YAG laser and cryotherapy.

4.4 Results analysis

The developed model is applied to the set of MDs identified, and for that purpose, in decision conference the decision makers assigned performance levels to each criterion for each alternative.

4.4.1 Assessment of medical devices

It was possible to verify that the diode laser is the MD with the highest value within the set of alternatives, presenting a score of 65.67, then cryotherapy with a score of 57.61 and argon-plasma coagulation with a score of 44.52. Finally, the YAG laser with a score of 35.46.

A set of tools that M-MACBETH provides was used to analyse the MD profile under consideration, where it was found that diode laser is the alternative that presents a more positive profile in all criteria. Additionally, a tool was used from which it is possible to see for each device the criteria that contribute most in a positive or negative way. Through which it was possible to infer which criteria contributed the most to the overall MD score.

4.4.2 Cost-benefit analysis

The software enables a cost-benefit analysis, by which the costs and benefits of alternatives in monetary units can be evaluated to compare incremental costs with incremental results. [23] Through the cost-benefit graph, it is possible to identify the frontier of effectiveness, in which the alternatives with the best ratio are to be found, namely diode laser and cryotherapy.

This analysis allows decision makers for a given investment value to have information about the MDs with the greatest benefit.

4.4.2 Sensitivity and robustness analysis

The software can perform sensitivity analyses, through which it is possible to evaluate changes in the overall values of the alternatives through variations in the weighting coefficients of the criteria. [23] A sensitivity analysis was carried out for the criteria that contributed the most to the overall MD score: “Security Risk” and “Quality”. It has been found that both criteria are not sensitive to variations in weightings, as the overall scores of the alternatives have not changed.

In addition to sensitivity analysis, a robustness analysis of the model results can also be conducted. This type of analysis allows the results to be analysed more broadly, in the sense that several parameters of the model are simultaneously changed, in such a way that it is possible to compare the alternatives and define dominance relationships. At an early stage, when only ordinal parameters were fixed in the sections on local and global information, it was found that it was not possible to conclude which alternative was the most attractive with information on the order of options and not taking into account the differences in attractiveness. Despite the various question marks in the cells, it was possible to verify that the diode laser dominates the YAG laser alternative, represented by a red triangle.

However, as other parameters were fixed it was possible to infer that the diode laser was the most attractive, dominating the YAG laser and additionally dominating cryotherapy and argon-plasma coagulation.

4.5 Construction of decision support system to be used in continuous assessment

FC considers it relevant to select and implement the latest technologies in the market and MDs that ensure good health care, add value to the patient and visibility to the work it does.

The proposed MD procurement process implements the use of the multi-criteria evaluation model developed, with the aim of supporting and structuring decision-making in the hospital environment of a private organization. Several stages of the current process are maintained, having sought through the suggested implementation of the model to optimize some of the steps.

The acquisition of a new MD follows the detection of the need for a service to replace or add a new technology complementary to that in use. It is proposed that the service concerned should periodically seek to identify the alternatives available on the market for the intended purposes.

FC has no instrument to monitor the results and returns of its activities at clinical, economic, and organizational level, and therefore has no way of reassessing possible investments and disinvestments. Thus, the question of periodicity is quite important since it is intended to enable the continuous evaluation of MDs so that the service in question can regularly identify the most valuable alternatives and re-evaluate their results.

Once the model identifies an alternative with a higher value than the current alternative, it is proposed that the service evaluates the benefits and risks of the identified alternative(s). In this case, if the unit manager and clinical director consider the acquisition of the device to be relevant and advantageous, an application is formalized.

Once the purchasing committee has received the completed form, it should try to gather all the necessary evidence to be able to assess the feasibility in financial terms.

The possible adoption of the instrument proposed in this chapter is intended to make the purchase order and the evaluation of the device itself more structured. It should be stressed that it is very important to draw on the professional and personal experience of the various decision-makers in a way that complements the adoption of the instrument.

5. Discussion

An analysis of the applied methodology, the proposed support system, based on multi-criteria decision analysis and the results of its application to continuously evaluate MDs in the context of invasive lung techniques is presented.

5.1 Model methodology and limitations

To support the process of MDs assessment and procurement in the context of invasive lung techniques, a multi-criteria decision-making analysis approach using MACBETH methodology was used. The multi-criteria model developed in parallel with a socio-technical approach involved a process of interaction through interviews and decision-making conferences with various decision-makers to ensure that all the information,

knowledge and points of view necessary for the development of the model were considered.

The multi-criteria evaluation model has been developed over several decision-making conferences with the involvement of several decision makers. Although some of the decision-makers were not present at the decision-making conferences, they were consulted at various stages of development to give advice and share knowledge in situations where there was a need.

During the structuring phase, the problem was broken down, areas of concern were identified, and criteria were defined. Subsequently, performance descriptors were constructed for each criterion to operationalize them. This phase represented a challenge for decision-makers, and it proved complex to identify all the levels of impact feasible for each criterion, given the context of the problem under analysis. Decision-makers had some difficulty in the construction of performance descriptor of the "Patient Satisfaction" criterion to cover all permissible impact levels of the effect of using the MD on the patient.

