ISCTE Business School
Instituto Universitário de Lisboa

FULL-TIME EMPLOYEE OPTIMISATION OF EMERGENCY DEPARTMENTS

Daniel Ferreira Amaral

Dissertation submitted as partial requirement for the conferral of
Master in Management of Services and Technology

Supervisor:

Prof. Dr. Rúben Filipe de Sousa Pereira, Assistant Professor, ISCTE – Instituto Universitário de Lisboa, Department of Sciences and Information Technology

Co-Supervisor:

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This dissertation is written in accordance with the vocabulary of the United Kingdom.

ABSTRACT

The Emergency Departments (ED) of public hospitals is an area in continuous improvement. The Emergency Departments are places where the efficiency of the services provided can save lives and therefore it should be seen as an area of maximum interest in order to make the processes optimised.

This research aims to verify if the application of redesign heuristics, from the perspective of Business Process Management, results in the improvement of the length of stay (LoS), without deteriorating the quality of the service provided. For the same process, three scenarios of the ED were considered.

The methodology that underlies this research is supported by a case study carried out in the Emergency Department of a public hospital. The data obtained during the investigation was gathered from individual interviews and focus groups, as well as direct observation and analysis of documents. According to the Business Process Management perspective, its life cycle stages were taken into account. In addition, a simulation tool was used, as well as the *Devil's Quadrangle*.

The results of the investigation indicate that positive impacts over variable time are possible without affecting the quality of the service, resulting in value gains for the patient, in this case, the client of the process. In terms of time, the average length of stay (LoS) in the process was reduced by 22.5%, 15.9%, and 20.9% for each of the scenarios, while the maximum length of stay (LoS) was reduced by 29.2%, 36.2% % and 37.4%.

Keywords: Emergency Departments, Business Process Management, Process Redesign, Redesign Heuristics, Process Simulation.

RESUMO

As Urgências Gerais dos hospitais públicos são uma área em melhoria contínua. As Urgências Gerais são locais onde a eficiência dos serviços prestados pode salvar vidas e, portanto, devem ser vistas como uma área de máximo interesse com o objetivo de tornar os processos otimizados.

Esta investigação visa verificar se a aplicação de heurísticas de redesenho, na perspetiva do *Business Process Management*, resulta na melhoria dos tempos (*length of stay*), sem que a qualidade do serviço seja deteriorada. Para o mesmo processo, três cenários da Urgência Geral foram considerados.

A metodologia que serve de base à investigação é sustentada num caso de estudo levado a cabo na urgência geral de um hospital público. A informação obtida durante a investigação foi recolhida a partir de entrevistas individuais e *focus groups*, bem como de observação direta e análise de documentos. Segundo a perspetiva *Business Process Management*, foram tidas em conta as suas fases do ciclo de vida. Adicionalmente, foi utilizada uma ferramenta de simulação e o *Devil's Quadrangle*.

Os resultados da investigação indicam que impactos positivos no tempo são possíveis sem que a qualidade do serviço seja afetada, originando ganhos de valor para o paciente, neste caso, o cliente do processo. Em termos de tempo, o *length of stay* (LoS) médio no processo foi reduzido em 22.5%, 15.9%, e 20.9% para cada um dos cenários apresentado, enquanto o *length of stay* (LoS) máximo foi reduzido em 29.2%, 36.2% e 37.4%.

Palavras-chave: Urgência Geral, Business Process Management, Redesenho de Processos, Heurísticas de Redesenho, Simulação de Processos.

THANKING NOTE

Alone, I would never have done this research. First of all, I have to thank my parents for letting me coming until here. Without their strength and support none of this effort would be possible. Secondly, I have special acknowledgement to give to my supervisor and co-supervisor for always being present. I am grateful to Professor Rúben Pereira for continually motivating me, for always being available to clarify my doubts and, above all, for helping me to improve the quality of my work. To Professor Luís Lapão, I have to thank for his significant contribution to this research given his vast experience and knowledge in the area. Each little contribution of yours added enormous value to my research. Thank you for walking by my side during this journey.

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Acronym	Meaning
BP	Business Process
BPM	Business Process Management
BPMN	Business Process Management Notation
BPR	Business Process Redesign
BVA	Business Value-Added
CAP	Clinical Analysis and Procedures
CPM	Care Process Management
CRM	Customer Relationship Management
ED	Emergency Department
ESGB	Serviço de Urgências dos Verdes e Azuis
IS	Information System
MRP	Material Requirement Planning
NVA	Non-Value-Added
PDCA	Plan, Do, Check, Act
PNS	Plano Nacional de Saúde
SNS	Serviço Nacional de Saúde
TQM	Total Quality Management
VA	Value-Added

1 Introduction

In the Introduction, we will introduce the problem around this research, the research questions, objectives and finally, a proposal to be studied.

1.1 PROBLEM STATING

At the level of health services, there are two major management challenges: the use of management evidence and management innovation (Lapão, 2016). According to the author, Management innovation takes into account the patient's quality, centrality, experience, the use of new technologies and new services. Management innovation seeks to leverage the effect of resources but requires strategic alignment in the medium to long-term. The challenge is to do this in the context of healthcare, with the appropriate involvement of professionals and patients.

In the Portuguese case, the national strategy already aimed this challenge for the quality of health and patient safety, which should motivate a more serious approach. Health organisations, through their quality and safety committees, should promote the implementation of actions aimed at improving the quality and safety of the care provided to the population (Portuguese Health Ministry, 2015).

In this research, we will focus on the first management challenge mentioned by Lapão (2016), the use of management evidence – more precisely, on the optimisation of work processes. The healthcare industry presents a poor design, high fragmentation and stunning inefficiency (Dickman *et al.* 2012). For the authors, individual achievements are no longer sustainable to reach the excellence of an overall functional healthcare system.

Emergency Departments (ED) are facing many problems (Di Leva and Sulis, 2017; Hoot and Aronsky, 2008). According to the authors, the common issues that ED are fronting come from the **lack of resources (P1), long waiting times (P2), excessive use of emergency services (P3)**. Workers often complain dissatisfaction in a high-stress work environment. These problems can lead to well-known situations of inefficiency, medical risk and financial losses.

The theme of healthcare in Portugal is a sensitive issue for society, due to the implications it has on the political, economic and social level, being under permanent scrutiny, and its weaknesses are the reason for frequent analysis and discussion. Analysing, for example, the data published in PORDATA (2015), it is possible to see that the major evolution in the last 50 years was the

reduction of infant mortality, being considered as an international indicator to measure the human development of the countries (Rosa, 2014). The average life expectancy of the Portuguese increased from 63 years in 1961 to 81 years in 2011. This same source indicates that the ageing rate is increasing, with a difference of more than 10% in the longevity index between 1961 and 2011 (PORDATA, 2015).

In this way, healthcare is one of the areas that requires greater attention in Portugal. The Portuguese population is increasingly ageing and there are fewer and fewer births (in 1960 the birth rate was 16.2% and in 2011 it was only 7.9%) (PORDATA, 2015). As such, in addition to ensuring adequate support for younger users, it is crucial to ensure the well-being of the elderly, as they are those who need more care and are more dependent on health services.

In addition to ensuring the conditions in specialised services, conditions must also be ensured in the ED. The ED has gained increasing importance, having to respond effectively and immediately to any problems that arise. However, over the last few years its operations has caused concern to the Serviço Nacional de Saúde (SNS), not only for the resources it consumes, but also for the **patients who come there without effective need for their services (P3)**, implying an increase in the number of patients in hospitals and as a consequence, a reduction in efficiency and a greater difficulty in providing adequate responses to the real needs of patients.

To help to respond to these problems, the Plano Nacional de Saúde (PNS) includes some goals aimed at reducing the impact of problems, such as reducing premature mortality rates, increasing healthy life expectancy and other measures. The PNS is a strategy adopted by several countries and allows health policies to be aligned in a structured and coherent way. There are a number of actors involved in setting up the PNS, such as national institutions, governmental and non-governmental organisations, public and private sector institutions. The PNS aims to analyse the health status of the population, in order to identify problems, needs and possible solutions. This plan also describes the importance of all stakeholders in health promotion, disease prevention, early diagnosis, disease minimisation and control, and adequate rehabilitation (Plano Nacional de Saúde, 2015).

However, despite this planning for the health area, problems continue to arise in hospitals, especially in the ED. In Portugal, at the end of 2014/early 2015, a major flu epidemic emerged, creating chaos in the ED Services. Long waiting times for patients to be attended due to lack of

beds to accommodate patients were the most relevant factors. As a consequence of this situation, there were deaths and more hours of work by doctors and nurses (Leal *et al.*, 2015; Santos, 2015). From the stated above, we may affirm that the primary problems that ED are facing comes from:

P1: Lack of resources that enhances work overload;
P2: Long waiting times turn the process of ED even longer;
P3: Excessive use of ED most of the times without effective need of it.

The problems in the ED remain a current topic of general concern to the population, and we believe it to be an interesting topic to investigate and deepen. Other researchers have already given their contributions for this theme around the world (Miró *et al*., 2003; Hoot and Aronsky, 2008; Bukhari *et al.*, 2014; Di Leva and Sulis, 2017; Adama *et al*., 2017). The ED must be a place always available for those who need an urgent consultation, so it is necessary to improve their management to ensure greater efficiency and effectiveness in care. Thus, Redesign Heuristics play a crucial role when improvement needs come up (Dumas *et al*., 2013). Sohail (2012) refers that previous researches on Business Process Improvement ignored the factor that optimised redesign is achieved only with the correct identification of the process problems. We want to focus part of our research on the identification of problems and the respective improvements for such problems. We want to be able to help to solve the problems aforementioned supporting our findings on Business Process Redesign Heuristics.

1.2 RESEARCH QUESTION

Taking into account the problems stated above and the current objectives of this research, the following research questions should be addressed throughout the research:

RQ: How can Business Process Redesign techniques help to optimise an ED regarding time without deteriorating the quality of the service provided?

1.3 RESEARCH OBJECTIVES

The primary objective of this research is to find the right redesign heuristics that better fit on improving the process of the ED under study regarding the total time of the process without deteriorating service quality.

Partial goals:

- To select the most appropriate ED process (or part of it) to be analysed;
- To select the methods and tools to be used throughout the research;

- To identify the customer and to define value for the customer on the process chosen;
- To model the chosen process;
- To simulate the process As-Is regarding three different scenarios in order to obtain processes to compare while applying redesign heuristics;
- To analyse the process As-Is regarding problems identification;
- To identify possible improvements to process As-Is;
- To select one process to use as a term of comparison in the process redesign phase;
- To identify the appropriate redesign heuristics to apply on the selected process;
- To measure the improvements, in terms of time and quality, after the application of redesign heuristics, supported by Devil's Quadrangle;
- To present a summary of the results of all redesign heuristics applied in three scenarios aforementioned;
- To present an improved version of the analysed process, the process To-Be.

1.4 PROPOSAL

In this research, we will orientate our efforts to ED of the healthcare institutions. Since it is one of the healthcare services with higher and direct impact on the patients - due to the inherent unpredictability of events -, we pretend to obtain valuable insights about ED that allow us to give useful and practical outputs for the ED of distinct public healthcare institutions.

To do that, we will use a Business Process Management (BPM) software to model the ED process of a Portuguese public healthcare institution, as it actually is (Process As-Is). Hereafter, we will use that process as a model of comparison and apply on it several redesign heuristics throughout a simulation tool used on BPM. Additionally, we want to compare the results of the application of every redesign heuristic on the process with the impact of it on the total time of the process considering the objectives of the research. Then, conclusions will flourish and the process To-Be will be introduced.

BPM has turned into a develop teach, with a settled arrangement of standards, techniques and instruments that consolidate learning from information technology, management sciences industrial engineering with the purpose of improving business processes (van der Aalst, 2013; Weske *et al*., 2003; Dumas *et al.* 2013). In accordance with vom Brocke and Rosemann (2014), BPM focuses on improving corporate performance by managing business processes. In this case, it will focus on the optimisation of the ED, improving the overall services provided by the healthcare institution.

2 THEORETICAL BACKGROUND

In the theoretical background, the main concepts relevant for the research will be introduced. An overview about BPM will be presented as well as the concept of BPMN and Redesign Heuristics. At the end of the section, the relevant cases of BPM in healthcare will bring together.

2.1 BUSINESS PROCESS MANAGEMENT

2.1.1. Evolution of Process Management

According to Craggs (2010), the business environment in today's developed economies is characterized by increased change, increased competition and the transparency. These changing market characteristics have impacted the needs of business prerequisites. The need to help dynamic business condition by rolling out improvement speedier and less expensive assumes a necessary role since the organisations that can adjust most effectively to the changing condition are the ones that will recuperate the fastest from the recent economic downturn. In this way, BPM provides an opportunity to implement those requirements. This concept will be defined next, but first, it is considered relevant to understand evolution over time.

In the industrial age, between the 1750 and 1960, the main objectives were a specialisation of labour, task productivity and cost reduction. In Table 1 and Table 2 are presented the main points of focus regarding business, technology and tools to achieve the defined objectives.

Table 1- Industrial Age of Process Evolution. Source: Sandra Lusk et al. (2005)

Business	Technology	Tools/Enablers
▪ Functional Hierarchies ▪ Command & Control ▪ Assembly Line	▪ Mechanization ▪ Standardization ▪ Recordkeeping	▪ Scientific Management ▪ PDCA ▪ Improvement Cycle ▪ Financial Modelling

According to Barney (2003), Ramias (2005) and Conger (2010), in 1970s/1980s, the most popular quality control methodology was named Total Quality Management (TQM). The application of TQM tools and techniques has begun to guide managers and policymakers' arbitrary command and control methodology with strong importance being given on leadership, teamwork and

continuous learning. The old culture of top-down management where the subordinates must wait infinitely for their superiors before they can perform has impinged the implementation of TQM in public hospitals. This time was known as Process Improvement were the focus was quality, management, continuous flow and task efficiency.

In accordance with the same authors, in 1990s, TQM began to be superseded by Six Sigma – an approach developed at Motorola. Six Sigma combined process analysis with statistical quality control techniques and a program of organisational rewards and emerged as a popular approach to continuous process improvement.

This time was known as Process Reengineering were the main themes was "Process Innovation", "Best Practices", "Better, Faster, Cheaper" and "Business via the Internet".

From 2000 year, we are in the Business Process Management era which it is focus on "Assessment, Adaptability, and Agility", "24X7 Global Business" and "Continual Transformation". Another methodology in use in managerial tradition was the Balanced Scorecard developed by Kaplan and Norton (1996).

