



NOVA

IMS

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BUSINESS PROCESS MANAGEMENT

MASTER'S DEGREE PROGRAM IN DATA SCIENCE
AND ADVANCED ANALYTICS

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Introduction

In the past years, the world has been experiencing several changes in how companies and businesses create value for different contexts, industries, environments, and people. The increasing competitiveness, fluctuations in stock markets, the recent pandemic, politics, and economics conflicts, all these subjects push businesses to move forward, adapting the way they have been managing their available resources such as people, time, and money, in order to generate more value for the customer, while seeking to continually innovate and remain competitive.

Background

Grace Hospital was founded in 1998. Located in Lisbon, Portugal, the hospital has more than 800 employees working across over 30 different departments, such as cardiology, orthopedics, dermatology, endocrinology, and others. Currently, the hospital has been struggling with one of its vital processes: attending patients in a typical medical consultation. Apart from being a core procedure, medical consultations have been generating a huge impact on patients' satisfaction, besides a potential waste of resources (time and supplies), which consequently could result in loss of money for Grace Hospital.

Objectives

Business Process Management (BPM) can be translated as “a body of methods, techniques and tools to discover, analyze, redesign, execute and monitor business processes.” (Dumas et al., 2013). In this project, the Business Process Management Lifecycle (*figure 1*) will be used to identify, understand, model, analyze, and redesign the process of attending patients during a medical consultation. From the many existent departments in the hospital, the project scope focuses on the Orthopedics, and any opportunity of improvement founded can be further implemented to different departments, if appropriate.

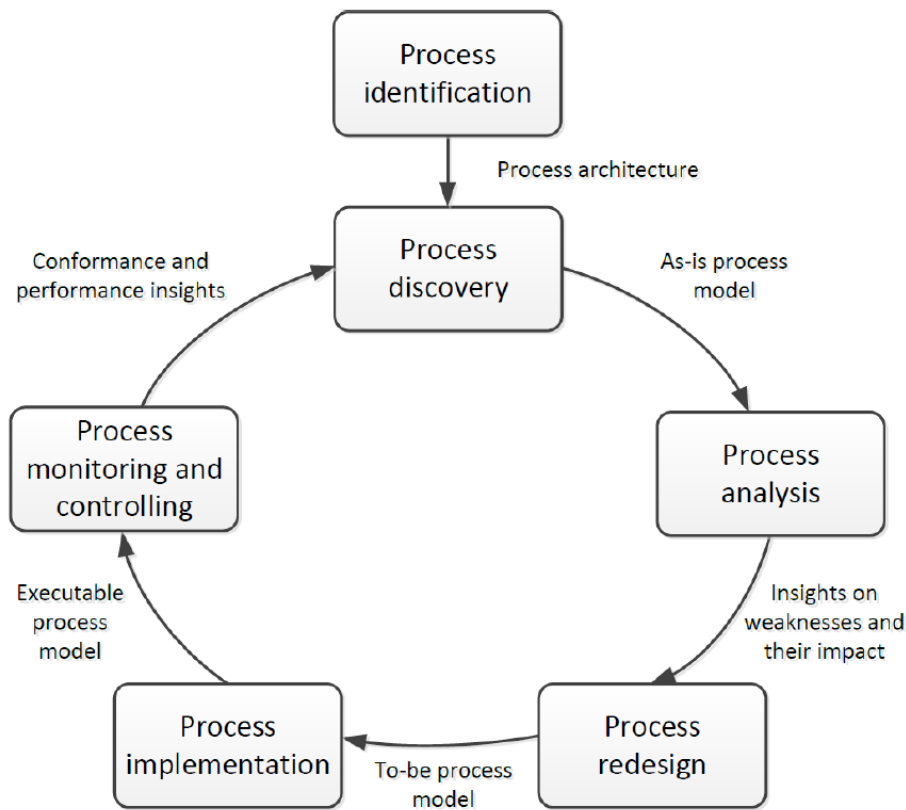


Figure 1: Business Process Management Lifecycle

Process Identification

A process is “a complete set of activities end to end that creates value for the customer” (Michael Hammer, Harper Business, 1996). In general, a business process consists of the following parts: events, activities, tasks, decision points, actors, and outcomes.

The process of attending patients during a medical consultation is defined as an order-to-cash (O2C) process, which according to Dumas, is a “type of process performed by a vendor, which starts when a customer submits an order to purchase a product or a service and ends when the product or service in question has been delivered to the customer and the customer has made the corresponding payment.”

From the situation presented in the project guideline, it is possible to abstract the Receptionist, Patient, Internal staff, Doctor, and the Information System as the actors of the process. The *figure 2* shows the main tasks performed across the Orthopedics department.

