Project Planning for Improvement in a Healthcare Environment:

Developing a prioritization approach to managing patients' access to the Urodynamics exam

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Abstract: The first-in first-out rule does not seem the most appropriated to manage the access of patients to health exams or services such as, for example, surgery. Indeed, each patient has his/her level of urgency and, furthermore, the utility that each patient retires from the service differs according to several clinical but also risk and social-related aspects. The decision of which patient to prioritize is tough because, in the current context, where capacity is much lower than demand, choosing one patient means to delay others. Thus, this paper proposes a project methodology to prioritize patients into a Urodynamic service. The methodology, developed by a multidisciplinary team, is applied in a public hospital in Brazil, taking into consideration clinical and social criteria. We interviewed Urodynamics specialists, and a Fuzzy-AHP method was used to compute the weight of each criterion. Our preliminary results show the potential of the proposed methodology and methods, and that not only for the described case, but for other health services facing similar problems.

Keywords: Prioritization, Urodynamics, Project, Fuzzy AHP, Healthcare

1. INTRODUCTION

The Urodynamic procedure of Hospital de Clínicas (HC) is a service with a substantial volume of exams, as well as attending patients from the urology outpatient clinic, and it also receives patients from other specialties such as gynecology and coloproctology. During recent years, the waiting list has grown to reach currently approximately 3,000 patients and an average waiting time of 3 years.

The HC's Ombudsman, who receives patients' complaints and compliments, has reported that urodynamics is the service of the urology unit that receives the most complaints, mostly because of the delays of the exams, which suggests that the hospital's capacity for this particular service is below the actual demand.

Hospital managers have therefore decided to create a team of experts to improve the patients' flow at the Urodynamics Service. The team includes members of all the professional categories involved in the service. Several meetings were organized to discuss the manner in which the service manages its patients' waiting list and, in particular, how patients waiting for the urodynamic procedure were prioritized, which lead us to the formulation of this research's objective: how to develop an uro-functional score for risk classification of patients who requests a urodynamic exam?

This paper formalizes and explains the phases and steps to identify and assess the main relevant criteria to elaborate a risk score to prioritize patients' access to a medical exam, named urodynamic procedure. It focuses on the managerial aspects of the project rather than the methodological ones (i.e., the multicriteria decision-making approach) that are out of the scope of this publication. The paper is structured as follows. The next section presents some theoretical background on the considered medical procedure and reports related works on decision-making applications in healthcare; Section 3 presents the applied methodology while current results are reported in Section 4. Finally, Section 5 presents our conclusions and sketches of the next steps of the project.

2. THEORETICAL BACKGROUND AND PREVIOUS RELATED WORKS

This section is divided into three parts, the first one being devoted to the Project Management's methodology used in this research, the second one providing some basic background on urodynamics exam, and the last one presenting scientific works that have applied the AHP methodology to healthcare management problems. It is not the purpose of this section to be exhaustive concerning the literature but to present the theoretical background of this work.

Harvard Business School (2016) identifies four main phases of project management, which should be used independently of the project's size, from a simple website to the construction of a car, or the determination of the prioritization for a very complicated exam in a public hospital. The four-phases are:

1. Planning Phase: Its primary goal is to determine the problem to be solved, identify the collaborators, the function of each one within the group, define spaces, time, tools, and costs. The definition of objectives, the determination of the scope, resources, and tasks that each collaborator will execute must be well defined. Underestimation of time and money may cause, many projects fail. Still, within the planning phase, the Harvard Business School (2016) suggests to initiate the analysis of the project's trade-offs – time, cost, and quality – that typically dictate the project's solution space.
2. Build-Up: It is the construction phase, where the coordinator must elect the group's members, defining tasks according to the ability of each of the participants, planning assignments for each one, creating a realistic scale of time and resources. At this stage, meetings are also organized to return to the established objectives and to the tasks performed by the participants. It is also at this stage that we must determine the costs with personnel, training, travel, supplies, among others.
3. Implementation Phase: It is time to put the project into action. This is the most rewarding phase of the project and sometimes the most frustrating. At this stage, rapid meetings should be held to monitor and control budgets, adjust dates and scales, exchange information, manage problems both related to the development of the project, and personal problems of employees. Evaluate the project results, reorganize efforts in the latter case to close the project.
4. Closeout: Once the project has been completed, hold a meeting with the collaborators to recognize the efforts and accomplishments of the team. Special attention is given to discuss "learned lessons". This time is for discoveries and not for criticizing or blaming some of the contributors.