Table 2- Three Waves Of Process Evolution In Information Age. Source: Sandra Lusk et al. (2005)

Business	Technology	Tools/Enablers
• Multi-Industry Enterprises • Line of Business Organisation • Mergers and Acquisitions	• Computerized Automation • Management Information Systems • MRP	• TQM • Statistical • Process Control / Process Improvement Methods
• Flat Organisation • End-to-end Processes Value Propositions – Speed to Market, Customer Intimacy, Operational Excellence	• Enterprise Architecture • ERP • CRM • Supply Chain Management	• Activity Based Costing • Six Sigma • Buy vs Build • Process Redesign/ Reengineering Methods
• Networked Organisation • Hyper Competition • Market Growth Driven • Process Effectiveness over Resource Efficiency • Organisational Effectiveness over Operational Efficiency	• Enterprise Application Integration • Service Oriented Architecture • Performance Management software • BPM Systems	• Balanced Scorecard • Self Service and Personalization • Outsourcing, Co-Sourcing, In-sourcing • BPM Methods

In the Table 2, it is assumed that every line of the table is a wave. That is, every wave correspond to an Information Age.

2.1.2. Concept of Business Process Management

First, it was considered relevant to define based on the literature the concept of BPM as a process and then as a management discipline, since they differ from author to author.

Weske *et al*.,(2003) defends that: *"Business process management is based on the observation that each product that a company provides to the market is the outcome of a number of activities performed. Business processes are the key instrument for organising these activities and to improving the understanding of their interrelationships".*

According to Ko *et al.* (2009), *"a business process is a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer".*

For Davenport (1993)*, "a process is simply a structured, measured set of activities designed to produce a specified output for a particular customer or market. It implies a strong emphasis on how work is done within an organisation, in contrast to a product focus's emphasis on what".*

Although, it is regular to allude Care Process Management (CPM) in the healthcare sector while discussing BPM. CPM is the use of business process automation and optimisation techniques to clinical care processes in the healthcare environment. It additionally utilizes best practices for BPM to enhance clinical results without changing health processes or dislodging the job of health stakeholders (Dickman *et al*. 2012; Carter 2015).

CPM offers a guide that will help the healthcare sector to change delivery. Without changing what human services specialists do best, it tends to the inalienable wasteful aspects of the care delivery process. Numerous parts of care delivery can be enhanced utilizing BPM to automatize the coordination of care delivery and to empower suppliers to team up more adequately (Dickman *et al*. 2012).

Companies hope to reach several goals when using the BPM approach. Becker and Kahn (2003) give an overview of such goals, which BPM is able to fulfil. The main objectives to be achieved according to the authors mentioned above are shown in Table 3. The explicit representation of business processes can help a company to get better understanding of the operations it performs and the dependencies between the different processes and it can also improve the communication between the different stakeholders by making it more efficient and effective.

Table 3- Goals of BPM. Source: Weske et al. (2003)

Goals of Business Process Management
Better understanding
Standardization of business process execution
Improved communication
More flexibility
Continuous process improvement
Repository of business processes
Benchmarking
Enabling cooperation/outsourcing

2.1.3. Business Process Management Notation (BPMN)

The essential goal of the BPMN effort was to give a notation that is visually understandable by all stakeholders, from the business analysts who make the underlying drafts of the processes, to the specialized engineers in charge of implementing the technology that will perform those processes, and, at last, to the agents who will oversee and screen those processes (Gebremichael, 2015). The main categories of elements used by this notation are: Flow Objects, Connections Objects, Swimlanes and Artifacts. All of these elements will be used and described later on the Methodology. In other words, BPMN creates a standardised bridge for the gap between the business process design and process implementation (White, 2004).

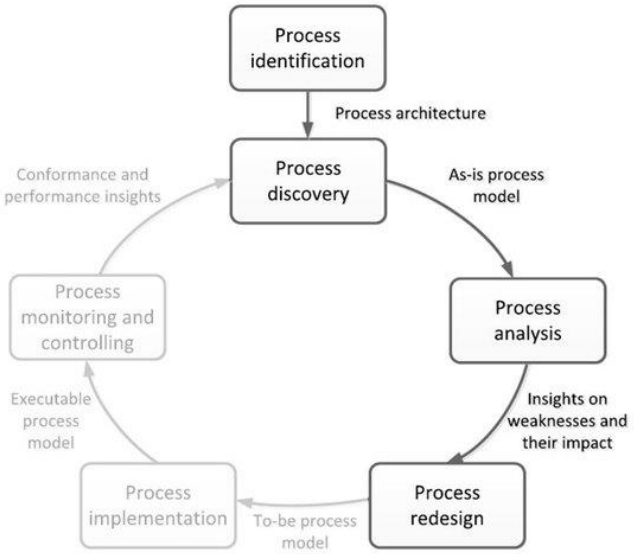
According to van der Aalst *et al.* (2013), different business process modelling languages have been developed to suit various needs of BPM users. Some languages such as BPMN activity diagrams focus on the graphical representation of processes for mainly analytical and documentation purposes, while other languages are machine executable languages, which can be interpreted by a workflow management system of a process aware enterprise applications.

2.1.4. Phases of BPM

To better understand this concept, and according to Ko (2009), there are several different views on BPM lifecycle. By the way, we present an actual and frequent view of BPM lifecycle by Dumas

et al. (2013). The BPM lifecycle consists of the six phases: Process identification, Process discovery, Process analysis, Process redesign, Process implementation and Process monitoring and controlling. This structure represents the evolutionary and incremental BPM approach and is introduced in Figure 1.

Figure 1 - BPM Lifecycle. Source: Razavian et al. (2016)



The first phase of the BPM lifecycle consists of two steps, depending on the company situation. Process identification and discovery refers to the selection and understanding of the critical process; and identification of all processes that are related with the chosen process.

After the discovery of the process, the process modelling comes up in order to define the process As-Is.

As the name refers, Process analysis is the phase where process is analysed. This is a crucial phase because is here that the problems and weaknesses of the process are identified. Also, the estimative for the resolution is prepared.

On the Process redesign phase, the possible improvements are indicated according to what are the objectives to achieve and measures of performance chosen. If it is the case, redesign heuristics are selected and applied in this phase.

Finally, the changes and improvements are applied in the real context, developing new business rules and ways of work throughout the Process implementation phase.

In the end, Process monitoring and controlling is conducted continuously in order to analyse the date provided by the process and analyse the KPI over the time but also implement new corrections.

Process Identification, Discovery and Modelling

In these phases of the BPM lifecycle, Dumas *et al.* (2013) say that the first step is to identify which processes contribute to the current problem. At this stage, the processes are hierarchized by the need of action (Baldam *et al.*, 2009). After finding one or more relevant processes, each one is surveyed, where each process is identified, delimited, related to other processes and the representation is performed as they are executed at the time of the study (Process As-Is) (Dumas *et al.*, 2013).

Process Analysis

At this stage, the issues associated with the process As-Is are identified, documented and, where possible, quantified using performance measures (Dumas *et al.*, 2013). In this way, it will be possible to understand the position of the process about the objectives established by the organisation (Valle, 2009). The aim is that at the end of the survey, all the problems will be prioritised regarding impact and effort required to be solved (Dumas *et al.*, 2013).

Process Redesign

Business Process Redesign (BPR) seeks to create new ways of organising tasks, people and redesigning information systems so that processes are improved in critical and contemporary performance measures such as cost, quality, service and speed (Sherwood-Smith, 1994; Hammer and Champy, 1993).

According to Vidgen *et al.* (1994), BPR supports organisational restructuring, focusing on business objectives. For such, business process are analysed, non-essential or redundant tasks are eliminated, and IT is used to redesign and simplify organisational processes.

According to Manganelli *et al.* (1994), BPR is seen as a double challenge: a technical challenge, due to the difficulty of developing an improvement of the current process, and a socio-cultural development resulting from the organisational effects caused by the people involved, who will react positively or negatively to change. (Manganelli *et al*., 1994; Galliers, 1997).

Moreover, Mansar (2007) states that redesigning a process decreases the time required to execute it, reduces its cost, improves the quality of the output, and improves the process's ability to react to variation. When Garvin (1993) states, "if you can not measure it, you can not manage it", the first step is to understand what the company's primary goal is for the redesign of a particular process. For this, Dumas *et al.* (2013) suggests the use of the heuristics described in Table 4 and Table 5, in the case of the redesign of an already existing process, in which the use of the Devil's Quadrangle presented in Figure 2, could support on the evaluation of the applicability of the redesign heuristics regarding time, cost, quality and flexibility.

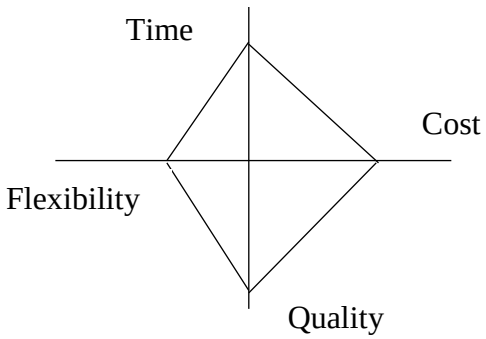
Mansar and Reijers (2005), as well as Dumas et al. (2013), proposed a new approach to process redesign by introducing Redesign Heuristics. It is used to incrementally optimise the processes addressing a specific heuristic to a specific issue or weakness of the process.

2.2 REDESIGN HEURISTICS

Heuristics are strategies derived from previous experiences with similar problems. These strategies rely on using readily accessible, though loosely applicable, information to control problem-solving in human beings, machines, and abstract issues (Ippoliti, 2015).

In the context of BPM, it is important to introduce heuristic process redesign as a method that builds upon an extensive set of redesign options and describe the motivations for doing it. When people redesigned a process they want to achieve a goal and for the measure if they are doing right, they use The Devil's Quadrangle framework (see Figure 2).

Figure 2- The Devil's Quadrangle framework. Source: Dumas et al (2013)



According to Garvin (1993), "*if you can not measure it, you can not manage it*". The performance indicators used to evaluate the impact of Business Process Improvement Patterns are based on the initial idea of Hayers and Wheelwright (1984). They suggested that companies compete in the marketplace by one or more of the following competitive priorities. For Clarck *et al*. (1988), time, quality, and cost are, along with flexibility, the basic measurements for assessing all business activities.

- ✓ **Flexibility:** *"Process flexibility is the ability of a process to cope with contextual changes by adapting its structure and behaviour in a goal-oriented manner"* (Wagner *et al*., 2011).
- ✓ **Time:** *"The consensus view is that BPS reduces process time, defined as the end-to-end time required to serve a customer or to create one unit of the process output"* (Muenstermann *et al.*, 2010).
- ✓ **Costs:** *"From a conceptual perspective, the positive effect of BPS on process costs is achieved through the elimination of errors* (Wuellenweber *et al*., 2008), *economies of scale* (Sanchez-Rodriguez *et al*. 2006), *and facilitated communication"* (Davenport 2005; Ramakumar and Cooper 2004).
- ✓ **Quality:** *"BPS increases process quality, as it helps organisations establish best practice processes as standards that exhibit higher quality and smaller error probability than do context-specific process variants"* (Muenstermann *et al*., 2010)

The goals and the strategy of the organisation determine which dimension should be maximized and what consequences these decisions have on the other dimensions.

After explored in the literature several articles and books about BPM but more intensively about BPR, it is presented in Table 4 what we decided to name as Heuristics in BPR as Dumas et al. (2013) did. This table is composed of six categories: Customers, Products, Business Process (operation view & behavioural view), Organisation (structure & population), Information and finally, Technology. However, it is important to mention that a redesign heuristic is not a model of a business process. These heuristics represent a set of ideas that help one think about the business process in the context of process redesign. In this case, redesign heuristics are applied in order to measure the impact on the process and then evaluate if that impact is positive or negative.

Table 4 - Heuristics In Business Process Redesign – Part 1. Source: Mansar and Reijers (2005)

Category	Redesign Heuristic	Definition
Customers	Control relocation	Move controls towards the customer
	Contact reduction	Reduce the number of contacts with customers and third parties
	Integration	Consider the integration with a business process of the customer or a supplier
Product	None	
Operation view	Order types	Determine whether tasks are related to the same type of order and, if necessary, distinguish new business processes.
	Task elimination	Eliminate unnecessary tasks from a business.
	Order-based work	Consider removing batch-processing and periodic activities from a business process.
	Triage	Consider the division of a general task into two or more alternative tasks' or 'consider the integration of two or more alternative tasks into one general task.
	Task composition	Combine small tasks into composite tasks and divide large tasks into workable smaller tasks
Behavioral view	Resequencing	Move tasks to more appropriate places
	Knock-out	Order knockout decisions in a decreasing order of effort and in an increasing order of termination probability
	Parallelism	Consider whether tasks may be executed in parallel
	Exception	Design business processes for typical orders and isolate exceptional orders from normal flow
External environment	Trusted party	Instead of determining information oneself, use results of a trusted party.
	Outsourcing	Consider outsourcing a business process in whole or parts of it.
	Interfacing	Consider a standardized interface with customers and partners

Table 5 - Heuristics In Business Process Redesign - Part 2. Source: Mansar and Reijers (2005)

Category	Redesign Heuristic	Definition
Organisation: structure	Order assignment	Let workers perform as many steps as possible for single orders
	Flexible assignment	Assign resources in such a way that maximal flexibility is preserved for the near future.
	Centralization	Treat geographically dispersed resources as if they are centralized
	Split responsibilities	Avoid assignment of task responsibilities to people from different functional units.
	Customer teams	Consider assigning teams out of different departmental workers that will take care of the complete handling of specific sorts of orders.
	Numerical involvement	Minimize the number of departments, groups and persons involved in a business process.
	Case manager	Appoint one person as responsible for the handling of each type of order, the case manager.
Organisation: population	Extra resources	If capacity is not sufficient, consider increasing the number of resources
	Specialist-generalist	Consider to make resources more specialized or more generalist
	Empower	Give workers most of the decision-making authority and reduce middle management
Information	Control addition	Check the completeness and correctness of incoming materials and check the output before it is sent to customers.
	Buffering	Instead of requesting information from an external source, buffer it by subscribing to updates
Technology	Task automation	Consider automating tasks
	Integral technology	Try to elevate physical constraints in a business process by applying new technology

2.3 BPM IN HEALTHCARE

According to Keyes (2012), some processes are most important for BPM to attack in order to create the best outcomes for patients. The back-office processes are well structured nowadays: the systems for financial, supply chain or HR are really good.