Receptionist	Internal Staff	Doctor
Receive patient on the desk	Verify medical availability	Attend the patient
Ask for patient Citizen Card and medical consultation	Direct patient to Doctor's office	Register prescription into system
Insert patient personal data into the system		Register exams into the system
Confirm consultation		Print the exams prescription
Receive the payment from patient		
Sign papers with hospital signature		
Print justification for the patient		
Deliver all necessary papers to the patient		

Figure 2: Main Tasks of The Process

Based on the knowledge acquired after Michael Porter's value chain model, business processes are designed to generate value for the customer, and in the observed case, offering an excellent service and experience during the medical consultation is considered the expected value. Some possible outcomes can be enumerated in two perspectives: customer satisfaction, consultations in time, correct prescriptions, and treatments as the positive possible outcomes. Consultations delay, customer unsatisfaction, and errors as the negative ones.

Process Description

The process starts when the patient arrives to the hospital and the receptionist calls his/her ticket number, then after a few minutes numerous steps take place to guarantee that the customer has all the documents required and that the consultation is in the right day and hour. Once the admission process has ended, the Internal Staff manages the waiting room to drive the patients to the Doctor's room only when the availability is confirmed. The patient is then attended by the Doctor, and whether it is necessary to prescribe medicines, exams, the patient leaves the room with a couple of information, digitally or in paper. The process finishes when the patient pays for the consultations, which occurs 90% of the time, and in the reception some extra procedures are made to provide the customer with medical certificate, signed prescriptions, new appointment, invoice, and other information, whenever required.

As-Is Model

The objective of the As-Is Model is to have a deep understanding of the current situation, involving all the activities, actors, and decision points, and finally performing qualitative and quantitative analysis which will help to raise improvements opportunities to model a more efficient process to achieve the expected results of Grace Hospital. In the figure 3 it is possible to see an overview of the As-Is process built in Bizagi, which comprehends the subprocesses *admission process*, *call patient*, *make consultation* and *finalize consultation*. About the process described in the project guideline, some assumptions have been made to support the As-Is modeling, particularly regarding the decision point after the *Make Consultation* sub-process. In this case, it is considered that the patient leaves the hospital right after the consultation ends, which means that the patient does not return to the reception but decides to exit the building not only refusing to pay at the time, but also without making any further requests (justifications, new appointments, stamped prescriptions, and others). Further details of the As-Is process can also be found in the Annex.

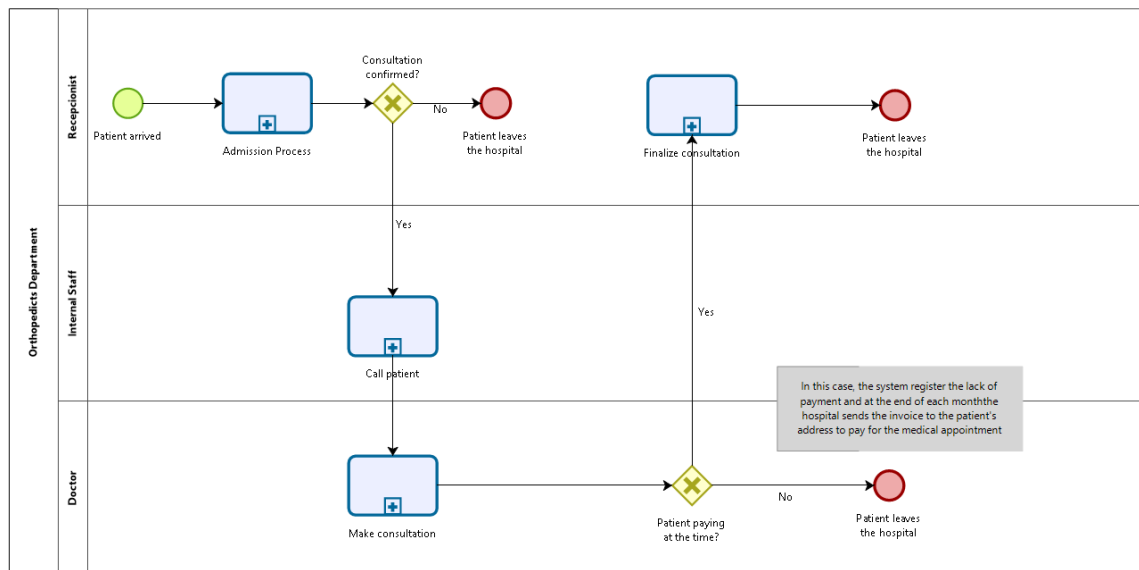


Figure 3: As-Is Model Overview

Qualitative Analysis

“Qualitative process analysis techniques allow us to identify, classify, and understand weaknesses and improvement opportunities in a process” (Dumas, M., La Rosa, M., Mendling, J., Reijers, H.A., 2018).