Urodynamics, also known as a urodynamic study, is the term that describes a set of tests that allows evaluating the transport, storage, and elimination of urine, especially in cases of complaints of lower urinary tract symptoms (MONTEIRO, 2012). The most common evaluations include filling and bladder storage through filling cystometry and urethral pressure profile, elimination of urine through the bladder through uroflowmetry and voiding study, and transport of urine. Besides, it is possible to perform, along with these steps, electromyography in order to evaluate the urinary sphincter (MAITIN, 2016).

Urodynamics has been considered a handy tool for the diagnosis of LUTS (Low Urinary Tract Symptoms), incontinence, neurogenic bladder, among others (COLLINS, 2014). Thus, the American Urological Association (AUA) and the Society of Urodynamics Female Pelvic Medicine and Urogenital Reconstruction (SUFU) published guidelines to the use of this test, listing a series of indications. Traditionally, urodynamics has been used to the following scenarios: identifying factors that contribute to lower urinary tract dysfunction and assessing its relevance, predicting the consequences of lower urinary tract dysfunction and outcomes of the intervention confirm and understand the effects of intervention techniques and investigate the reasons for therapeutic failure (COLLINS, 2014).

Although the literature suggests a set of conditions justifying the need for this exam, there is still no Brazilian guideline that standardizes care considering our social reality and medical indications. However, the literature proposes several prioritizations or waiting lists management schemes used in other medical specialties.

Déry et al. 2020, in a systematic review on Patient Prioritization Tools (PPT), states that long waiting times and other problems of access to healthcare services are key challenges that public healthcare systems face. Patient prioritization policy could help to manage access to care equitably. Their findings suggest that generic criteria, such as non-clinical or social factors, could be added to condition-specific criteria in PPTs to represent more fairly and precisely patients' needs to receive healthcare services. Patient prioritization is a strategy used to manage healthcare services access. The PPT could help ease the patient's prioritization decision process in an explicit, transparent, and fair manner. Other advantages associated with PPT use were identified, mostly related to the acceptability of the tools by clinicians and increased transparency and equity for patients. (DÉRY et al. 2020)

Mullen (2002) studied waiting list management in UK, and concluded that the UK's health systems do not have clear objectives in placing patients in waiting queues. To the author, waiting lists are influenced by the discipline of the queue, since traditionally, the selection of patients can be determined by factors such as medical urgencies, professional priorities and time in the queue. Waiting lists have a fast growth when resources are scarce, and rationing for time is better than price rationing, (Mullen, 2002). The downside is that long waiting periods aggravate the patient's clinical situation causing distress and pain. Viberg et al. (2013) conducted a study on waiting lists from 23 countries, and concluded that waiting lists are a severe health policy issue and that institutions have tried to remedy this problem through different methods of evaluation.

Rahimi et al. (2016) proposed a prioritization framework for orthopedic patients in a hospital in Iran. The authors emphasize that although prioritization and triage approaches exist for patients waiting for transplants, emergency cares, and intensive cares, there is a lack of adequate prioritization systems and tools for elective exams and surgeries. They also insist on the fact that the prioritization criteria should be determined by the clinical experts, but that other stakeholders among which patients and their families, must participate in the process. Finally, they report that surgeons that participated in the study concluded that the framework produces a precise and reliable prioritization that is more effective than the prioritization method currently in use.

In decision-making theory, some issues are subjective and determined by the choice of people or a group of people. As a simple example, the purchase of a house, where price, size, and location would be criteria for the purchase or not of the property. Price and size are objective or quantifiable criteria, but the definition of "a well-located home" is different for each person. Due to the subjectivity and the personality of this decision, it becomes a characteristic of the decision-maker. In healthcare, we have these types of subjective decisions, too; as the prioritization of a patient to have surgery or exam, or the prioritization of a particular surgical specialty to use an operating room in the Surgical Center.