In fact, what is essential to go after are the processes in people's heads. A doctor, for example, can spend up to 90% of their time outside of systems, that is, solving other issues that are not part of

the system (emergent situations that require special attention, for example); nurses, probably very high as well, and other health professionals the same (Dankelman, 2010; Keyes, 2012). The tasks of the doctors, nurses and other health professionals are those that should be reflected in BPM even if those tasks have a high variance due to each patient context.

On the other hand, the interaction between health professionals and the IT system of the hospital should not be variable. It should be standardised as possible. Moreover, those interactions with the IT system should be simple, smooth and each health professional must know how to deal with it (Brandenburg *et al*., 2015).

We need to make sure that current operation processes not supported by systems, are executed as well as possible, and are just not in people's heads (Keyes, 2012). According to the same author, those processes that are "in people's heads" have to be exposed. They must be put inside of a system and make them standardised as possible. Thus, even if variability is a good thing, what is needed is predictive variability.

Process inefficiencies aspects in many businesses influence incomes. Lack of efficiency in the healthcare industry, then, influence the lives of individuals. That is the reason patient flow processes and incrementing efficiency in the healthcare sector is of central significance for the general great of mankind. BPM encompasses long-standing progress with the aim to continuously improve how organisations across contexts manage their business activities. It also allows us to appreciate what we have achieved in terms of our comprehensive understanding to date and what prospects it holds (Lega, 2013).

BPM systems in the healthcare sector have proven more difficult because of the highly complex and multidisciplinary processes within the healthcare departments. Apart from this, the healthcare sector is continuously facing challenges which require it to respond by adapting these processes as necessary (Rebuge, 2012).

According to Shortell *et al.* (2004), the big reason for the difficulties in healthcare management appears from lack of communication and understanding between managers and professionals, who by virtue of their professional training, tend to focus on individual patient and effectiveness of health systems in which they operate. Shortell and Schmittidiel (2004) define this as "*disintegration in the healthcare system*".

For others words, the business challenges in the healthcare sector are: reduce costs, dynamic access to reliable patient information, compliance and business evaluation. To face its problems BPM application can:

- Increase quality of service delivery;
- Decrease waiting times between activities;
- Improve revenue cycle management initiatives;
- Decrease overall administration costs.
- Enterprise wide collaboration;
- Collate documents and records;
- Increase inherent process flexibility;
- Extend value of core healthcare systems.

Fundamentally, BPM sort out the working process considering the organisation's financial plan, policies and business requirements. It mechanizes all parts of business administration and patient care and monitors them. BPM consents to every one of the controls, raise incomes and remain competitive.

As the requirements in sector progress with emerging technologies, requests on BPM have expanded. Be that as it may, these generic developments for the business brought about constraints for adjustments of the product to particular settings. To adapt to these impediments, BPM should be joined with an extra layer to fulfill these necessities.

Table 6 presents a framework for addressing the most important problems in the healthcare system through specific BPR principles.

Table 6 - A Framework for the Application of BPR Principles to Healthcare Problems. Source: Adapted from Bliemel and Hassanein (2015)

3 RELATED WORK

In this section of the research, it became relevant to allude some authors who focused part of their studies on the performance of BPM, more concisely, on the study of business processes optimisation in healthcare. These authors studied how redesigning by using heuristics could help to improve the healthcare institutions.

For the elaboration of this research, a methodology was chosen based on its allowance to correspond to the objectives proposed in section 1.3 of this study. Such methodology should allow the modelling of the process as-is, allow the redesign based on heuristics, allow the simulation of several study scenarios, modelled previously, in order to choose what best corresponds to the needs of the research. Finally, it should have a generalised modelling language.

In order to turn this study deeper, it was need to search which studies, related to the topic in question, try to answer the question that we want to go through. For that, we must understand what have been done, which methodology was used by the researchers, and whether the results obtained were as expected.

After an in-depth inquiry on the topic, we selected six articles (as can be observed in Table 7), which consisted in the redesign of organisational processes, supported by heuristics and having the BPM tool as an ally in order to obtain the best results .

The studies were chosen by several search engines, namely, IEEE Explore, Google Scholar and ABI/INFORM Collection. The main keywords used during the search were: “Process Optimisation”, “Business Process Management”, “Process Redesign” and “Redesign Heuristics”.

Table 7 presents a brief summary of the topics that were studied.

Table 7 – Redesign Heuristics Application in the Healthcare Sector

#	Case Study Title	Author & Year	Location	Field Of Study	Citations*	Redesign Heuristics Applied
1	Improving Emergency Departments efficiency by patient streaming to outcomes-based teams	Kelly *et al.*, (2007)	Melbourne, Australia	ED	104	Customer teams;
2	Process Analysis for a hospital Emergency Department	Di Leva and Sulis (2017)	Italy	ED	2	Extra resources
3	Commonalities in Reengineered Business Processes: Models and Issues	Buzacott (1996)	None	Healthcare	204	Contact reduction; Empower; Task elimination; Task composition; Parallelism; Case manager; Control addition;
4	Business Process Redesign in Healthcare: Towards a Structured Approach.	Jansen-Vullers and Reijers (2005)	Ottawa	Healthcare	45	Case manager; Empower; Extra resources; Parallelism.
5	An Application of Business Process Method to the Clinical Efficiency of Hospital.	Leu and Huang (2011)	Taiwan	Healthcare	37	Task automation; Integration; Order types; Task elimination; Centralization
6	Eliminating emergency department wait by BPR implementation	Kumar and Shim (2007)	Singapore	ED	18	Resequencing

*(Data from Google Scholar)

A brief description of each case study analysed (Table 7) is presented in the following paragraphs.

At case study 1, the authors describe the process and results of a process redesign based on task analysis and lean thinking approaches. The authors wanted to improve emergency department efficiency and to achieve it, they decided on applying, implicitly, a redesign heuristic through process redesign: "re-allocation of medical and nursing staff in two teams" ("Customer teams" from Table 5).

At case study 2, Di Leva and Sulis (2017) analysed the care pathway of patients of an ED in a public hospital of Italy. By the BPM model presented by the authors, professionals were able to run different scenarios, to identify bottlenecks and to explore solutions that can lead to better performance. The authors gathered the information need from the ED to elaborate the process modelling and then, simulated it. Several scenarios were presented based on the addition of resources to the clinical teams ("Extra resources" from Table 5).

At case study 3, by using a kind of system models from queueing theory, the author focused on researching the conditions under which several changes occur in system structure are likely to be adequate. Within these conditions, the author presented a theory on how contact reduction and empower could improve the system overall. On the other words, the author applied theoretically and based on its calculations, two redesign heuristics: contact reduction and empower, among others.

At case study 4 and 5, the authors identified some problems on a healthcare institution in Ottawa and Taiwan, respectively, such as, lack of communication that originated data duplication and dispersed responsibility of the managers (Jansen-Vullers and Reijers, 2005) and lack of automation (Leu and Huang, 2011). In line with the problems, the authors defined some possible improvements to apply on the healthcare institution such as increased control (Jansen-Vullers and Reijers, 2005; Jansen-Vullers and Reijers, 2005) and reallocation or elimination of tasks (Jansen-Vullers and Reijers, 2005). At case study 4, redesign heuristics were implicitly or explicitly identified. Namely, Case manager, Empower, Extra resources and Parallelism (see Table 4 and Table 5). At case study 5, redesign heuristics like Task automation, Integration, Order types, Task elimination and Centralization were recognised (see Table 4 and Table 5).

At case study 6, Kumar and Shim (2007) conducted a case study in a Singaporean Hospital to and elaborated a deepen analysis on such ED. All the variables of the Devil's Quadrangle were evaluated (time, cost, quality and flexibility). The authors decided to resequencing (see Table 4)

the activities of such a process. Until then, the payment was done at the end of the service, but it originated longer queues. So, the authors proposed to add a payment counter between the registration and triage when significant waiting times occurred. Instead of only waiting for triage, patients could pay the clinical bill and then avoid to pay it in the end.

According to Webster and Watson (2002), a literature review should be concept-centric. By this approach, concepts determine the organizing framework of a review. On the other hand, it is also usual to see some authors taking an author-centric approach and essentially present a summary of the relevant articles. Taking this statement, we decided to present both approaches in order to make easier for the reader to find the information he/she required. In Table 7, an author-centric approach is presented while in Table 8, we present a concept-centric approach, using the redesign heuristics as main concept.

Table 8 - Concept Centric For Redesign Heuristics (Concept by Webster and Watson, 2002)

Redesign Heuristic	Ref# of Research papers*
Customer teams	1
Extra resources	2; 4
Contact reduction	3
Empower	3; 4
Task elimination	3; 5
Task composition	3
Parallelism	3; 4
Case manager	3; 4
Control addition	3
Task automation	5
Integration	5
Order types	5
Centralisation	5
Resequencing	6

** REF# is the number of the case study presented in Table 7 named Redesign heuristics application in the healthcare sector.*

All the cases studied, where BPM was used as a modelling and redesign method, organisations were satisfied that they had achieved the objectives by combining management knowledge with technology (van der Aalst, 2013). BPM is an approach that allows covering several processes or interactions (Lehnert *et al*., 2015), guiding the managers to put the improvements in practice (Zellner, 2011).

In this way, it is concluded that BPM is the methodology that is most interesting to be applied in this study, not only for the easy understanding of the modelling but also for its detail and the possibility of simulation (Smith and Fingar, 2007).

3.1. LR SYNTHESIS

In response to the continuing demands of the healthcare environments, healthcare reform initiatives have been implementing globally in different healthcare settings using different management tools such as total quality management, continuous quality improvement, just-in-time, BPR and benchmarking, among others.

Some studies present improvements of healthcare services due to the implementation of healthcare reform using BPM as a tool. For example, in Singapore, the second largest hospital in the country was able to eliminate oriented healthcare reform totally. In Italy, the BPM system used in a hospital achieve the major aim of improving service quality and efficiency. As a result, it was able to identify areas for improvement such as the number of operating sessions, preparation of the operating rooms for each operation, availability of specific surgical instruments and so one.

4 METHODOLOGY

In this chapter, the adopted research methodology is justified and contextualized based on the problem identified, the research question and objectives (presented in section 1). All the steps to be performed in the present case study are presented and specified. In addition, the main purpose of this study is raised, so that a breakthrough on some partial research goals is realized. The criteria that led to the choice of the processes studied are disclosed, in order to justify such an option when the process are presented. Furthermore, a detailed description of all the stages of the analysis is also elaborated as well as the literature review on the theoretical background that underpins the approach to the problem. The last but not the least, the appropriate analysis tools are chosen and how the information will be collected is described.

4.1 CASE STUDY APPROACH

A case study is a useful methodology when the investigation is focused on a holistic, in-depth view (Feagin *et al.*, 1991). A case study is an empirical survey that allows the research of the contemporary observable phenomenon in real events. The phenomenon and the events themselves are not fundamentally separated from one another (Yin, 1989). According to Zucker (2009) and Bromley (1990), it is a systematic inquiry into an event or a set of related events which aims to describe and explain the phenomenon of interest.

Compared to other methods, the positive point of the case study method is its allowance to analyse, in-depth, a real-life case within its real-life context. (Yin, 2013). Data come largely from the documentation, archival records, interviews, direct observations, participant observation and physical artefacts (Zucker, 2009; Yin, 2013).

According to Yin (1989), case studies preferably tend to be aligned with the three characteristics presented in Table 9.

Table 9- Case study characterisation. Source: own source

A case study by Yin	The practical case study of this research
a) the research question of the type "how" or "why"	RQ: **How** can Business Process Redesign techniques help to optimize an ED?
b) little or none control over the events under research	Due to the **unpredictability** of an ED, there is little or even no control over the events.
c) the focus of the research is on contemporary events within the real-life context	ED of a real-life and public healthcare institution in Portugal.

The option for a case study methodology, according to Yin (1989), also fits the fact that the observation is performed in an emergency department of a healthcare institution, limiting scientific generalisation.

Yin (1989) elaborates on the concept of "analytic generalisation". For the author, such concept describes the usage – as a template – of previously developed theory, working as a comparison point for the empirical data obtained in the case study. In this case, the process gathering "as is" could be used as the comparison point mentioned by the author, while the case study itself will focus on the optimisation reached through heuristics application during the simulation phase of the process gathered.

By such concept, hereafter, research on ED optimisation will be developed, sustained upon the usage of a previously recognised theoretical background, namely the application of the redesign heuristics.

Additionally, to support the use of the case study, some complementary methods will be used, such as direct observation, archival analysis, interviews and focus groups with professionals like doctors, nurses and hospital administrators.

4.2 CASE STUDY STRUCTURE

The case study structure that will be used in this research follows the recommendations of Yin (2013) and include the following four steps:

(1) Design the case study;
(2) Conduct the case study;
(3) Analyse the case study evidence;
(4) Develop the conclusions, recommendations, and implications.

In this chapter, we will approach only the characterisation and design of the case study adopted while the development, analysis, and conclusions of the case study will be addressed in the next sections. However, Yin's case study steps will not be explicit throughout the case study. Since this is a case study based on BPM, we decided to structure the research based on the BPM phases that we will address (Process Modelling, Process Analysis and Process Redesign). Within each of the three phases of the BPM, we will then follow, implicitly, Yin's steps.

4.3 CASE STUDY CHARACTERIZATION

The methodology of the case study is used by several researchers for the development and production of new theories as well as to challenge existing theories (Dooley, 2002). According to Yin (2013), this methodology is most appropriate when the focus of the research is to understand, explore or describe a contemporary phenomenon framed in a real-life context.

Yin (2013) identified three types of case studies: exploratory, descriptive, or explanatory. Like any of case study, study's questions and unit of analysis may be addressed *a priori*. Additionally, exploratory case study must have a purpose as well as the criteria by which exploration will be judged successful.

The primary purpose of this research is to find the redesign heuristics that better fit on improving the process of the ED and the criteria to judge if the improvement is done successfully is presented below:

- The redesign heuristics selected are framed with the context of the ED;
- The redesign heuristics applied reduce the time of the process;
- The total average time on the process of the process To-Be is significantly lower than in process As-Is;

- The quality inherent of service provided by the ED, increase, or at least, maintains equal.

According to the statements mentioned in this subchapter, we can assume that an exploratory case study is the most appropriate type of case study for this research.

4.4 CASE STUDY DESIGN

According to Yin (2013), the present study may be characterized as:

- Single-case Design, since it considers the application of many methods in the same context, an ED of one Public Hospital;
- Holistic, since it has a single unit of analysis, a single process flow.