In the next sections, a set of qualitative process analysis is going to be performed to evaluate the process under different perspectives, such as Value-Adding Analysis, Waste Analysis, and Issue Register. At the end, the decision on which activities and tasks must be kept or eliminated tends to be smoother.

Value-added Analysis

Value-added analysis aims to identify unnecessary parts of the process that can be eliminated. Following, each activity of the subprocesses is going to be decomposed into steps and classified from the value-adding perspective.

Admission Process - Receptionist

Activity	Steps	Classification	Justification
Call patient's ticket	a) order the system to call the next ticket	BVA	Makes the process run efficiently
Receive Patient on the Desk	a) wait for the patient to arrive; b) confirm the ticket	NVA	It does not add value to the business or the client
Ask for Patient ID	a) ask for the ID and wait b) check if the ID corresponds to the person	BVA	It is mandatory to check the identification of the patient
Ask for Medical Consultation	a) ask for which is the doctor to be consulted	NVA	The patient ID could give access to this information
Insert Patient Personal Data into the Information System	a) open Hospital's IS system; b) ask for more information	BVA	Important for the hospital management
Register Patient's Health System	a) ask for health system; b) add health system info on IS, if exists	BVA	Important for the hospital management
Confirm Consultation	a) confirm consultation and provide details	VA	Relevant to patient whether the consultation is confirmed

Figure 4: Admission Process - Value-Adding Analysis

Call Patient – Internal Staff

Activity	Steps	Classification	Justification
Verify Medical Availability	a) checks the list of medical appointments on IS	BVA	Checking is often BVA
Call the Patient	a) call the patient when the consultation is about to start	VA	The patient expects to be informed about the service
Direct Patient to Doctor's Office	a) show the way to the Doctor's office for the patient	NVA	It does not add value to the business or the client

Figure 5: Call Patient - Value-Adding Analysis

Make Consultation - Doctor

Activity	Steps	Classification	Justification
Attend the Patient	a) ask questions about complains and general state; b) examine the patient; c) register main state on IS	VA	It is one of the patient's main objectives
Register Prescription into IS	a) if the patient needs a medication, it is registered into the IS and sent by message to his/her phone.	BVA	It is a part of the data on the IS and needed to provide the service
Print Prescription	a) ask for printed prescription necessity; b) if yes, print the prescription for the patient	VA	If the patient aks for the printed version, it is because he/she has this necessity
Register Exams into the IS	a) if necessary, register exams on the IS	BVA	It is a part of the data on the IS and needed to provide the service
Print the Exams Prescription	a) print patien's exams prescription	VA	Because the patient would need it to do his exams

Figure 6: Make Consultation - Value-Adding Analysis

Finalize Consultation - Receptionist

Activity	Steps	Classification	Justification
Call the Patient Ticket	a) call patient's ticket b) if the patient does not come, skip to another ticket number	NVA	It does not add value to the business or the client
Receive the Payment from the Patient	a) ask for the payment form (money, debit/credit card ...) b) inform the value c) generate the payment d) receive it e) register fiscal information f) generate a receipt	BVA	Core activity for receiving money and registering fiscal information
Mark Papers with Hospital Signature	a) stamp the prescription with a certified hospital signature	VA	It is necessary for the patient
Print Justification for the Patient	a) print a work/school justification	VA	It is required by the patient
Ask for Patient's ID card	a) ask for client's ID for new appointment	NVA	It does not add value to the business or the client
Verify Slots on Doctor's Agenda	a) verify doctor's agenda and inform options to the client	BVA	Important for the hospital management
Make the Appointment	a) make the appointment in the agenda	VA	It is required by the patient
Print the Information about the New Appointment	a) print the appointment informations	NVA	It is just an informational and redundant step
Deliver All Necessary Papers to the Patient	a) give additional information, and required documents to patient	VA	It is necessary for the patient

Figure 7: Finalize Consultation - Value-Adding Analysis

Waste Analysis

The Waste Analysis is a method focused on finding wastes throughout processes, and can be grouped into three categories: Move, Hold, and Overdo.