In order to quantify this subjective preference of the decision-makers, the multi-criteria decision methods were developed, among them the Analytic Hierarchy Process (AHP) designed by Thomas Saaty in the 1970s (SAATY, 1977). In this method, the decision problem is disaggregated into criteria, and these are structured in hierarchical levels which facilitates their understanding and evaluation. After applying a questionnaire to a person (or a group) that will perform the decision, and using matrix calculus, the AHP is able to determine the weight of each criterion. The main feature of this method lays in the ability to convert subjective opinions into quantitative data. Unlike statistical methods, the AHP does not require sample size because its purpose is to map how a person (or group) makes decisions.

Muhlbacher and Kaczynski (2016) applied the AHP to identify and evaluate the relevant decision criteria of physicians regarding the drug treatment of functional dyspepsia and motility disorders. Attributes such as the onset of action, reduction of symptoms, and side effects should be examined to test their relevance to health decision-makers. Applying the AHP methodology, the study concluded that the following criteria were found to be the most relevant and their relative importance (weights): reduction of abdominal cramps (0.302), reduction of epigastric pain (0.250), and time of onset of action (p: 0.117). Rahimi et al. (2016) use AHP in conjunction with other Operational Research techniques to prioritize patients in an orthopedics' service. Otay et al. (2017) carried out research in 16 hospitals in Istanbul that used the Fuzzy AHP method for performance evaluation. In this problem, uncertainty and subjectivity is an unavoidable component of the decision-making process. As part of their evaluation, they chose to transform the answers coded in Fuzzy linguistic states to a crisp number.

Jamshidi et al. (2015) used the AHP to consider the risk into prioritization decisions. Their study concerned how to select the best maintenance strategy for hospital medical equipment such as incubators, monitors, infusion pumps, among others. Their proposal produces accurate and reliable results and not merely an ordering. They prove to be possible to select the best maintenance policy of the equipment based on the importance and the level of complexity of each device.

Nazari et al. (2018) developed a Clinical Decision Support System (CDSS) for heart diseases in collaboration with a hospital in Tehran, Iran. The CDSS was intended to identify patients with a high risk of heart disease. In their study, 100 patients were evaluated by the CDSS, and the results compared to the diagnostics made by professionals. Eighty-one of the professional diagnostics required further high complexity exams, to conclude that only 20 of the patients had heart diseases. For the same 100 patients, the CDSS which encompasses Fuzzy-AHP technology, suggested further exams to only 26 patients including the 20 patients that were finally confirmed as suffering heart diseases, confirming the potential of CDSS to reduce the hospital workload and to achieve a more efficient use of the resources.

3. THE METHODOLOGY

The primary goal of this project is to provide an unbiased prioritization score for patients waiting for the urodynamics' test. As it was said before, there are currently more than 3000 patients on the list, so waiting times for the test are too long. To mitigate this problem, a multidisciplinary team was put together; it was agreed that the methodology to solve the problem would be divided into four phases, following the Harvard Business School (2016). A team of healthcare professionals, mostly physicians and nurses, was responsible for defining the prioritization criteria that should be used to assess the needs of each patient. A second-team composed of Mathematicians, Engineers, and Statisticians was in charge of computing the weights of the criteria defined by the Healthcare Team.

Currently, the project is entering into the Implementation Phase, where the Healthcare Team will analyze a pilot sample of patients. Only after this validation, the full-scale implementation will take place. It is essential to notice that even after the implementation, a cycle of control and adaptation of the weights and criteria might be necessary to fine-tuning of the prioritization tool. It is also important to stress that once this methodology will be validated, it will be ready to be adapted to any other waiting list in the hospital.

Figure 1 shows the steps of the proposed methodology, starting from the Planning Phase, where a literature review lays the basis of the steps of our project, the methods of prioritization, and the clinical criteria were defined. In the Build Up phase, the data were acquired, treated, and a proposal of weights for each criterion and a sample of prioritization are the main output. In the Implementation and Close-Up phases, this sample is analyzed by the Healthcare Team and once validated, the implementation will start. It is worth notice that the criteria and the weights may be revised until convergence is found.