4.4.1 Methods of Data Collection

Yin (2013) argues that data should be collected from different sources, in order to verify and validate the credibility of the data collected. On the other hand, Dumas *et al.* (2013) states that there are three classes of discovery techniques. In this way, the collection of data will be done through the following methods, described by the authors as more effective:

Table 10 - Yin and Dumas perspectives' of data collection. Source: Own Source

Yin (2013)	**Dumas *et al.* (2013)**	**Execution**	**Stakeholders**
Individual Interview	Interview-Based Discovery	There will be as many rounds of interviews as needed. The first ones for process modelling, the second ones for process analysis and the last ones for process redesign. Each round of interviews will contemplate all the interviewees and, in a specific situation, it could be needed to do more than 1 interview with the same professional.	Administrator Nursing Manager
Direct observation	Evidence-Based Discovery	Method of getting more insights and specifications of the process.	Nursing Supervisor
Documentation analysis		It will be done as a form of validation of the information collected and as a comparison between what is being done and what is written.	Medical Manager
Focus group	Workshop-Based Discovery	Meetings with the professionals interviewed in each round in order to cross and discuss information collected in previous phases.	

Data collection took place between 1st of April 2018 and 31st July 2018.

Table 11- Data Collection Phases. Source: Own Source

Phase	Input	Method	Output	Stakeholders
Choice of Process	---	Meeting	The process to be studied and scope of the research	Administrator Nursing Manager Nursing Supervisor Medical Manager
Process Modelling	---	1st round of interviews	1st draft of the process As-Is	Nursing Manager Nursing Supervisor Medical Manager
	1st draft of the process As-Is	Direct observation and Documentation analysis	2nd draft of the process As-Is	---
	2nd draft of the process As-Is	2nd round of interviews	3rd draft of the process As-Is	Nursing Manager Nursing Supervisor Medical Manager
	3rd draft of the process As-Is	Focus group	Final Process As-Is	Administrator Nursing Manager Nursing Supervisor Medical Manager
Process Analysis	---	Interviews	Listing with all problems identified	Administrator Nursing Manager Nursing Supervisor Medical Manager
	Listing with all problems identified	Focus group	Shorter listing with the main problems	Administrator Nursing Manager Nursing Supervisor Medical Manager
Process Redesign	---	Interviews	Identification of all possible improvements	Administrator Nursing Manager Nursing Supervisor Medical Manager
	Identification of all possible improvements	Focus group	Improvements association to the main problems	Administrator Nursing Manager Nursing Supervisor Medical Manager

As can be seen in Table 11 methods of data collection will be done in different phases.

Firstly, a meeting with all stakeholders will be held in order to define the scope of the research and limits of the process to be studied.

Then, information will be collected through the first round of individual interviews with all stakeholders. The primary objective of these interviews is to understand, generally, how the process is. In parallel with the information gathered in this first round of interviews, we will review the documentation related to the research and proceed to direct observation with all those involved in the various stages of the process. The second round of interviews will take place in order to validate the process modelled until then and make adjustments. At the end of this phase, there will be a focus group where the process will be presented to all stakeholders according to the information collected from the interviews, direct observation and document analysis. In case of contradictions between the testimonials of the stakeholders, the focus group will be the moment to solve them and make everything clear regarding the process. The last purpose of this focus group will be to come out with the process As-Is defined and validated upon by all stakeholders.

The third phase is related to the problem identification. This phase starts with a round of interviews with all the problems (managerial problems and processual problems) will be identified by the stakeholders. Then, those problems will be discussed in another focus group in order to obtain a shorter listing of the main problems identified.

The last phase is related to the possible improvements regarding the problems identified. The last round of interviews will take place focusing on gathering the information from each stakeholder regarding to improvements; then, the last focus group will be held in order to select the possible improvements for the shorter listing of main problems.

4.4.2 Choice of Tools

The main objective was well defined. Therefore, the right tools had to be chosen in order to correctly answer the main objective, that is, reduction of the time (Length of Stay) and, at least, maintain the quality level of the service provided by the ED under study.

To meet the objective, the modelling of the current process (as-is process) has to be performed. After that, BPM tools will be required. According to Dumas *et al*. (2013), BPM can be defined as a “body of methods, techniques and tools” that enable the researcher to discover, analyse and redesign business processes. Additionally, Dumas *et al*. (2013) refers that “BPM is the art and science of overseeing how work is performed in an organisation to ensure consistent outcomes and

to take advantage of improvement opportunities". Depending on the objectives of the organisation, typical examples of improvement can be, for instance, reducing costs, reducing execution times and reducing error rates (Dumas *et al*., 2013). Whenever there is the possibility of identifying processes with some waste, whether they are related to costs, time, material or even length of deadlines, it is possible to make use of business process modelling (Jacoski and Grzebieluchas, 2011).

According to this approach, it is required to know the process adopted by the hospital. It is imperative to collect as much information as possible referring to the process, taking into account the company's culture and the limitations of the process (Jacoski and Grzebieluchas, 2011).

After modelling, it will be needed to redesign the current process in order to obtain an optimized one (process To-Be). This is the process to be presented in the hospital.

Regarding to process optimisation, Redesign Heuristics will be used tentatively in order to elaborate on many scenarios. To evaluate the impact of the application of redesign heuristics in the process, two tools will be used simultaneously. First, process simulation will be used to instantly obtain quantitative insights about the application of each redesign heuristic without the need of a real application on the real context; second, the Devil's Quadrangle will be used to assess time and quality constraints after the application of each redesign heuristic.

In this context, BPM will be used as a tool regarding not only to modelling and redesign but also to process simulation. BPM can be defined as a "body of methods, techniques and tools" that enable the researcher to discover, analyse and redesign business processes, which are the focal point of BPM (Dumas *et al*., 2013).

4.4.3 Choice of the Process

In order to choose the process to be studied and improved, a meeting was held on 2nd April with the administrator of the ED, the Nursing Manager, the Nursing Supervisor, and the Medical Manager. The discussion was focused on defining the most time-consuming processes that occur in the ED of the Hospital.

The process was chosen based on three criteria: higher time-consuming processes than expected; process with room for improvements; and, be a critical process for the stakeholders of ED.

Taking into account these criteria, the patient flow in the ED was the process chosen, starting with patient's entry into the ED and finishing after patient's re-evaluation. The process will be described in detail in the next chapter.

5 CASE STUDY

5.1 CONTEXTUALIZATION OF AN ED

In this case, we will study part of a process of the general ED of a Portuguese public hospital. This hospital is located in Lisbon and is considered one of the leading hospitals among others. It plays a pivotal role in responding to urgent cases given its geographic location.

The emergency department has the objective of receiving, diagnosing and treating patients who are injured or have sudden illnesses requiring immediate care in a hospital unit. CRRNEU (CRRNEU, 2014) report mentioned that "Regarding the care activity, we understand urgency as a process that requires evaluation and/or correction intervention in a short time (curative or palliative); emergency is a process for which there is a risk of loss of life or organic function, requiring intervention in a short time; the situation is critical if it is not rapidly reversible, that is, whenever it is prolonged over time, and it needs advanced support methodologies of life".

An important episode is defined as the whole clinical situation in which the delay in diagnosis, or treatment, can bring severe risks to the patient. Examples of urgent situations are cases of severe trauma, acute poisoning, burns, heart or respiratory attacks. All situations that do not fit this definition should not, as a matter of principle, be observed in an ED.

Unfortunately, many times the patient goes to the ED without an urgent clinical situation. According to the *Tackling Wasteful Spending on Health* report of OECD (OECD, 2017), at least 31% of the Portuguese patients went to an ED without a necessity of this kind of service. Additionally, Portugal is the country with the higher rate of ED visits per 100.000 inhabitants (OECD, 2017).

This ED is placed in a Public Hospital. The hospital has three emergency departments: obstetric, pediatric and general. In this research, whenever we talk about ED, we are referring only to General ED.

First of all, it should be mention that the process under study do not contemplate the whole process of the ED but part of it (as can later be seen in Figure 4). The scope of the process under study, begins with the entry of the patient in the ED and ends with the re-evaluation of the patients. When we mention ED itself, we are talking about the part of the process that we are studying.

The ED is composed by three observation areas: Emergency Services of Greens and Blues (ESGB), Ambulatory and Clinical Observation. After the Manchester's Triage, the patient receives a priority (colour), which according to his physical situation will be sent to the waiting room of one of these three areas. There is another designated area for red priority patients called the Revival Room. However this area is outside the scope of this research.

ESGB treats non-urgent patients with green and blue priority who have no locomotion conditioning. Ambulatory and Clinical Observation treat urgent patients of yellow and orange colour. However, in this research, we will not study the ESGB's patients.

The path of the patient within the ED can be quite long and complex. The main stages of this process are, sequentially, the admission at the ED, the triage, the medical observation, the conduction of many medical examinations (if any), the medical re-evaluation, the hospitalization, the repetition of medical examinations (if necessary) and the successive medical re-evaluations until the patient's plan be defined. Depending on the patient's situation, the patient may stay within the ED for hours or days in a row.

Also, there are social cases of patients who are left in the ED without support, some of them with mental problems requiring additional attention from the health professionals who should be providing their emergency services.

The variables involved in the ED are so complex and unpredictable that makes this study very hard but at the same time very challenging.

From the patient's point of view, he travels to the ED whenever he thinks he has an urgent situation that must be treated in an ED. However, as mentioned earlier, some of these situations should not be addressed in the ED. This lack of clinical interpretation on the part of the patient is a failure of the society that should educate the population with underlying health issues. In Portugal, this issue is worrying, since the flow of patients to the ED is very high, that is, 3 out of 10 patients unnecessarily move to an ED (OECD, 2017).

There are a high variety of resources working in the ED. This research focuses mainly on those who has direct relation with the patient flow of the ED. The type of resources and quantity of each one available per shift are presented in Table 12.

Table 12 - Resources available per shift

Type of Resource	Quantity
Doctors (general medicine)	11
Doctors – Specialist*	3
Nurses – T	2
Nurses – CAP	8
Desk supporters	2
Technicians	3

*-The specialist (many specialities) is not 100% allocated to the ED, but he/she provides her/his services every time is asked for that.

As can be seen in Table 12, there are two types of nurses to differentiate the ones that operate in the triage (Nurses-T) and those who operate in the Clinical Analysis and Procedures (Nurses – CAP).

Activities like triage and re-triage are done by the same resources as medical observation and medical re-evaluation. In the Table 13 the main activities, rooms available for each activity and the type and quantity of resources needed are introduced.

Table 13 - Resources needed per activity

Activity	Rooms	Type/Quantity per Room
Admission	2	1 of 2 Desk Supporters
Triage / Re-Triage	2	1 of 2 Nurses - T
Medical Observation / Medical Re-evaluation	10	1 of 11 Doctors
Evaluated for specialist	3	1 of 3 Doctors - Specialist
Medical Exams	3	1 of 3 Technicians
Clinical Analysis and Procedures	2	2 of 8 Nurses - CAP

5.2 CUSTOMER IDENTIFICATION AND VALUE CREATION

The customer of an ED is the patient. The primary purpose of this ED is to provide the customer with a service within the quality standards and times defined as acceptable for the treatment of the patient.

About quality, the ED intends that the problem that brings the patient to the ED be solved, if possible. If not, a medical plan should be defined in order to solve the problem within the period necessary for each specific case.

Regarding timing, there are some standards defined by the ED. Regarding the waiting times until the patient is attended for medical observation, this ED takes into consideration the waiting times presented in Table 14.

Table 14 - Satisfactory waiting times to be attended until medical observation. Source: provided by the ED under study

Priority	Time (min.)
Red	0
Orange	10
Yellow	60
Green	120
Blue	240

On the other hand, according to the ED administrator, there are also satisfactory times to perform the medical observation activity. Since red priority is seen as very urgent situation, there are no time specified. When this situation occurs all necessary efforts are made available. The satisfactory times to perform such activity are shown in Table 15.

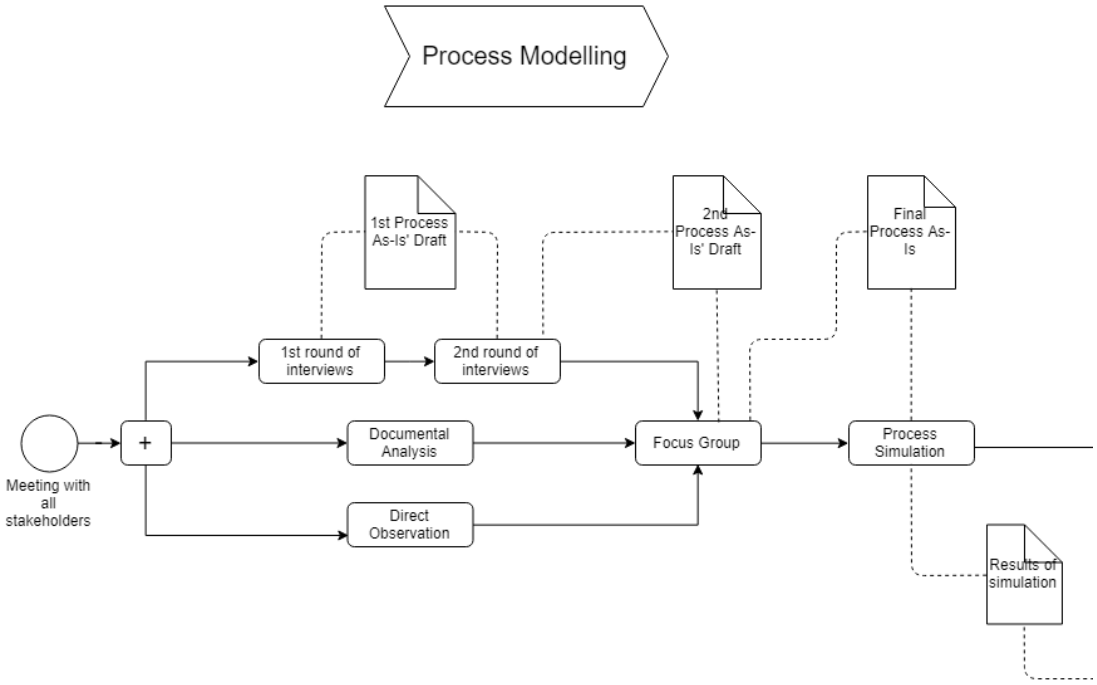
Table 15 - Medical observation activity - performing times. Source: provided by the ED under study

Priority	**Time (min.)**
Red	*No time defined*
Orange	*45*
Yellow	*30*
Green	*15*
Blue	*10*

6 PROCESS MODELLING (AS-IS MODEL)

The As-Is process is the current ED process. The purpose of this section is to describe what has been done to get the As-Is process, and finally to present the As-Is process itself, as can be seen in Figure 3.