Activity	Situation	Category	Subtype	Justification
Admission Process	Waiting for the client / patient to come when receptionist calls the ticket ID	Hold	Waiting	The receptionist (resource) has to wait, on average 30s for the patient arrival to the desk.
Admission Process	Client is waiting to be called by the receptionist	Hold	Inventory	The client has to wait to initiate the service.
Admission Process	Client goes to the receptionist's desk	Move	Transportation	The client has to go to the desk and find the correct receptionist's desk.
Admission Process	Waiting for the client's ID when asked to have it	Hold	Waiting	The receptionist waits for the document.
Admission Process	The receptionist asks for the medical consultant	Over-do	Over-processing	With the client ID, there is no need to ask for the consultation that could lead to more waiting time as the patient could forget the doctor's name, give a different name, etc.
Admission Process	Client responds to receptionist's questions and waits	Hold	Inventory	Client has to wait to confirm his/her consultant and answers / provides all the informations that the receptionist asks.
Call Patient	Internal staff checks medical's appointment list availability	Over-do	Over-processing	It could be done by the receptionist or by IS.
Call Patient	Internal staff calls the patient	Hold	Waiting	There could be a delay between the time of the call and when the patient comes.
Call Patient	Client waits to be called to the doctor's office	Hold	Inventory	After consultant's confirmation, the client has to wait to be called and oriented to the doctor's office.
Call Patient	Internal staff directs patient to doctor's office	Move	Motion	The member of the internal staff needs to go to the patient and direct him/her to the correct office.
Call Patient	Client goes to the office	Move	Transportation	The client needs to go to the doctor's office.
Make Consultation	The doctor has to wait for the patient's arrival	Hold	Waiting	The doctor has a delay between one patient to another due to internal staff motion and client transportation.
Make Consultation	The client has to wait for the entrance in the IS of the prescription (if needed)	Hold	Inventory	The client must wait for information entrance on the hospital's IS and eventual printing.
Make Consultation	The client has to wait for the printed prescription (if asked)	Hold	Inventory	
Make Consultation	The client has to wait for the entrance in the IS of the exam prescription (if needed)	Hold	Inventory	
Make Consultation	The client has to wait for the printed exam prescription	Hold	Inventory	
Finalize Consultation	The client has to wait to be called by the receptionist after leaving the doctor's office	Hold	Inventory	The waiting is uncertain as the client misses the initial calling order.
Finalize Consultation	The receptionist has to wait for the client's arrival on the desk	Hold	Waiting	There is an inconsistency on how the receptionist knows when the patient leaves the doctor's office
Finalize Consultation	The client has to go to the receptionist's desk to proceed with the payment	Move	Transportation	The client has to physically go to the desk again.
Finalize Consultation	The client has to wait for the stamp / signature	Hold	Inventory	If there is a prescription.
Finalize Consultation	The client has to wait for the printed justification	Hold	Inventory	If there is this necessity.
Finalize Consultation	The client has to show again the ID if a new appointment is needed	Over-do	Over-processing	The receptionist already has the client's information on the IS.
Finalize Consultation	The client has to wait for the doctor's agenda verification	Hold	Inventory	Nothing to do.
Finalize Consultation	The client has to wait for the printed appointment	Hold	Inventory	
Finalize Consultation	Print the new appointment	Over-do	Over-processing	Print the new appointment seems to be too much.

Figure 8: Waste Analysis

Issue Register

The Issue Register aims to maintain, to organize and to prioritize identified weaknesses within the business process. The spreadsheet below illustrates the main issues identified throughout the process, and the impacts to the business in a quantitative and qualitative perspective.

Activity	Issue	Data / Assumptions	Qualitative Impact	Quantitative Impact	Impact	Effort / Cost	Justification
Receive Patient on the Desk	Long time waiting for the patient to start the admission process	The receptionist has to wait, on average 30s for the patient arrival to the desk.	Reducing impact on other patient's experience	Reducing the Circle Time Efficiency, increasing the Work in process	LOW	HARD	There is a window of time between each doctor's attendance and this time is, in general, inside it.
Receive Patient on the Desk	Long time waiting to the receptionist to start the admission process	There is no information on how long the patient waits to be called	Patient's perception about the efficiency of the service.	Increasing the risk of reducing the Circle Time Efficiency and increasing the Work in process	MEDIUM	MEDIUM	As the main purpose is to retain more clients, improving its experience.
Ask for Medical Consultation	Repeated client info	The receptionist is already with the client ID and can retrieve on the IS his appointment without asking	Patient's perception about the efficiency of the service.	Increase process time	MEDIUM	EASY	As the main purpose is to retain more clients, improving its experience.
Verify Medical Availability	Internal Staff appointment list verification could be done in other manner	Verifying the availability of the doctor and the patient could be done by as IS or even the receptionist	Making the process more efficient.	Increase process time	HIGH	EASY	There is no reason for keeping a person just to check the availability.
Call Patient	Calling the patient could be an automated task	The doctor could trigger the "call for the patient" automatically when the current consultation has finished	Making the process more efficient.	Increasing the risk of reducing the Circle Time Efficiency and increasing the Work in process	HIGH	EASY	There are several technologies to make this work
Direct Patient to Doctor's Office	Orientation of the client on how to get to the doctor's office	The hospital could get more accurate signs and even letting the receptionists ready to orient the patient	Making the process more efficient.	Increase process time	MEDIUM	MEDIUM	A survey about the challenges that patients meet to find the office should be made
Call the Patient Ticket	Uncertainty on how long is going to take to be called by the receptionist	When leaving the office, the client could have priority to be called by the receptionist	Patient's perception about the efficiency of the service.	Increasing the risk of reducing the Circle Time Efficiency and increasing the Work in process	MEDIUM	EASY	This is a issue that would have impact on the client perception.
Mark Papers with Hospital Signature	The task of stamping could be made by others	The doctor could stamp / digital sign the prescription when printing it	Patient's perception about the efficiency of the service.	Increase process time	HIGH	MEDIUM	The IS and all its linkage to the printing pool and regulatory mandate has to be ready and always available to use
Print Justification for the Patient	The task of the justification could be made by others	The doctor could print it, avoiding eventual confusions on delivering lots of papers by the receptionist	Patient's perception about the efficiency of the service.	Increase process time	HIGH	MEDIUM	The IS and all its linkage to the printing pool and regulatory mandate has to be ready and always available to use
Take the Patient's ID card	Repeated client info	The receptionist already have the client info, being repetitive to show the ID again	Patient's perception about the efficiency of the service.	Increase process time	MEDIUM	EASY	There is no justification on asking for the ID again
Print the Information about the New Appointment	No need for printing the new appointment	The appointment could be sent by SMS and /or e-mail.	Patient's perception about the efficiency of the service.	Increase process time and increased costs and expenses	HIGH	EASY	The issue is linked to a Value-Added process