3.1 Planning Phase

The planning phase of a project seeks to define its fundamentals: what problem needs to be addressed, who will be involved, and what will be done (Harvard 2016). The main problem of this project is clearly stated, the size of the queue and the resulting waiting times for the patients needing

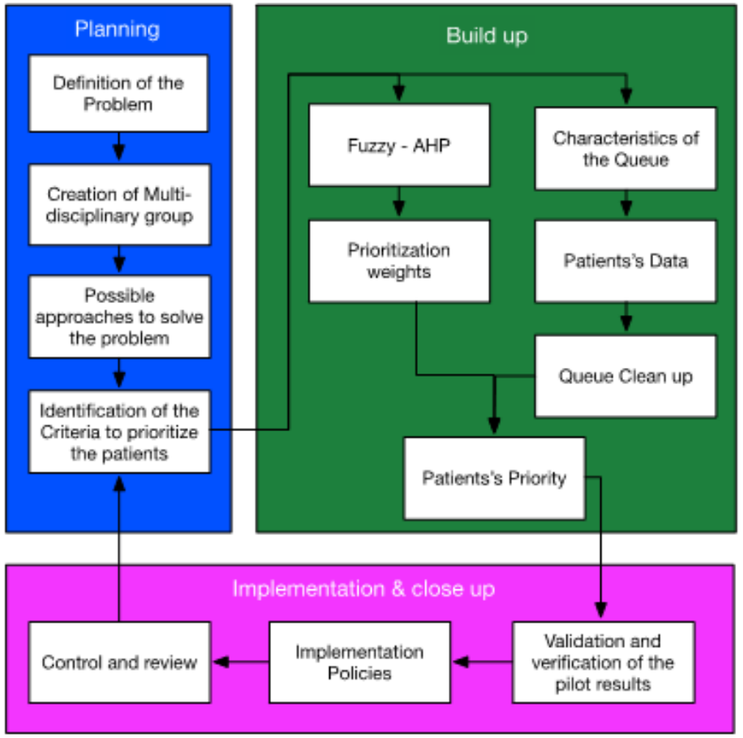

Figure 1 – The project phases.

urodynamics. The stakeholders of the project are the patients, the medical team, and also the administrative team. The project objectives are: identify, from all the patients in the list, the ones who really need to be there, and for the remaining patients, prioritize from the most to the least urgent using an uro-functional risk score.

3.1.1 Creation of the uro-functional multidisciplinary group

A multi-professional research group, containing professionals from all the stakeholders, was constituted to plan this project, from the identification of the objectives to the indication of the urodynamic risk score in the Clinical Hospital of the Federal University of Paraná (UFPR). The group has 13 professionals including a Urology Medical Professor, a Urological Physician, Medical Academics, Statistical Academics, Hospital Nurses, an Information Technology Technician, and a Business Administrator. After their first meeting, the group decided to invite analytics professors from the Business Department. All the members are related to the Federal University of Parana.

During the first phase, the research group met once a week for discussion and elaboration of the project, including the evaluation criteria, as well as other essential subjects according to the need of each participant of the project. Constant communication between the group members was assured by instant message groups; we believe that the interaction between the Analytics Team with the Healthcare team was one of this project's key to success.

3.1.2 Risk Criteria Mapping

The risk criteria are guided by the definitions of the Brazilian Society of Urology (2010). At this point, each member of the group was responsible for carrying out a part of the work, making the necessary considerations to create the criteria risk mapping, which attends to the clinical necessity but also to the data necessity. All the criteria were categorized by the clinical importance but also by the availability of the data, once it is unworthy of having criteria that we did not have access to the data. Other essential parts of this project planning included the identification of the methods to be used, the essential data for medical evaluation of the need for the exam, the administrative steps to be followed according to institution norms, and the statistical and information technology to be used to the data analysis. This diversified team with complementary strengths made the discussions very dynamic and productive. It is worth emphasizing that the team put together people in charge of data analysis, people offering direct assistance to patients, and even people performing administrative tasks.