Figure 3 - Process Modelling steps



6.1 DATA COLLECTION

In order to gather all the information necessary to complete the As-Is process, several interviews were required with many ED professionals, as already mentioned in section 4.4.1 In addition, several documents provided by the ED have been analysed, which contained several rules and standards for the proper functioning of the ED. In order to understand, in detail and *in loco*, all the phases of the ED process, two direct observation sessions were carried out in order to validate the process modelled in *Bizagi* software. (Bizagi, 2018. Retrieved from https://www.bizagi.com/)

The data obtained through the several sources used will be properly mention throughout the section 6.2 when describing the steps carried out until the elaboration of the final version of the process As-Is (see Figure 4).

Table 16 - Process Modelling steps

Average Time Used	Input	Method	Output	Stakeholders
45 minutes per interview	---	1st round of interviews	1st draft of the process As-Is	Administrator Nursing Manager Nursing Supervisor Medical Manager
Two sessions of 120 minutes	1st draft of the process As-Is	Direct observation	2nd draft of the process As-Is	---
240 minutes		Documentation analysis		
45 minutes per interview	2nd draft of the process As-Is	2nd round of interviews	3rd draft of the process As-Is	Administrator Nursing Manager Nursing Supervisor Medical Manager
90 minutes	3rd draft of the process As-Is	Focus group	Final Process As-Is	

6.2 PROCESS AS-IS

The process begins with the patient's entry into the ED. If he/she is a critical patient, he/she is immediately referred to the Emergency and Revival Room. Otherwise, the patient or his/her companion should go to the queue (if any) to register in the ED after been called, and then, be admitted. This is the first step for the patient to be admitted to the ED.

The critical patients are out of the scope of the process due to the effectiveness of the Emergency and Revival Room. It was defined in the meeting when the process was chosen in the presence of all the stakeholders. This meeting is mentioned in Table 11 of section 4.4.1. This situation is presented in the process As-Is (see Figure 4) with the end-event “Emergency and Revival Room”. In accordance with Medical Manager, the patients assigned to the Emergency and Revival Room are those with red priority and few with orange priority within a set of symptoms defined. The full set of symptoms that make a patient goes to this room are discriminated in a norm of the hospital that could not be provided to the public due to confidentiality.

The patient should then awaits for his turn in the waiting room before being called to do the Triage. According to the Nursing Manager, the first waiting room is located very close to the two Triage rooms. This fact was verified through direct observation.

During the Triage, a bracelet with a number is assigned to the patient with the colour of their priority according to the clinical situation evaluated by a nurse. The administrator of the ED

confirms that triage on this ED is performed supported on the Manchester Triage System. According to his colour and situation, the patient is referred to a medical area of the ED. Again, this information was consulted from a norm of the hospital.

After triage, the green and blue priorities get out of the process to the ESGB area (except those on wheelchair or stretcher) as can be seen in Figure 4. ESGB area was not to take under consideration since it mostly deals with "no urgent cases" of the ED, explained the Nursing Supervisor during the first meeting and agreed by the other stakeholders.

In a few situations, the patients could be re-triaged. The patient is re-triaged if under certain circumstances waits for too much to be attended by a doctor and under the terms mentioned in Table 17. This information was also verified from the analysis of a norm of the hospital.

Table 17 - Re-triage

Priority (Colour)	Waiting time after Triage	Re-triaged?
Red	Already left the process under study	-
Orange	More than 35 minutes	Yes
Yellow	More than 80 minutes	Yes
Green	Not re-triaged	-
Blue	Not re-triaged	-

After triage (or re-triage), the step that comes next is the Medical Observation. This step is preceded by the call of the patient who was in the waiting room of the respective medical area. In the process, there is no distinction between the different areas since the data that was collected contemplates both clinical observation and ambulatory agglomerated (ESGB is out of the scope). There are six medical observation rooms distributed equally for both areas. After the patient is called to one of the observation rooms, the doctor reviews the patient's history and collects the patient's current situation. After this step, several following steps can happen. If the doctor feels comfortable following the patient, he or she may request medical examinations such as ECG, x-ray, CT scan or blood tests, urine, therapeutic preparation, and invasive procedures.

If the doctor notices that there is no need to perform any medical examination, analysis or procedure, then after delineating the medical plan for the patient, the patient may be discharged.

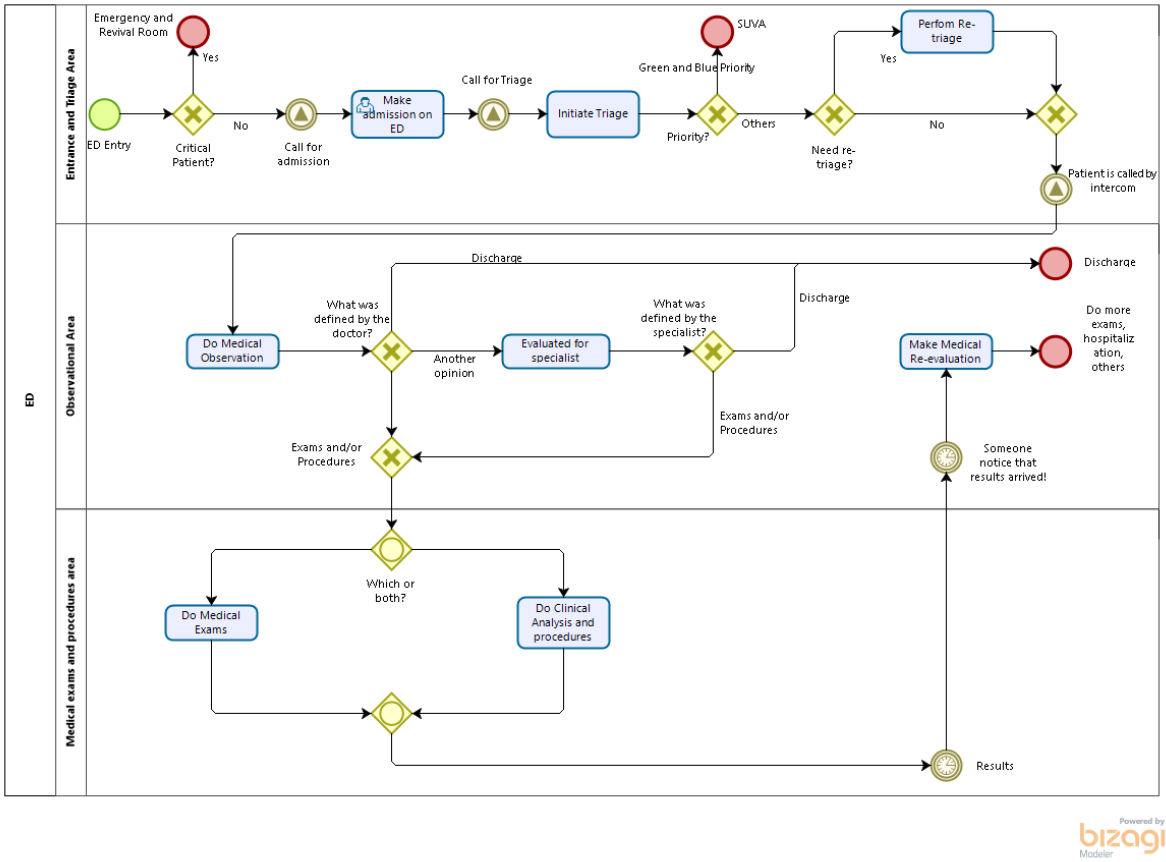
If the doctor does not have full knowledge to accompany the patient, he or she can request the patient to be observed by another doctor of another speciality. In this case, the patient will again have to wait until the specialist doctor is available to take care of him, as he may not be 100% allocated to the ED and may have other tasks to do. As soon as the specialist doctor treats the

patient, he or she will have the same procedure as a normal patient and therefore, the doctor may request to perform medical exams or clinical analysis and procedures or even discharge the patient. After performing medical exams, clinical analysis or procedures, the patient have to wait for the results of the exams and/or clinical analysis or wait for the medication to take effect in order to be re-evaluated by the doctor. The ED resort to an external service in order to elaborate the results of the medical exams and clinical analysis.

Medical re-evaluation is the last step of the process that we are studying; however, in the real-life of this ED, there may be more steps, such as performing more exams, hospitalisation, surgery, and others.

Medical re-evaluation serves essentially to reassess the patient according to the outcome of the examinations or clinical analyses performed and/or procedures and medication ingested. At this point, if the doctor already has enough information to diagnose the patient's problem, then he or she can outline a medical plan for the patient. In this way, the patient will be discharged. Otherwise, the patient will continue in the ED.

Figure 4 - Process As-Is of the ED



6.3 INPUTS FOR PROCESS SIMULATION

The collection of data for simulation was, probably, one of the hardest parts of this research since the data provided by the IS of the ED was not feasible. Also, the data was scarce and did not provide us with a reflection of the real context of the ED. Therefore, we needed to cross the data from the IS of the ED with information gathered from interviews and direct observation.

First of all, it is essential to mention that the period that we will use to simulate the models regarding this research was previously defined with the help of the stakeholders is aforementioned. The time of the day chosen is from 9 a.m. to 12 p.m for a total of 15 hours. This decision was made based on the daily period with a higher flow of patients to the ED. In order to provide a broad vision of the ED, we also decide to define three distinct scenarios. Each scenario has a different ratio of patient per hour. Further, on this subchapter, more detail will be provided regarding the three scenarios.

In order to proceed to process simulation of the process As-Is, it was needed to collect data that supported this simulation. To do a proper simulation, the following data was needed:

- Resources available per shift;
- Type of resource needed for each activity;
- Rooms available for each activity;
- Work Time per activity (minimum, maximum and average);
- Required waiting time for each activity (if any);
- Percentage to be defined in the gateways;
- Patient's flow – three scenarios (S1, S2, and S3);
- Statistical distributions were chosen.

Resources available per shift

Due to high rotation and variability of combinations of resources per shift, it was decided to establish a set of resources that are typically on the ED in a specific period.

On Table 12 of section 5.1, the set of resources available during the period defined for the simulation is characterized:

Type of resources needed and rooms available for each activity

Each activity needs resources to make them happen. The activities need one or two resources to be performed. Each activity has more than one room available to be performed. The characteristics of the ED regarding rooms available and resources needed for activity are defined in Table 13.

Work Time per activity (minimum, maximum and average)

The working times were gathered both from the IS of the ED and individual interviews with stakeholders. Regarding data extracted from the IS of the ED, unfortunately, it was inaccurate and incomplete. Thus, the times presented in Table 18 are as close as possible from the real context of the ED under study.

Table 18 - Working times

Activity	Required Waiting Time (mins)	Min. (mins)	Avg. (mins)	Máx. (mins)
Admission	-	*1*	*3*	*7*
Triage	-	*12*	*8*	*14*
Re-Triage	-	*3*	*6*	*14*
Medical Observation	-	*24*	*33*	*61*
Re-evaluation	-	*15*	*28*	*54*
Observation for specialist	*10*	*22*	*25*	*47*
Medical Exams	*5*	*20*	*30*	*43*
Clinical Analysis and Procedures	*5*	*15*	*26*	*40*

Percentage to be defined in the gateways

Along the process, some decision points (gateways) was necessary to implement. Those gateways help us to screen the patient flow in the right way; making simulation looks as close as possible to the real context of the ED. To do so, the gateways and the respective percentage are presented in Table 19.

Table 19 - Gateways

Gateway	Possible Paths	% (Percentage)
Critical Patient? (excluded from the process)	Yes	*2%*
	No	*98%*
Priority? (excluded from the process)	Green and Blue Priority	*33%*
	Others	*67%*
Need re-triage?	Yes	*15%*
	No	*85%*
What was defined by the doctor?	Discharge	*8%*
	Another opinion	*5%*
	Exams or CAP	*87%*
What was defined by the specialist?	Discharge	15%
	Exams or CAP	85%
Exams or CAP?	Medical exams	40%
	CAP	60%

Patient's flow – three scenarios (S1, S2, and S3)

A day in the ED is not equal. There are some tendencies depending on the day of the week. According to the Medical Manager, Mondays are the most complicated days due to the high flow of patients. It was possible to verify through the data collected from the IS of the ED. In order to fulfil the variety of each day during a work week, three scenarios (Table 20) were created based on the information collected from the IS but also taking into consideration the values of reference given by the Medical Manager.

From the data gathered from the IS of the ED, it was possible to verify that, on average, 85% of the patients go to the ED between 9 a.m. and 12 p.m.

Table 20 - Patient's entry rate (3 scenarios)

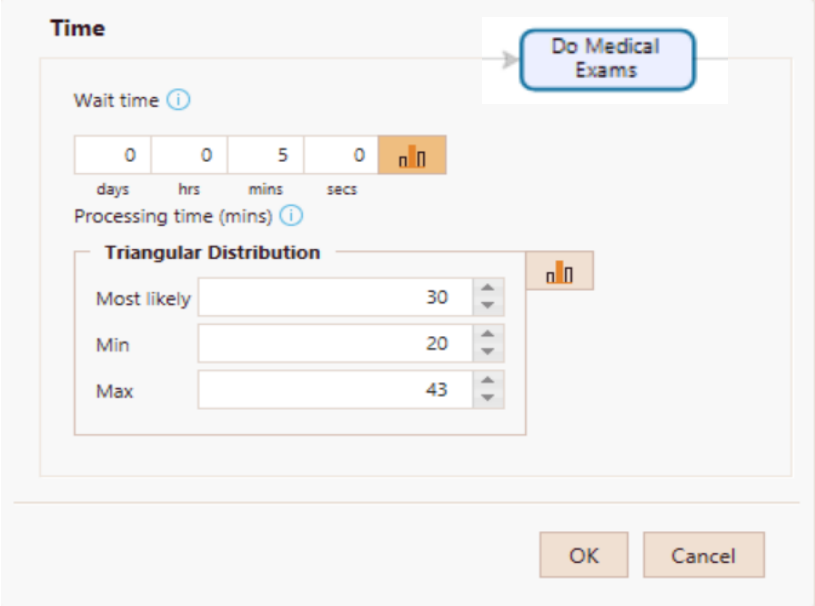
Scenario	Patient Ratio/Working Hour	Total Patients/day	Working Time	Total Patients/Working Time (85% of total)
As- Is S1	13 patients	230	15h (9-24)	196
As- Is S2	16 patients	280	15h (9-24)	238
As- Is S3	19 patients	350	15h (9-24)	298

Statistical Distributions

Triangular Distribution was used to simulate the work time of all activities. It is used when the information about the real time of the activity is scarce. A triangular distribution uses minimum, maximum and most likely times for the conclusion of each activity.