Figure 9: Issue Register

Pick Chart

From the Issue Register, a Pick Chart was raised to better illustrate the prioritization and which tasks must be eliminated or modified in order to increase the process efficiency from a qualitative perspective.



Figure 10: Pick Chart Prioritization

Quantitative Analysis

This section introduces techniques for analyzing business processes quantitatively in terms of process performance measures such as cycle time, waiting time, cost, and resource utilization. The outputs presented below were obtained after a simulation on Bizagi, aimed to evaluate the Instances Completion rate, Resource Utilization, and the Cycle time. More information about the parameters used in the simulation can be found in the Annex.

The Grace Hospital receives around 200 patients per day for the medical consultation in the Orthopedics department. With the process As-Is, only 39% of the patients finalizes the consultation after the end of the day, as it is possible to verify in the funnel below.

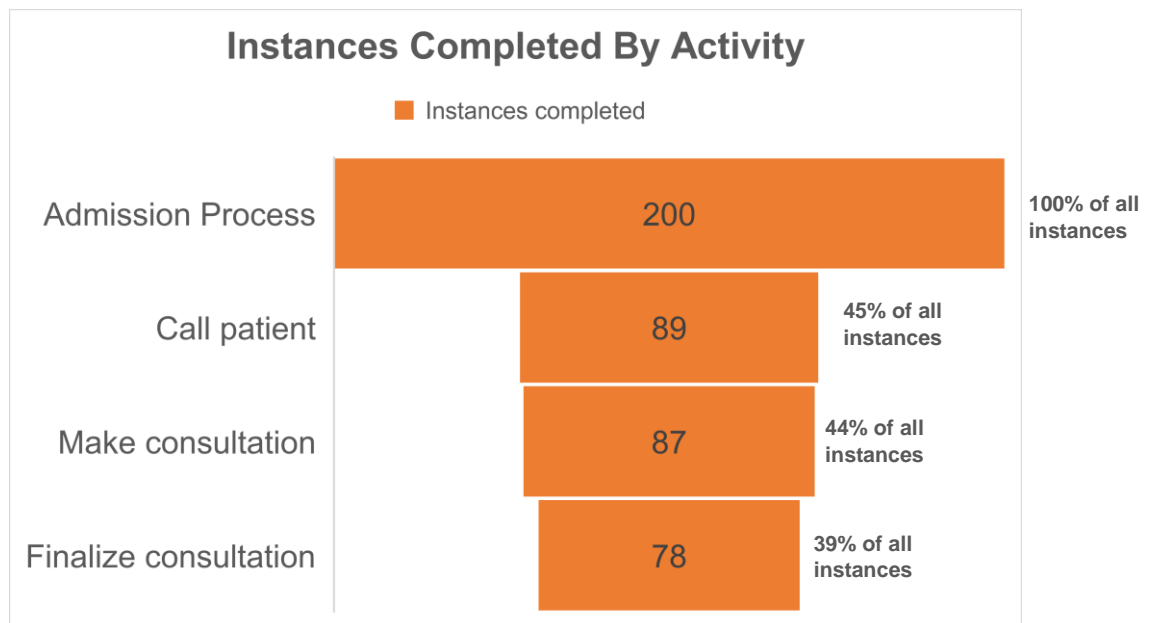


Figure 11: Instances Completed by Activity

According to Gartner analyst Robert Handler¹ the best rate for resource utilization ranges from 70% to 80%. Anything above this can present risks of burnout for the employees, and anything below will not utilize resourcefully. The chart below shows that Internal Staffs are too busy and working around 100% of the capacity, while Doctors are under the acceptable utilization rate.