The planning phase was closed with the criteria mapping, which was elaborated under the coordination of the urologist medical professor, and that takes into account both the needs of each pathology and the social aspects of the patients. The mapping leads to a criteria structure, depicted in **Figure 2**, and that hereafter will be referred to as Urofunctional Structure. It is composed of five main criteria: Disease Found, Health Problems, Social condition, Quality of Life, and Complementary Exams. Each of these main criteria includes two to four sub-criteria. The next paragraphs describe the main criteria and the sub-criteria they encompass.

Disease Found – identify and consider specific symptoms that can be observed in patients referred for a urodynamics test. Includes:

- **Benign prostatic hyperplasia (BPH)** is the most common benign neoplasm in men. It is the clinical manifestation of prostate enlargement, causing urinary symptoms that harm the quality of life of the population. The statistics show that from 55 years, 25% of men have complaints about some urinary symptoms.
- **Urinary Incontinence Refractory** (UI): Urinary incontinence is already treated clinically with physiotherapy, drug therapy, psychology, among others, unsuccessfully.
- **Stress Urinary Incontinence** (SUI): is defined as involuntary loss of urine during exertion such as exercise, coughing, or sneezing.
- **Mixed Urinary Incontinence** (IUM) is the combination of urinary urgency and stress urinary incontinence.
- **Overreactive bladder** (OB) is a syndrome characterized by the symptoms of urinary urgency with or without urge incontinence, usually accompanied by increased voiding frequency and nocturia (urinating at night) with no local or metabolic cause.
- **Neurogenic Bladder** (NB) term created to describe vesical-sphincter dysfunctions that affect patients with diseases of the central or peripheral nervous system. Neurogenic bladder carriers may have changes in the voiding pattern in the filling and bladder emptying phases.

Health Problems – describes common symptoms or comorbidity observed in patients referred for a urodynamics test. Includes:

- **Kidneys Problems**: swelling in the leg, little urine during the day - IR (lower limb edema; low urine volume <500ml in 24hrs).
- **Kidney Infection**: Pyelonephritis, recurrent infection in the bladder or urine with lumps - recurrent Low Urinary Tract Infection.

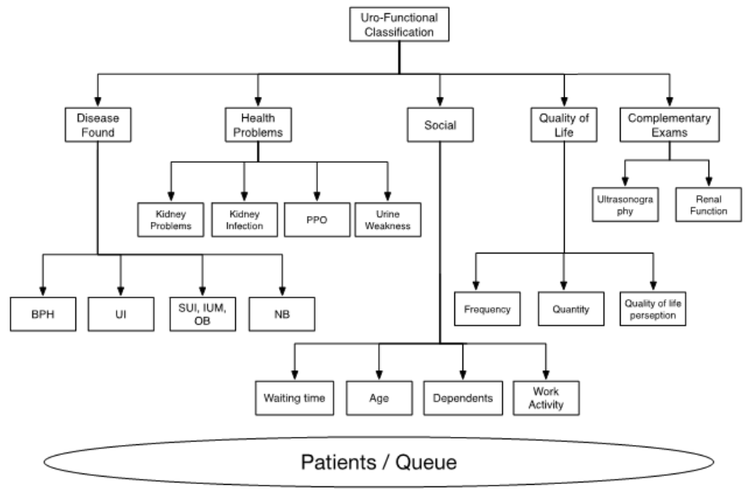

Figure 2 - AHP Structure applied to the service of urodynamics.

- **Pelvic Organ Prolapse** (PPO): it is a herniation of the pelvic organs through the vagina. It is a prevalent condition of low morbidity and mortality, but it affects women in their daily lives, sexuality, and physical activity. The prevalence of this condition is close to 22% in women between 18-83 years of age, varying up to 30% in women aged 50-89 years.
- **Urine Weakness** (UW): Urination is an act performed comfortably and effortlessly; its appearance involves difficulty in bladder emptying of inflammatory, neurogenic, infectious, or more commonly, obstructive origin.