Some activities have required waiting time. This time is set on average time basis only.

Figure 5 - Time configuration of "Do Medical Exams" Activity

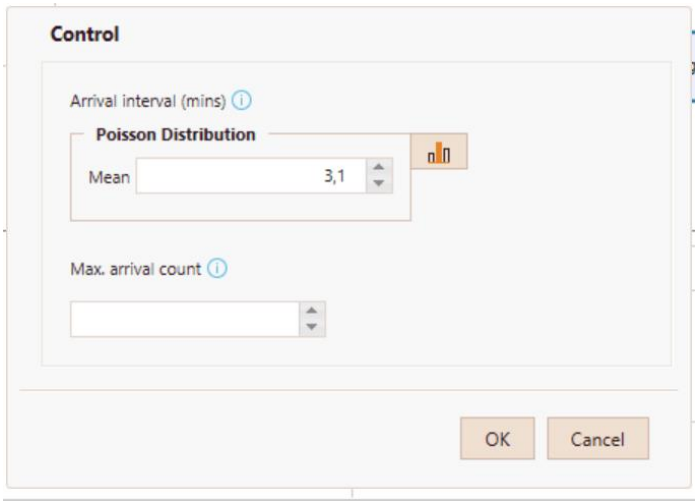


As an example of both situation mentioned above,

Figure 5 presents how “Do Medical Exams” activity is configured regarding required waiting time (i.e. the time that the patients consume to dress up before the exams) and processing time taking into consideration the parameters of the Triangular Distribution.

In order to simulate the entry of patients in the ED, a Poisson distribution was used (Figure 6). This distribution is characterized by the dispersion of results that are generated based on a single parameter - *lambda*.

Figure 6 - Entry point configuration



6.4 RESULTS OF PROCESS SIMULATION (PROCESS AS-IS)

In process simulation, What-if analysis was performed based on three scenarios mentioned in Table 20 with the same resources for each. ED S3 is the scenario with a higher rate of patients per hour. In 15 hours of the working day under study, 280 patients entered in the ED S3. The rate of patients in the ED S3 is 20.2% higher than ED S2 and 48.9% higher than ED S1.

Again, it is important to mention that the results that we get out of the simulation to refer only the scope of the process under study, that is, from the moment when the patient enters in the ED, to the moment when the patient is re-evaluated. Moreover, so, the average time that a single patient is within the process is 2 hours and 9 minutes in the ED S3, taking at the maximum 6 hours and 37 minutes on it.

Comparing the maximum and average times between the scenarios, we can affirm that higher the rate of patients per hour, higher the maximum and average times that patients stay in ED. The maximum and average times that a patient stays within the ED S3 are 15.6% and 20.9% higher than in ED S1, and 11.5% and 11.8% higher than in ED S2.

Taking into account the results of this simulation introduced in Table 21, we decided to take only one scenario to use as a term of comparison in the process redesign phase. The scenario chosen is the ED S3 since it presents a higher margin of improvements and it is the one that represents more problems for the ED. However, for the other two scenarios, the final results will also be presented for each at the end of section 8.3 where the redesign heuristics will be applied.

Table 21 – Scenarios of Process As-Is

Name	Scenario	Type	Instances completed	Instances started	Max. time (hrs)	Avg. time (hrs)
ED S1	As-Is S1	Process	161	188	5h 43m	1h 47m
ED S2	As-Is S2	Process	202	233	5h 56m	1h 55m
ED S3	As-Is S3	Process	212	280	6h 37m	2h 09m

Table 22 introduce the resources utilization in the process chosen (ED S3). Doctors, both types of Nurses are those with the highest utilization. On the other hand, the Doctor – Specialist has the

lowest utilization since he/she is not fully allocated to the ED. He/she only works on the ED on is called for another doctor to treat a specific patient.

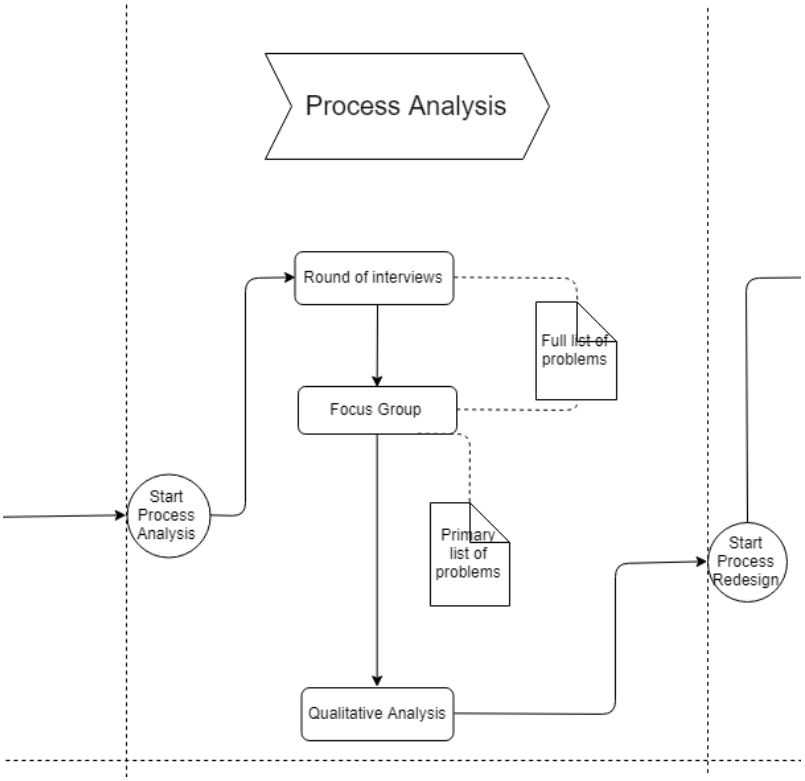
Table 22 - Utilization of resources

Resource	Utilization
Doctor	*91.95 %*
Nurse - T	*87.36 %*
Nurse - CAP	*81.18 %*
Technician	*79.54 %*
Desk Supporter	*77.92 %*
Doctor - Specialist	*10.08 %*

7 PROCESS ANALYSIS

Throughout this section, a deeper analysis of the process As-Is and its problems will be performed. The steps that will be taken can be seen in Figure 7.

Figure 7 - Process Analysis steps



7.1 DATA COLLECTION

In order to elicit the main problems identified by the professionals of the ED, a round of interviews with all the stakeholders involved in this research followed by a focus group session, as already mentioned in section 4.4.1. The purpose of the interviews was to make a brainstorm with all problems presented in every professional's mind. Then, to better treat all the ideas originated by everyone, a focus group took place in order to summarise and define the list of main problems of the ED.

Additionally, some evidence were taken from the simulated model of the process As-Is. With simulation, it was possible to verify the existence of correlations between the bottlenecks presented in the model and the problems mentioned by the stakeholders.

Table 23 - Process analysis steps

Average Time Used	Input	Method	Output	Stakeholders
30 minutes per interview	---	Interviews	List with all problems identified	Administrator Nursing Manager Nursing Supervisor Medical Manager
120 minutes	List with all problems identified	Focus group	Main List with the main problems	

7.2 LIST OF PROBLEMS

The following list presents the problems mentioned by all the stakeholders. Some problems were mentioned by more than one stakeholders, as can be seen in Table 24. The list of problems was obtained through individual interviews with each stakeholder.

Table 24 - Wide list of problems

Problem	Stakeholders				Total	%	FG
	Admin	MM	NM	NS			
Work overload		X	X		2	50	X
Information system used is obsolete			X	X	2	50	X
Information system is not fully used		X	X	X	3	75	X
Lack of information flow from external services and ED		X		X	2	50	
Lack of physical space in the ED	X	X	X	X	4	100	X
Inefficient disposition of areas	X	X			2	50	X
The medical team is inexperienced	X	X			2	50	X
Many patients go to the ED with no emergent situations	X	X	X		3	75	X
The unnatural high flow of patients	X	X	X	X	4	100	X
Inexperienced Nurses in Triage			X		1	25	
Non-specialized doctors	X	X			2	50	X
Lack of basic health knowledge from the population	X	X			2	50	X
Response after exams results is prolonged		X		X	2	50	X
Lack of security in the infrastructure		X		X	2	50	X
Low Organisational Culture				X	1	25	
Call for medical observation and patient's picking in the IS may not match			X	X	2	50	

***P/M**: Processual/Managerial; **Admin**: Administrator; **MM**: Medical Manager; **NM**: Nursing Manager; **NS**: Nursing Supervisor; **FG**: consensus reached during Focus Group.*

The list of problems gathered through the interviews was used as input for the focus group. The objectives of this focus group were:

- To find out which problems have obtained consensus among all stakeholders (see Table 24);
- To merge similar problems into one, and rename problems if needed (see Table 25);
- To define the list of problems to be analysed in the next sections (see Table 25).
- To elaborate a value-added analysis and root-cause analysis (see section 7.3).

The information about the consensus is presented in the column "FG" of Table 24. Some of the problems mentioned in the first list of problems were disregarded or did not obtained consensus among the stakeholders. For example, "Lack of information flow from external services and ED", "Inexperienced Nurses in Triage", "Low Organisational Culture" and "Call for medical observation and patient's picking in the IS may not match" problems did not obtain consensus among stakeholders at all.

Table 25 presents the output of the focus group session. The main problems undermentioned will be used as input for the next sections of the research.

Table 25 - Main list of problems

Main Problems		**Problems from** Table 24
P1	Work overload	Work overload
P2	The medical team is inexperienced	The medical team is inexperienced
		Non-specialized doctors
P3	Information system is not adjusted to the needs of ED	Information system used is obsolete
		Information system is not fully used
P4	The patients wait too much time for re-evaluation	Response after exams results is prolonged
P5	The physical space of ED is fully used	Lack of physical space in the ED
		Inefficient disposition of areas
P6	The population is not well informed about basic health knowledge	Many patients go to the ED with no emergent situations
		Lack of basic health knowledge from the population
P7	The unnatural high flow of patients	The unnatural high flow of patients
P8	Lack of security in the infrastructure	Lack of security in the infrastructure

These problems will be essential for the analysis of this research since they will be the input for the discovery of the improvements. In section 8 the problems will be associated with the possible

improvements mentioned by the stakeholders, which will, therefore, be aligned with the redesign heuristics.

7.3 QUALITATIVE PROCESS ANALYSIS

The data needed to proceed to the process analysis was also collected during the interviews and focus group. Also, we bring together two techniques for qualitative process analysis presented by Dumas *et al.* (2013), the value-added Analysis and the Root-Cause Analysis. First, it is presented a technique that aims to make the process leaner by identifying unnecessary parts of the process in order to evaluate its elimination. Second, it is presented as a technique for identifying and analysing the parts that create problems that negatively affect process performance. In particular, we discussed how to analyse the impact of problems to prioritize redesign efforts that will be addressed in section 8.

Both of the analysis was executed during the focus group mentioned in the previous section 7.2 in the presence of the four stakeholders.

Value-Added Analysis

In order to proceed to the Value-Added Analysis (Dumas *et al.*, 2013), we elaborated a table with all the activities identified through the process modelling and evaluate each one regarding their value to the client, to business or inexistence of value. For that, we classified each activity of the process modelled taking into account three categories: Value-Adding for the customer (VA); Business Value-Adding (BVA); and, Non-Value-Adding (NVA).

Table 26 - Value-Added Analysis

Activity	Performer	Classification
Make admission on ED	Receptionist	BVA
Initiate Triage	Nurse – T	BVA
Perform re-triage	Nurse – T	BVA
Do Medical Observation	Doctor	VA
Evaluated for specialist	Doctor - specialist	VA
Do Medical Exams	Technician	BVA
Do Clinical Analysis and Procedures	Nurse - CAP	VA/BVA
Make Medical re-evaluation	Doctor	VA

The objective of Table 26 is to identify which activities are non-value-adding for the patient neither for the ED. However, non-value-adding activities were identified. That means that the process under study has no tasks to eliminate according to Value-Added Analysis. Taking this into consideration, none of the activities will be eliminated in the Process redesign section.

Root-Cause Analysis

When analysing a business process, it is essential bearing in mind that even a process seen as good has always room for improvements (Hammer, 2010). Conforming to Dumas *et al*., (2013) almost all non-trivial business process, regardless of how much it has been improved, suffers from various problems. There are always mistakes, misunderstandings, incidents, unnecessary steps, and other forms of waste when a business process is run on a day-to-day basis.

The problems of the process were already identified in section 7. Those problems were identified during the interviews and focus group sessions with the stakeholders, supported by a depth analysis of the data collected from the other sources as direct observation and documental analysis. In consonance with Dumas *et al*., (2013), each stakeholder has a different opinion on the process and may tend to raise problems from their perspective. The same problem can be perceived differently by two stakeholders.

Root-cause analysis is a family of techniques that help identify and understand the root-causes of problems or undesirable events. In the context of business process analysis, the root-cause analysis is helpful to identify and to understand the issues that prevent a process from having a better performance (Dumas *et al*., 2013).

The root-cause analysis encompasses a variety of techniques (Wilson *et al*., 1993). However, this research was only applied the Why-Why Diagrams (also known as Tree Diagrams) that helped us to understand better the root-causes of the primary problems identified. Why–why diagrams are a technique to analyse the cause of negative effects, such as issues in a business process. The basis of this technique is to consecutively ask "Why" questions regarding an issue and the respective contributing factors of that issue until the real causes of the problems are found.

Full-Time Employee Optimisation of Emergency Departments

Issue 1 *Patients sometimes wait too much time for re-evaluation, why?* (P4 in Table 25)

The time between results and re-evaluation is too long, why?

- Doctors do not notice that results have arrived, why?
    - The system does not alert for results arrival, why?
        - Functionalities of the system are not fully used.
    - The doctor forgets the patient's record, why?
        - The doctor is too busy with other cases that arrived after.

According to the Why-why diagram for Issue 1, the reasons why patients wait too much for re-evaluation are mainly two:

a) The functionalities of the IS are not fully used (P3 in Table 25);
b) Doctors are too busy with other cases that forget the previous ones.

Issue 2 *Work overload, why?* (P1 in Table 25)

Lack of resources, why?

- Limited budget to contract more resources.
- Lack of physical capacity from ED (P5 in Table 25).
- Hard to forecast the future patient flow accurately, why?
    - Low investment on the forecast.
    - Lack of tools to forecast.
    - The ED does not treat historical data in the right manner and information is lost.