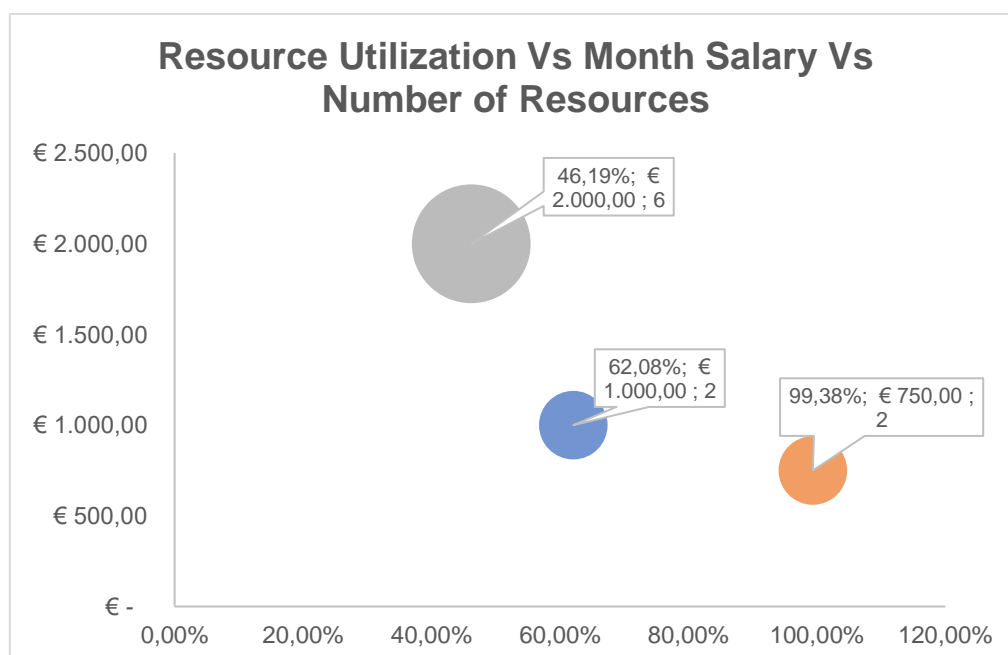


Figure 12: Resource Utilization by Resource Type

Process cycle time is the average time it takes between the moment a process starts and when it ends. The table below shows the average processing time, waiting time and cycle time efficiency for the Orthopedics department and each subprocess within it. Theoretically, in average the total cycle time should be 30 minutes, but in the process As-Is it could take around 4.65 hours from the moment a patient enters the hospital until the moment he leaves. The Cycle Time Efficiency is 11%, which is mostly impacted by the Call Patient activity.

Activity	Avg. Processing Time (min.)	Avg. Waiting Time (min.)	Cycle Time	Theoretical Cycle Time	Cycle Time Efficiency
Admission Process	2,34	0,34	2,68	2,00	75%
Call patient	133,10	125,11	258,21	10,50	4%
Make consultation	15,05	0,03	15,08	15,00	99%
Finalize consultation	2,82	0,32	3,14	2,50	80%
Orthopedics Department	135,17	143,93	279,11	30,00	11%

Figure 13: Cycle Time Efficiency for As-Is Model

The information and results observed in the quantitative and qualitative analysis were the basis for the following decisions that will be presented in the To-Be model.

To-Be Model

Before moving to the process redesign, it is important to define what are the expected outcomes to be achieved with the To-Be Model. From the previous analysis, it was possible to identify problems such as the low level of instances (patients) that finish the cycle, only 39%. Also, there is an unbalanced resource utilization that needs to be addressed. The internal staff working around 99,38% of the capacity, while Doctors with 46% approximately. The overall Cycle Time efficiency for the Orthopedics department is about 11%, mainly impacted by Processing Time and Waiting Time within the Call Patient activity. Furthermore, it is necessary to meet some key expectations raised by the Hospital in the project guideline, which are: increasing customer service satisfaction, and reducing costs with supplies, such as papers and print toners.