Social Condition – relates to the personal and family environment of the patient and his specific context. In particular, the following sub-criteria were suggested as relevant for prioritization:

- **Waiting time**: the waiting time in the queue characterizes when the patient has entered the queue, in that year, since we have a queue of approximately three years.
- **Age**: The age of the patient.
- **The number of dependents**: we took into consideration not only children but any person who depends on this patient.
- **Impact on labor activity**: in which the patient works, needs physical strength, works more seated, does a work activity that requires traveling, among others.

Quality of life - In order to determine the quality of life, the ICIQ: International Consultation on Incontinence Questionnaire-Short-Form (ICIQ-SF) questionnaire is applied in patients with urinary incontinence. It is a simple, brief, and self-administering questionnaire chosen to be translated and adapted to our culture by rapidly assessing the impact of UI on quality of life and qualifying urinary loss of patients of both sexes. In this criterion, the frequency and amount of urinary loss were considered.

Complementary exams – describe the results of the two most common exams to evaluate the Renal condition.

- **Ultrasonography**: imaging exam that evaluates the following criteria: reduction of renal cortical thickness, cortical scarring/retraction, pelvic-incisional dilatation.
- **Renal Function**: Creatinine Clearance Calculation (glomerular filtration rate).

3.2 Build up Phase

The build-up phase is divided into two parallel processes related to the data source. The first process, aimed to find the weights for each criterion, requires the collection of data and opinions provided by the physicians. The second axis deals with patients' assessment and therefore focuses on the acquisition of patients' data. Although both processes deal with data collection, they are very different in nature. In the first axis, the goal is to extract and formalize knowledge from experts opinions by means of multicriteria methods. The second axis concerns mainly structuring and analyzing patients' files.

3.2.1 Physician data

After determining the criteria to be evaluated, and their hierarchical structure, we need to attribute weights for each criterion. To this end, we chose the Fuzzy AHP (Analytical Hierarchy Process), an extension of the original Saaty's AHP (Saaty, 1976). This method allows situations involving subjective criteria to be quantified, determining scores for each criterion.

The data collection for the Fuzzy AHP was done using an electronic questionnaire listing all the pair-wise questions to evaluate the relative importance of each criterion with respect to the others, as instructed in (Saaty, 1976) and the hierarchical tree of **Figure 2**. Before applying the questionnaire, a pre-test was administrated to the urology resident in order to identify the need for changes or adaptations, as well as how much time it would require to be completed. Only after this, the full-scale questionnaire was conducted, both personally and by telephone, with the most diverse experts in urodynamics in Brazil. The interviews targeted urologists but also gynecologists, since these two specialties deal with urinary incontinence. In the end, answers from 15 experts to the AHP-Fuzzy questionnaire were successfully collected.

The interviewer explained briefly to the interviewee the objective of this study and the method used to analyze it. The questionnaire focused on the pair-wise comparison, i.e., the relative importance that the expert gives to one criterion with respect to each of the others; the interviewee has thus presented combinations of each two criteria and was required to express which one and to which extend, one criterion seemed to him more important than the other for established patients' priorities. The original Saaty's scale goes a degree of preference ranging from 1 to 9. Having nine different degrees of preference, maybe very confusing for the respondent, therefore we decided to map Saaty's scale into four fuzzy linguistic states represented by triangular functions. Therefore, each interviewee could qualify the relative importance between of a criterion with respect to another one by using a fixed qualitative scale including the terms "equivalently important", "a little more important than", "more important than", and "clearly more important than", which are related to the pertinence fuzzy functions depicted in **Figure 3**. The state "Equivalent" is represented by the function Triangular (1/4, 1, 4), Low Preference by Triangular (1, 3, 6), Priority by the function Triangular (2, 5, 8) and finally Clearly by Triangular (4, 7, 9).