The inexperience of doctors, why?

- Most resources have no-specialization, why?
    - They are cheap;
    - They are more flexible;
    - They accept work when expert doctors do not.

The flow of patients is increasing even more, why?

- Local health centres do not work accurately, why?
    - Limited resources;
    - Limited working hours;
    - Lack of confidence from the patients on the Local Health centres.

According to the Why-why diagram for Issue 2, the reasons why work is overloaded are:

a) Lack of resources;
b) The inexperience of doctors (P2 in Table 25);
c) The flow of patients is increasing even more (P7 in Table 25).

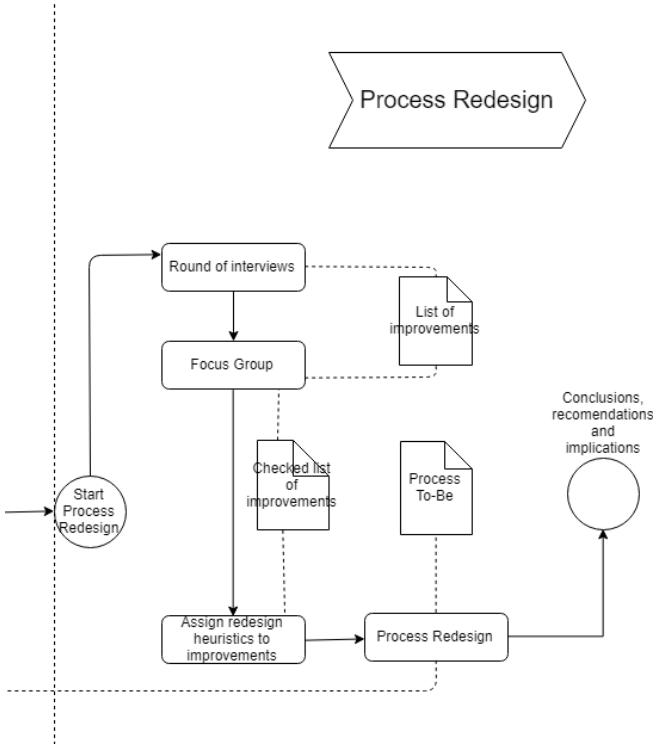
As a conclusion to Root-Cause Analysis, we can affirm that almost all of the problems mentioned in Table 25 are also causes of other problems introduced in the same list. This means that there are different levels of problems. For example, the inexperience of doctors (P2 in Table 25) is a cause of the work overload (P1 in Table 25). Anyway, the “inexperience of doctors” still be a problem in our point of view and will be addressed as a problem (like “work overload”) throughout the research.

8 PROCESS REDESIGN

According to Dumas *et al*. (2018), there are two approaches to make process redesign: exploitative redesign and explorative redesign. The first one aims to identify the main problems of a process and improve them incrementally, one at the time. The second one seeks to achieve a radical change in the process. In our research, we used the exploitative redesign where some redesign heuristics were addressed to the problems identified to solve them one by one.

In order to elaborate on this section, the steps presented in Figure 8 were followed.

Figure 8 - Process Redesign steps



8.1 DATA COLLECTION

At this stage of the research, we had already elaborated the As-Is and identified the primary problems. Now, we are going to proceed to the last stage of BPM approached on this research: Process Redesign.

Once again, the data that support the process redesign was, firstly, gathered through another round of interviews and then a focus group session. Farther, the results of process simulation presented

in section 6.4 were also a source of information that offered us more valuable insights that were not possible to obtain through the aforementioned methods of data gathering. Finally, the process analysis elaborated on section 7 gave us helpful information regarding the problems to address on process redesign.

Table 27 - Process redesign steps

Average Time Used	Input	Method	Output	Stakeholders
30 minutes per interview	---	Interviews	Identification of all possible improvements	Administrator Nursing Manager Nursing Supervisor Medical Manager
90 minutes	Identification of all possible improvements	Focus group	Improvements association to the main problems	

8.2 ANALYSIS OF IMPROVEMENTS

Taking into consideration the problems identified in the previous section of the research, a round of individual interviews with all the stakeholders took place in order to find the possible improvements. For this purpose, each stakeholder gave his/her opinion about what should be improved in the ED.

The nature of the improvements found was both processual and managerial. Since BPM focus mainly on improving processual issues, we must distinguish both in order to approach only the processual issues on our research. We will only consider the problems that have processual nature.

The improvements mentioned by each stakeholder during the interviews are presented in Table 28. As can also be verified, some stakeholders mentioned the same improvements. Finally, the distinction between the natures of the improvements is referred in the column “Type” of Table 28.

Table 28 - Results of interviews (Process Redesign)

Improvements		Type (P/M)	Stakeholders				Total	%
			Admin	MM	NM	NS		
I1	Increase the type of resources needed when needed	P		X	X		2	50
I2	Training sessions for the medical team	P	X			X	2	50
I3	Contract more expert doctors than non-experts	P		X		X	2	50
I4	Improve the IS to fulfil all the needs of the ED and automatically provided notifications to the key-users	P			X	X	2	50
I5	Make use of more functionalities of the IS	P		X	X	X	3	75
I6	Create a notification that alert doctors when results of exams arrive at IS	P		X	X	X	3	75
I7	Increase the physical space of the ED	M	X	X	X	X	4	100
I8	Predict in advance the need for increasing the number of Doctors and Nurses	M	X	X			2	50
I9	Marketing campaigns to inform patients about when to go to ED	M		X			1	25
I10	Create synergies with the near local healthcare centres	M	X	X			2	50
I11	Increase security staff of the ED	M		X	X	X		75

***P/M**: Processual/Managerial; **Admin**: Administrator; **MM**: Medical Manager; **NM**: Nursing Manager; **NS**: Nursing Supervisor*

After interviews, the list of improvements was analysed. The improvements were classified in Processual or Managerial (as can be seen in Column "Type (P/M)" of Table 28) and ordered by Type.

Another focus group session took place in order to verify the consensus with all stakeholders about the improvements mentioned by everyone. Additionally, stakeholders also verify and validate the

nature of each improvement. Finally, a proposal of redesign heuristics was presented to the stakeholders.

As a result of the focus group, the consensus about all improvements was achieved, and none of the improvements was disregarded. The nature of improvements was approved, and stakeholders agreed on disconsider the managerial improvements of the research. The list of problems and improvements disconsidered is presented in Table 29.

The improvements I7 and I9 (see Table 29) was both related to high investments that were considered out of the scope of the research. The solutions pointed by stakeholders during the focus group for I7 was the construction of a new building while the improvement I9 required an involvement between other institutions to be successful. I10 required involvement with local health centres that was considered out of the scope as well. I8 is a managerial improvement to be analysed by the administration of the ED. Security staff was not considered as a resource on the modelling and analysis of the process since it has not an active duty on the core business of the ED. Thus I11 was also disregarded.

Table 29 - Managerial Improvements

Problems		Managerial Improvements	
P5	The physical space of ED is fully used	I7	Increase the physical space of the ED
P6	The population is not well informed about basic health knowledge	I9	Marketing campaigns to inform patients about when to go to ED
P7	The unnatural high flow of patients	I8	Predict in advance the need for increasing the number of Doctors and Nurses
		I10	Create synergies with the near local healthcare centres
P8	Lack of security in the infrastructure	I11	Increase security staff of the ED

Taking into consideration the processual improvements presented, an analysis of possible redesign heuristics (Mansar and Reijers, 2005; Dumas *et al.*, 2013) were elaborated. The redesign heuristics was chosen to take into account both the objectives of this research and the processual improvements referred in Table 30. The redesign heuristics was approved by stakeholders during the focus group.

8.3 APPLICATION OF REDESIGN HEURISTICS

Table 30 can be considered as the juice of process analysis. In this table are selected the problems that will be addressed throughout the application of redesign heuristics chosen. For the problem P1, extra resources will be added to the process in order to satisfy the improvement proposed by stakeholders, I1. The relation between problems, improvements and redesign heuristics can be consulted in Table 30.

Table 30 - Alignment of redesign heuristics with Problems and Improvements

Problem		**Improvement**		**Redesign Heuristic** (see Table 4 and Table 5)	
P1	Work overload	I1	Increase the type of resources needed when needed	H1	Extra Resources
P2	The medical team is inexperienced	I2	Training session for the medical team	H2	Specialist
		I3	Invest in more expert doctors that will make work faster and keeping the degree of quality, adjusting the ratio of specialist/non-specialist		
P3	Information system is not adjusted to the needs of ED	I4	Improve the IS to fulfil all the needs of the ED and automatically provided notifications to the key-users	H3	Integral Technology
		I5	Make use of more functionalities of the IS		
P4	The patients wait too much time for re-evaluation	I6	Create a notification that alert doctors when results of exams arrive at IS		

Many combinations of redesign heuristics will be simulated regarding three redesign heuristics selected. Firstly, each redesign heuristic will be applied to the process As-Is and then, simulated. Secondly, redesign heuristics will be combined with two. Moreover, finally, the three redesign heuristics will be simulated together. The different combinations that will be simulated are presented in Table 31.

Table 31 - Combinations of redesign heuristics

Redesign Heuristic	Devil's Quadrangle		H1	H2	H3	C1	C2	C3	C4
	Time	Quality							
Extra Resources	-	.	X			X	X		X
Specialist	-	+		X		X		X	X
Integral Technology	-	+			X		X	X	X

H1, H2, H3 = Heuristic 1, 2, 3; C1, C2, C3, C4 = Combination of Heuristics 1, 2, 3, 4.

Since primary objective of this research is to find the accurate redesign heuristics that better fit on improving the process of the ED under study regarding total time of the process without deteriorating service quality, the redesign heuristics chose decrease the time of the process and, at least, remains equal the quality provided according to the Devil's Quadrangle (Dumas *et al*., 2013). The information that Devil's Quadrangle provides us will be validated, regarding time constraint, through simulation of each of combinations of redesign heuristics presented in Table 31. Since there is not enough information to evaluate the quality constraint on practice through the simulation, we will follow only the information that Devil's Quadrangle provides us.

Process Simulation (H1) – "Extra Resources"

"Extra resources" redesign heuristic – "If capacity is not sufficient, consider increasing the number of resources" (Mansar and Reijers, 2005; Dumas *et al*., 2013).

Taking Table 22 as a reference, we suggest increasing the number of resources in three different type of resources. One in each of resources with higher utilization. They are Doctors, Nurses – T and Nurses – CAP as can be seen in Table 32. The other resources remain equal.

The choice of resources to increase was made based on information gathered from interviews and on the results of process simulation of process As-Is. According to the Medical Manager, the doctors are scarce when the high flow of patients happen. On the other hand, the Nursing Manager stated the same regarding nurses, during an interview.

In Table 33 we check and validate the information stated from the Medical and Nursing Managers that Doctors, Nurses – T and Nurses – CAP are those with the highest utilization in the ED.

Table 32 - Extra Resources

Process As-Is	**Process H1**
Doctors = 11	*Doctors = 12 (+1)*
Nurses – CAP = 8	*Nurses – CAP = 9 (+1)*
Nurses – T = 2	*Nurses – T = 3 (+1)*

Table 33 - Comparison of resources utilization (H1)

Resources	**Utilization As-IS**	**Utilization H1**	**Variation**
Doctor	91,95%	90,39%	-1,56%
Nurse – T	87,36%	79,41%	-7,95%
Nurse – CAP	81,18%	68,92%	-12,26%
Technician	79,54%	83,79%	4,25%
Desk Supporter	77,92%	77,92%	0,00%
Doctor – Specialist	10,08%	11,28%	1,20%

As presented in Table 33, Nurses – CAP suffered the highest variation with the increment of one resource, following by Nurses – T and Doctors. All have decreased the degree of utilization.

In Table 34 the comparison of results is introduced. The maximum and average times of the activities performed by both types of nurses and doctors have decreased. On the other hand, the maximum and average times of "Do Medical Exams" performed by Technicians (that have not been increased) have increased by 13.0% and 10.7%, respectively.

However, the overall maximum and average times of the process decrease 7.3% and 7.0% respectively. The maximum time of the process decreased from 6h37m to 6h08min (-29min) while the average time decreased from 2h09m to 2h00 (-9min).

Table 34 - Simulation of H1

Name	Scenario	IC	IS	Min.	Máx.	Avg.
#0 ED (whole process)	As-Is	212	280	-	6h 37m	2h 9m
#0 ED (whole process)	H1	221	280	-	6h 8m	2h 0m
#2 Initiate Triage	As-Is	263	266	8	31m	13m
#2 Initiate Triage	H1	263	266	8	17m	11m
#3 Perform Re-triage	As-Is	15	15	4	18m	9m
#3 Perform Re-triage	H1	15	15	4	10m	6m
#4 Do Medical Observation	As-Is	146	154	29	2h 12m	1h 10m
#4 Do Medical Observation	H1	155	162	29	1h 40m	56m
#6 Do Clinical Analysis and procedures	As-Is	70	73	20	1h 21m	44m
#6 Do Clinical Analysis and procedures	H1	76	80	20	53m	34m
#7 Do Medical Exams	As-Is	58	61	27	1h 32m	56m
#7 Do Medical Exams	H1	61	64	27	1h 44m	1h 2m
#8 Make Medical Re-evaluation	As-Is	101	104	20	1h 59m	1h 8m
#8 Make Medical Re-evaluation	H1	110	115	20	1h 27m	50m

IC='Instances Completed'; IS='Instances Started'

Process Simulation (H2) – "Specialist"

Specialist-generalist – "Consider to make resources more specialised or more generalised" (Dumas *et al*., 2013; Mansar and Reijers, 2005)

Resources in a process may be changed from specialists into generalists or the other way around. Training session could be given to a specialized resource in order to obtain even more qualifications. One the other hand, a generalist may be assigned to the same type of work for a longer period, so that skills in this area deepen while other qualifications become obsolete (Dumas *et al*., 2013). In the context of process redesign, the application of this redesign heuristic needs to take into consideration the specialist-generalist ratio of the working teams. Obviously, specialist resources build up routine more quickly and may have more profound knowledge in an area than generalists have. As a result, they work more quickly and deliver higher quality. On the other hand, the availability of generalists adds more flexibility to the business process and can lead to better utilization of resources. In this case, the balance should tend more to the specialist. Thus, two options come up: contract more expert doctors than non-experts or give a training session to non-experts in order to specialize them.

As can be seen in Figure 9, more specialised doctors have a positive impact on time and quality, that is, decrease time while increase the quality of the service provided. For simulation, we will assume that the specialisation of doctors will decrease the time of the activities “Do medical observation” and “Make medical re-evaluation” in 10%, as represented in Table 35.