Process Redesign

To proceed with the prescriptive modeling of the To-Be model, the Exploitative Redesign approach was adopted. Its objective is to identify problems within the system, and to solve them incrementally. The redesign was focused on bringing improvements under the perspective of cost, time, quality, and flexibility. From the many different heuristics applied regarding the task, flow, and process levels, the ones that brought more impact were the Heuristic 1 (task elimination) and the Heuristic 9 (automation), which is based on task-level and process-level, respectively. Following each activity is going to be classified, using the heuristics approach.

Admission Process – Receptionist

Activity	Heuristics	Level	Time	Cost	Flexibility	Quality	Justification
Call the Patient Ticket	Task Elimination	Task	Improves	No effect	Worsens	No effect	The task would be done by an automated system
Call the Patient Ticket	Communication optimization	Process	Improves	Ambiguous	Worsens	Ambiguous	Implementing the automated system to call the patient's tickets
Ask for Patient ID and Medical Consultation	Triage	Task	Improves	Ambiguous	Worsens	Improves	Using a self-checkin machine to enhance the process for those who are already registered in the hospital's IS.
Insert Patient Personal Data into the IS							
Register Patient's Health System							

Figure 14: Admission Process Redesign

Call Patient – Internal Staff

Activity	Heuristics	Level	Time	Cost	Flexibility	Quality	Justification
Verify Medical Availability	Triage	Task	Improves	No effect	No effect	Improves	The task could be done by an automated system.
Call the Patient			No effect	No effect	Worsens	Improves	
Direct Patient to Doctor's Office			Ambiguous	No effect	Worsens	Worsens	
Direct Patient to Doctor's Office	Parallelism enhancement	Flow	No effect	No effect	Improves	Improves	We would maintain the internal staff just to minimize the effects on quality and flexibility by the triage.

Figure 15: Call Patient Process Redesign

Make Consultation - Doctor

Activity	Heuristics	Level	Time	Cost	Flexibility	Quality	Justification
Print Prescription	Task Elimination	Task	Improves	Improves	Improves	Ambiguous	The hospital can use a electronic signature to send the document to the costumer (by email, SMS) and he can print it by himself (not using the hospital resources).
Print the Exams Prescription	Task Elimination	Task	Improves	Improves	Improves	Ambiguous	

Figure 16: Make Consultation Process Redesign

Finalize Consultation – Receptionist

Activity	Heuristics	Level	Time	Cost	Flexibility	Quality	Justification
Call the Patient Ticket	Triage	Task	Improves	No effect	Worsens	No effect	An automated system would call the patient to the correct receptionist desk when leaving the doctor's office.
Sign Papers with Hospital Signature	Task Elimination	Task	Improves	Improves	Improves	Ambiguous	The hospital can use a electronic signature to send the document to the costumer (by email, SMS) and he can print it by himself (not using the hospital resources).
Print Justification for the Patient	Task Elimination	Task	Improves	Improves	Improves	Ambiguous	
Take the Patient's ID card	Task Elimination	Task	Improves	No effect	Improves	Improves	The receptionist has all the client's info on the IS and doesn't need to bother him again asking this confirmation.
Print the Information about the New Appointment	Task Elimination	Task	Improves	Improves	Improves	Ambiguous	The hospital can use a electronic signature to send the document to the costumer (by email, SMS) and he can print it by himself (not using the hospital resources).
Deliver All Necessary Papers to the Patient	Task Elimination	Task	Improves	Improves	Improves	Ambiguous	

Figure 17: Finalize Consultation Process Redesign

WHAT-IF Analysis

What-if analysis is about making changes on the simulation parameters, by adding or removing resources, and re-running the simulation. Starting from the results obtained in the As-Is model simulation, four different What-if scenarios were performed to improve the baseline efficiency. Each simulation is demonstrated below:

- What-if 1 - based on As-Is: reducing the average time from 10.5 min to 5 min in the activity Call Patient.

- What-if 2 - based on What-if 1: reducing the average time from 15 min to 10 min in the activity Make Consultation.
- What-if 3 - based on What-if 2: adding three receptionist machines on Admission process and using a gate “OR” to parallelize the task into more resources.
- What-if 4 - based on What-if 3: adding two internal machines on the activity Call Patient and using a gate “OR” in the resource option.

Resource	As-Is	What-If 1	What-If 2	What-If 3	What-If 4
Receptionist	62%	82%	84%	43%	45%
Internal staff	99%	95%	95%	95%	36%
Doctor	46%	93%	65%	65%	67%
Receptionist Machine				27%	28%
Internal machine					60%




Figure 18: What-if Scenarios Simulation

The What-if scenarios reinforced the possible changes that could be applied in the prior process to improve the overall performance of the business. Afterwards, the To-Be model was built based on the insights collected from the qualitative and quantitative analysis of As-Is model, the application of the heuristics of process redesign, and finally from the simulation of different scenarios. It is possible to verify the outputs of each What-if scenario, and the final proposal for the To-Be process in the Annex.