In the context of invasive lung techniques, the target of the study are MDs used as palliative therapy resources to reduce obstructions and for symptomatic relief, and not as a curative form. In this way, constructing a performance descriptor for the criterion "Quality of Therapy" has also raised some questions with decision-makers, as the ability of a device to deliver effective therapy with good performance implies several other factors in addition to the technical and operational capabilities of the device. It should be noted that monetization by decision-makers of performance descriptors for cost criteria such as "Cost of Medical Device", "Cost of Therapy for the Patient" and "Cost of Therapy" was avoided. It is considered that this criterion does not fully exploit the impact of the criterion on the model, because the construction of a qualitative constructed descriptor has been chosen, thus representing a limitation in the constructed model.

Once the structure of the model has been validated in decision-making conferences, the model construction phase follows, where the value functions and weighting coefficients of the criteria have been determined. At the first decision-making conference, the value functions were determined by filling in the matrix of judgment. Through the analysis of value functions, it is possible to see that decision-makers have penalized some levels of impact of some criteria by assuming the compensatory model of additive aggregation.

At a second decision-making conference, weightings of the criteria were determined by filling in the matrix of judgements. After decision-makers validated and were satisfied with the model developed, alternatives were identified to which performance levels were assigned for each criterion.

In the process of assigning performance levels to each criterion for each alternative, some subjectivity issues arose, as was the case for the Patient Satisfaction criterion. The decision-makers considered it quite subjective to attribute to a given device a level of patient satisfaction because there are different types of patients, cancer types and stages, among other factors.

In this context, it is concluded that the model developed in accordance with the criteria established, value functions and weighting coefficients established by the decision-makers makes it possible to obtain the value of the various alternatives according to the relative importance attributed to each criterion. Thus, since each patient inevitably reacts differently to treatment, assigning a higher level of performance to a device is not directly related to better results in the same patient.

5.2 Analysis of the results of the evaluation model developed

The model developed was applied to a group of four MDs to study their potential. Through the additive model, an overall score was established for each alternative.

The results of the methodology applied are not in line with what was expected by decision-makers. The model identifies the diode laser as the MD with the highest value within the set of alternatives, followed by cryotherapy, argon-plasma coagulation and finally the YAG laser. However, it was expected by decision makers that the YAG laser would score higher than argon-plasma coagulation. This was due to the impact of weighting coefficients and value functions on the model.

The analysis of the results, based on the tools made available by the software, has made it possible to reinforce that the most attractive alternative is the diode laser. Through the sensitivity analyses carried out for the two selected criteria, it was found that both criteria are not sensitive to variations in the weighting coefficients, so that there are no changes in the overall values of the alternatives. Regarding the robustness analysis, it was also possible to conclude that the diode laser is the most attractive MD when there is inconclusive information.

5.3 Implications of the evaluation model and system developed for FC

The multicriteria evaluation model is an exploratory model that can be developed and tested in other subjects. Considering that the model was developed in the context of invasive lung techniques, it is necessary to adapt the model to the different services.

In addition to investigating whether criteria need to be added or eliminated, it is also suggested that performance descriptors, value functions and weighting coefficients be reviewed so that the model is aligned with the needs and objectives of the service concerned. It is advised that changes are made when decision makers deem it necessary and appropriate, so that the model is kept updated.

The various services should, through a careful assessment process, evaluate the alternatives. So, it is proposed to use the developed model as an aid tool for their evaluation. However, the decision to purchase a MD depends on several factors as can be seen from the model developed. Lastly, the collection of this information must be carried out with all the necessary input, so that all the necessary data is available when the time comes to apply the model to a set of alternatives.

6. Conclusions

FC seeks to adopt and implement devices in an economically sustainable manner, which add value to the patient and give visibility to the work it carries out, hence always seeking to adopt the latest technologies on the market, in order to have the necessary technical means. Selecting health technologies is a complex process. Many are the objectives to be considered in the evaluation, and in the same organization many are the different perspectives.

Recognizing the complexity of decision making, there are few instruments to support it in a health care setting where decisions tend to be taken in an unstructured way, drawing on professional experience, interest, and personal knowledge. This unsustainable form may lead to choices that are not provided by the best available information.

Facing the continuing technological change and diversity of options, health technology assessment seeks to identify those of greatest value and assist in resource allocation decisions. This is a growing and under-developed area, mainly within the MDs.

This Dissertation is intended to develop a tool to support and structure decision making regarding the valuation and procurement of MDs. This instrument is supported by a multi-criteria decision-making approach using the MACBETH methodology. The model is developed for continuous assessment of MDs in the subject of invasive lung techniques, with potential to be adapted and applied to other subjects. Once the relevant alternatives for FC have been identified, it is possible to obtain an overall assessment of the value of each identified alternative and consequently analyse the potential of the model and support purchasing decisions.

The application of the MACBETH methodology, although sparsely explored in the MDs assessment, has the potential to be explored in solving problems involving multiple objectives, multiple criteria, and multiple decision makers. It should be noted that the multi-criteria model was developed in the context of invasive lung techniques, so for future work it would be interesting to apply the model developed to other contexts and services to test its consistency and potential.

In addition, the multi-criteria model developed has proved to have potential for future work both to be applied in FC activities and as a basis for the development of future methodologies. Although multicriteria decision analysis is an emerging area in decision support, it is still growing and under-developed within the MDs. Thus, although there are still several theoretical and practical challenges to be explored, it proves to be an innovative and promising topic for future work.

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