Table 35 - Scenario H2

Scenario	Activity	Required Waiting Time (mins)	Min. (mins)	Avg. (mins)	Máx. (mins)
As-Is	Medical Observation	-	24	33	61
H2			**21.6**	**29.7**	**54.9**
As-Is	Re-evaluation	-	15	28	54
H2			**13.5**	**25.2**	**48.6**

Figure 9 - Devil's quadrangle relation with H1 and H2

	Time	Cost	Quality	Flexibility
Extra resources	−	+	·	+
Specialist	−	+	+	−

Table 36 - H2 Simulation

Scenario	Instances completed	Instances started	Max. time (h)	Avg. time (h)
Process As-Is	212	280	6h 37m	2h 09m
H2 – Specialist	222	280	6h 42m	1h 58m

The number of patients attended increased by 10 in the overall process. Regarding the whole process, the maximum time increased by 5 minutes (+1.3%) while the average time decreased by 11 minutes (-8.5%).

Table 37 - H2 Simulation - activities detail

Name	Scenario	Instances completed	Instances started	Min. time (m)	Max. time (m)	Avg. time (m)
Do Medical Observation	Process As-Is	146	154	29m	2h 12m	1h 10m
	H2 - Specialist	158	167	25m	1h 16m	48m
	Variation	**+12**	**+13**	**-4m**	**-56m**	**-22m**
Make Medical Re-evaluation	Process As-Is	101	104	20m	1h 59m	1h 08m
	H2 - Specialist	111	113	15m	1h 07m	42m
	Variation	**+10**	**+9**	**-5m**	**-52m**	**-26m**

Only 10% reduction on working time (due to specialisation) of activity "Do Medical Observation" decrease the maximum time in 57.6% and average time in 31.4% of such activity.

As can be seen in Table 37, the results of the simulation show that "Make Medical Re-evaluation" activity has a similar impact regarding times.

Process Simulation (H3) – "Integral Technology"

Integral Technology - "Try to elevate physical constraints in a business process by applying new technology" (Dumas *et al*., 2013; Mansar and Reijers, 2005).

New technology can change the traditional way of doing business by giving professionals completely new opportunities. On this case, the application of this redesign heuristic comes up to answer three improvements identified (see Table 30) that are associated to two problems: "Information system is not adjusted to the needs of ED" and "The patients wait too much time for re-evaluation". The use of "Integral Technology" redesign heuristic will essentially change the way how results of exams are treated. Previously, no one knew when the exam results came to the IS. The doctors had to sporadically go to the patient's record to find out if the exams results were already available. With the application of this heuristic, it is intended that an alert is created in the IS that notifies the doctor that the results of the exams of a given patient are already available for consultation. Thus, the estimated time between the moment the results of the exams arrive at the IS and the moment the doctor observes the results is reduced by 75%, from 40 minutes to 10 minutes.

Figure 10 - Devil's Quadrangle for H3

	Cost	Quality	Time	Flexibility
Integral technology	+	+	+	·

Table 38 - H3 Simulation

Name	Scenario	IC	IS	Min.	Máx.	Avg.
#0 ED (whole process)	As-Is	212	280	-	6h 37m	2h 9m
#0 ED (whole process)	H3	215	280	-	6h 4m	2h 4m
#1 Make admission on ED	As-Is	266	268	4m	15m	6m
#1 Make admission on ED	H3	266	268	4m	15m	6m
#2 Initiate Triage	As-Is	263	266	8m	31m	13m
#2 Initiate Triage	H3	263	266	8m	29m	14m
#3 Perform Re-triage	As-Is	15	15	4m	18m	9m
#3 Perform Re-triage	H3	15	15	4m	18m	8m
#4 Do Medical Observation	As-Is	146	154	29m	2h 12m	1h 10m
#4 Do Medical Observation	H3	146	153	31m	2h 23m	1h 14m
#5 Evaluated for specialist	As-Is	6	7	36m	48m	42m
#5 Evaluated for specialist	H3	6	7	36m	48m	42m
#6 Do Clinical Analysis and procedures	As-Is	70	73	20m	1h 21m	44m
#6 Do Clinical Analysis and procedures	H3	70	73	20m	1h 14m	44m
#7 Do Medical Exams	As-Is	58	61	27m	1h 32m	56m
#7 Do Medical Exams	H3	58	61	27m	1h 35m	53m
#8 Make Medical Re-evaluation	As-Is	101	104	20m	1h 59m	1h 8m
#8 Make Medical Re-evaluation	H3	104	108	23m	2h 15m	1h 12m

The number of patients attended increased by 3. Moreover, the maximum and average times of the whole process decreased by 33 minutes (8.3%) and 5 minutes (3.9%), respectively. There is no significant variance between the activities. Even positive, the variance on the average time of the whole process is minimal.

Final Results

Throughout the previous section, the results of simulation of individual redesign heuristics application were introduced. The three redesign heuristics chose decreased both maximum and average times of the process, except H2 that increased the maximum time by 1.3%. Curiously, H2

is the redesign heuristic with the best impact on average time, applied individually. Thus, we may affirm this three redesign heuristics, applied individually, provided a positive impact on the process.

Moreover, it could be very interesting to verify how combinations of redesign heuristics work. In this sense, four combinations of redesign heuristics were created and then, simulated. The results of all combinations are presented in Table 31.

Regarding average times of the whole process, it is possible to see that C4 is the combinations of redesign heuristics that better improve the process As-Is. C4 increased the number of patients attended by 28 while the maximum and average times decreased by 29.2% and 22.5% respectively. As can be seen in Table 39, the effect on time is improved when redesign heuristics are combined.

Table 39 - Final results of all combinations for the main scenario (S3)

Scenario S3	**IC**	**IS**	**Overall times of the process**		**Variation on overall times of process regarding As-Is**	
			Max. time (h)	**Avg. time (h)**	**Max. Time**	**Avg. Time**
As-Is	212	280	6h 37m	2h 9m	-	-
H1	221	280	6h 8m	2h 0m	-7,3%	-7,0%
H2	222	280	6h 42m	1h 58m	+1,3%	-8,5%
H3	215	280	6h 4m	2h 4m	-8,3%	-3,9%
C1	235	280	5h 42m	1h 52m	-13,9%	-13,2%
C2	229	280	5h 19m	1h 53m	-19,6%	-12,4%
C3	229	280	4h 55m	1h 50m	-25,7%	-14,7%
C4	240	280	4h 41m	1h 40m	-29,2%	-22,5%

IC='Instances Completed'; IS='Instances Started'

In Table 40 and Table 41 are presented the results of simulation of the same combinations of redesign heuristics mentioned in Table 31 for the other two scenarios mentioned in Table 21.

The results obtained from the other two scenarios are similar to those presented in Table 39. Regarding average times, the application of C4 provided a better impact on the main process studied (Scenario S3 in Table 21) by improving the average total time of the process by 22.5%.

Table 40 - Final results of all combinations for the Scenario S1

Scenario S1	IC	IS	Overall times of the process		Variation on overall times of process regarding As-Is	
			Max. time (h)	Avg. time (h)	Max. Time	Avg. Time
As-Is	161	188	5h 43m	1h 47m	-	-
H1	162	188	5h 31m	1h 47m	-3,5%	0,0%
H2	164	188	5h 29m	1h 44m	-4,1%	-2,8%
H3	167	188	3h 46m	1h 36m	-34,1%	-10,3%
C1	165	188	5h 24m	1h 44m	-5,5%	-2,8%
C2	167	188	3h 46m	1h 35m	-34,1%	-11,2%
C3	169	188	3h 39m	1h 31m	-36,2%	-15,0%
C4	169	188	3h 39m	1h 30m	-36,2%	-15,9%

Table 41 - Final results of all combinations for the Scenario S2

Scenario S2	IC	IS	Overall times of the process		Variation on overall times of process regarding As-Is	
			Max. time (h)	Avg. time (h)	Max. Time	Avg. Time
As-Is	202	233	5h 56m	1h 55m	-	-
H1	203	233	5h 16m	1h 48m	-11,2%	-6,1%
H2	206	233	5h 38m	1h 48m	-5,1%	-6,1%
H3	206	233	4h 10m	1h 40m	-29,8%	-13,0%
C1	206	233	5h 15m	1h 44m	-11,5%	-9,6%
C2	209	233	4h 1m	1h 36m	-32,3%	-16,5%
C3	209	233	3h 56m	1h 32m	-33,7%	-20,0%
C4	211	233	3h 43m	1h 31m	-37,4%	-20,9%

On another hand, regarding maximum times, the same combination of heuristics, C4, provided a better impact on the Scenario S2 (see Table 41) by improving the maximum total time of the process by 37.4%.

In terms of patients attended, taking as reference the combination C4, on scenario S3, 85.7% of patients that entered in the ED was successfully attended. On the other hand, on scenarios S1 and S2, the percentage of patients attended was 89.9% and 90.6%.

According to data of simulation presented in Table 39, Table 40 and Table 41, we can assure that the best combinations on all scenarios are the C4. C4 is composed of the three redesign heuristics. Thus, we may declare that regarding the problems identified and the improvements proposed, the C4 can be named as the Process To-Be.

9 CONCLUSIONS

The main purpose of this thesis was to analyse if the application of redesign heuristics to ED business process of a public healthcare hospital induced time reduction and, at least, maintained quality standards of the service provided.

For such, the process was chosen, and the customer such process serves was identified, as well as the perspective of value for such customer.

The modelling of the process was elaborated based on the evidence gathered from the Process Modelling phase. In accordance, a simulation of the Process As-Is was performed. Then, the process was analysed based on evidence gathered from interviews, documental analysis, direct observation and focus group. Moreover, a qualitative analysis was made. The primary problems of the process were identified.

On process redesign, the redesign heuristics were properly chosen based on the objectives of the research and the processual improvements and problems pinpointed. The results of the application of each redesign heuristic were analysed and compared with results of process simulation of process As-Is.

The combination of redesign heuristics that better improve the process, in terms of time (without deteriorating the quality), was selected to be implemented and the process To-Be was defined.

In the following chapter, the objectives aforementioned and partial goals are given a final assessment, and the research question is revisited in the light of the research results. Following, the validation of the results and their limitations are considered. As final considerations, some opportunities for future research possibilities are underlined.

9.1 RESEARCH QUESTION AND GOALS ANALYSIS

Returning to the partial goals of this research, it can be confirmed that:

- The scope of the process to be studied was defined during the first meeting with the stakeholders of the ED;
- For such a process, the customer was identified, as well as its value perception (see section 0);
- Methods and tools were selected on sections 4.4.1 and 4.4.2;
- The modelling of the process and the respective process As-Is is presented in section 6 and Figure 4;
- Three scenarios were identified for the same process As-Is;
- Process simulation was executed for each of the scenarios (see section 6.4);
- The process analysis of the chosen process is elaborated on section 7, from such analysis, a list of primary problems of the ED was written;
- From the list of problems mentioned above, some possible improvements were assigned (see section 8.2);
- For the processual improvements, redesign heuristics were assigned, aligned with the primary objective of this research;
- One scenario was chosen to take as a term of comparison for the process redesign. Anyway, at the end of such section, all the scenarios are taken into consideration, and all the combinations of redesign heuristics are applied to the three scenarios;
- The application of each redesign heuristics is evaluated through the Devil's Quadrangle regarding time and quality constraints. Time constraint is validated through the simulation as well;
- The simulation results of the process redesign are presented in section 8.3;
- The process To-Be is described in section 8.3.

As can be seen, all the partial goals were addressed. The process was identified, modelled, analysed and then redesigned.

This is the research question that we tried to address:

RQ: How can Business Process Redesign techniques help to optimise an ED regarding time without deteriorating the quality of the service provided?

The process analysed proved to be optimised in terms of time after the application of the chosen redesign heuristics. The quality, at least, remained the same. BPMN proved to be a very useful tool to modelling and simulate the process chosen. On the other hand, the phases of BPM taking as a guide throughout the research was also successfully fulfilled.

On this research, three redesign heuristics were chosen. All, in a general way, optimised the process regarding times, and according to the Devil's Quadrangle, it did not decrease the quality. Thus, through generalisation, we may assume that BPR, more concisely, the redesign heuristics, optimised the ED regarding time without deteriorating the quality of the service provided.

9.2 RESEARCH LIMITATIONS

The results obtained are limited to the scope defined to this research. That is, it could be chosen other methodology or other tools to address such a problem. On the other hand, the process of data gathering was not easy. The data gathered was not as lean as desired and it was not possible to get all the information that we would like to. The data obtained was limited.

In this way, the findings of the present research are only applicable to the specific ED process studied in the context of a specific public hospital. As Yin (1989) deliberates, case studies findings may be generalised to theoretical propositions only.

However, the results of this research may be very useful for the specific ED where the present study was perpetrated. Moreover, such findings, though not to be generalised, may still offer astute insights to practitioners or researchers who wish to consider more information regarding the importance of improvement of ED through the application of business process redesign heuristics.

9.3 FUTURE RESEARCHES

After completing this research, recommendations will now be given for future researches that may be carried out in this area. Since the literature review on this subject is scarce, we suggest to researches to elaborate more studies on the ED context, particularly, studies related to BPM.

In a business context, one organisation is not the same as another, from its processes to its internal structure and culture. Taking this into account, it is difficult to imagine that in another organisational context the same redesign heuristics can be taken without any need for adjustment to that specific process. However, with regard to the generalisation of results, according to Yin (1989), similar investigations in other ED may, in the future, allow comparisons between them and evaluate if it is possible to generalise results.

As proposals for future works, we suggest to the researchers to elaborate more studies of comparison between ED in order to validate the generalisation of results stated by Yin (1989). Additionally, we propose a deepen research on an ED taking into consideration the four constraints of Devil's Quadrangle.

Finally, we also propose the implementation of this research on the ED that was studied. Taking this work to another level of fulfilment, using all the phases of BPM. Thus, the next phases of Process Implementation and Process Monitoring and Controlling should be approached.

9.4 RESEARCH CONTRIBUTIONS

With this research, we contribute with a case study based on BPM in an ED of a public hospital, more concretely, we allude how process redesign heuristics can be applied to the process of patient flow of an ED improving it. This researches adds a new study on the analysis of such an interesting area as healthcare. Real data about an ED is provided. The outputs of this research will be a valuable input for other ED that pretend to optimise their processes regarding time and quality, using redesign heuristics.

For academics, we pretend to provide them a new baseline to base their future researches on the analysis of ED using redesign heuristics.

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