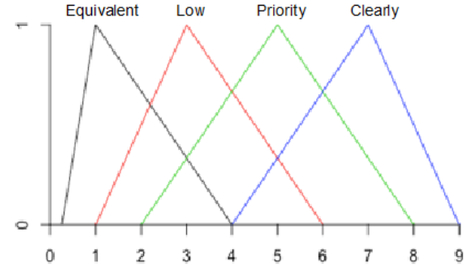

Figure 3 – Fuzzy Mappings

After the data collection and using the fuzzy-AHP process described in Srichetta and Thurachon (2012) which complements the method described in Chang (1996), the weights for each criterion were calculated. **Table 1** reports the numerical results produced for our problem, where the two first columns are the description of the three structures, and the last two columns the weights found. The main criteria with the highest weight is Health Problems, which receives 28.81% of the total weight, followed by Complementary Exams (24.90%) and Disease (21.45%). The criterion Social received a weight of only 8.38%. Unsurprisingly, clinical criteria received higher weights than the social one. As for the sub-criteria, it is worth recalling that the sum of the weights of all the sub-criteria under the same parent criterion must equal the parent's weight. The sub-criteria considered as the most relevant were Ultrasonography and Renal Function which received weights of 12.49% and 12.41%, respectively. Followed by Kidneys Problems (10.28%). The criteria considered as the least important belong to the main social criterion: Dependents (1.95%), Age (2.09%), and Impact on labor activity (2.09%).

Criteria	Subcriteria	Weight	Weight Sub
Disease		21.45%	
	BPH		4.00%
	(UI)		5.94%
	SUI,IUM,OB		3.03%
	NB		8.48%
Health Problems		28.81%	
	Kidneys Problems		10.28%
	Kidney Infection		8.40%
	PPO		5.21%
	UW		4.91%
Social Condition		8.38%	
	Waiting time		2.27%
	Age		2.09%
	Number of Dependents		1.95%
	Labor Activity		2.09%
Quality of life		16.46%	
	Frequency or Urinary Incontinence		4.80%
	Overall Impact of Urinary Incontinence		5.41%
	Amount of Leakage		6.26%
Complementary exams		24.90%	
	Ultrasonography		12.41%
	Renal Function		12.49%

Figure 2 - AHP Structure applied to the service of urodynamics.

3.2.2 Patients' Data

In most of data analytics projects, the part of structuring and organizing the data is usually the one that takes a longer time and deep effort. This project was no different. We started with a sample of 322 patients' files randomly drawn from a list with more of 3000. From those 322, 87 patients were successfully contacted, and 86 agreed to answer the questionnaire, while one refused, 225 were classified as "does not exist/does not answer the call" and 10 where dead. Among the 86 collected responses, there was a predominance of women (81%); 54 of the 86 interviewed were over 60 years old (62,7%). This work is vital to have a real view of the waiting list. This is an ongoing part of the project, and the careful review of each patient should be continuously done before we launch the full-scale implementation.

Once the patients' data were collected, we used the weights produced in Section 3.2.1 to compute a priority score for each patient. The priority list is simply obtained by sorting them according to them to their score in decreasing order.

3.2.3 Patients' Priority and validation

The preliminary priority list produced by the Fuzzy-AHP method was successfully validated by the chief medical officer of the urology department, after a thorough analysis of the patients' files and their respective priority in the list. Having a fully functional and validated algorithm capable of prioritizing a sample of patients closes the build-up phase of these project.

The implementation phase will take place in the months to come. In a nutshell, this phase will include an online platform accessible to all the concerned personnel, training of these personnel in the use of the prioritization platform, full-scale implementation of the Urodynamics queue, including new patients and a daily update of the queue situation.

4. CONCLUSION AND FUTURE WORKS

This work proposed a methodology to elaborate a computer-based prioritization tool to manage the patients' access to an elective exam named urodynamics. The importance of this work lays in the fact that, in the case that we studied, more than 3000 people currently wait to access this exam. The long waiting times strongly affect the day to day of the patients, hence deteriorating their quality of life. The prioritization process aims to give quicker access to those that need more service. In the prioritization process, we considered criteria related to clinical, social and quality of life aspects. As expected, the three clinical criteria (Disease, Health Problems and Complementary Exams) are the most important in the decision-making, and together they receive weight or relative importance of 73.07%. The criterion Quality of life receives a weight of 18.99%, and finally, the Social criterion receives a weight of 7.94%. The approach and the results produced by the proposed Fuzzy-AHP method have been validated by the clinical chief of the Urology department. The implementation of a prioritization tool constitutes the next step of this project that aims to contribute to better use of the healthcare system's resources.

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