Flow Analysis

Flow analysis is a family of techniques that allow to assess the global performance of a process given some knowledge about the performance of its activities. Following, the principal metrics such as Average Processing Time, Average Waiting Time, Cycle Time, and Working in Progress, will be used to compare the results between the To-Be model and the As-Is model.

The next figures show an increase of 117% in the number of instances completed, which can be noticed step by step.

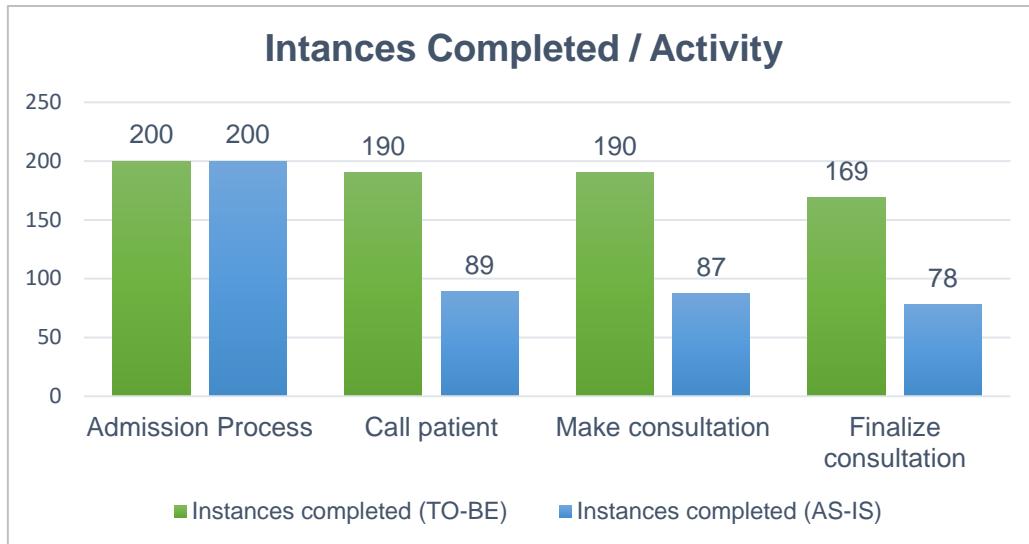


Figure 19: Instances Completed / Activity To-Be vs As-Is

At the end of the day, with the To-Be model, 169 patients finish their medical consultations in the Grace Hospital.

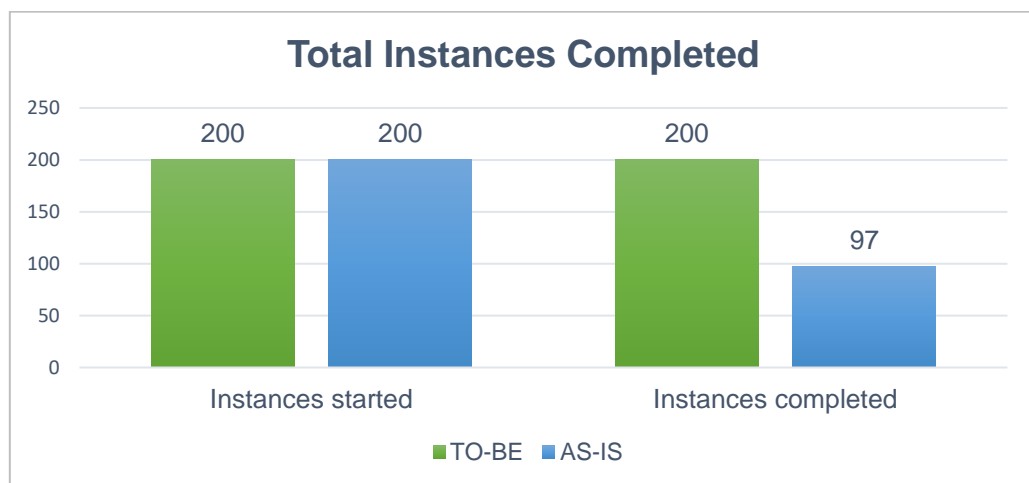


Figure 20: Instances Completed To-Be vs As-Is

The average processing time of the To-Be model presented a reduction of 86% when compared to the As-Is model. The activity Call a Patient had its average processing time decreased from 133 minutes to 5 minutes, which mostly contributed to the overall performance improvement.



Figure 21: Average Processing Time To-Be vs As-Is

From the following radar plot, it is visible that the cycle time efficiency increased in virtually in all the activities within the department and reached an overall improvement of 753% compared to the prior efficiency of the As-Is model.

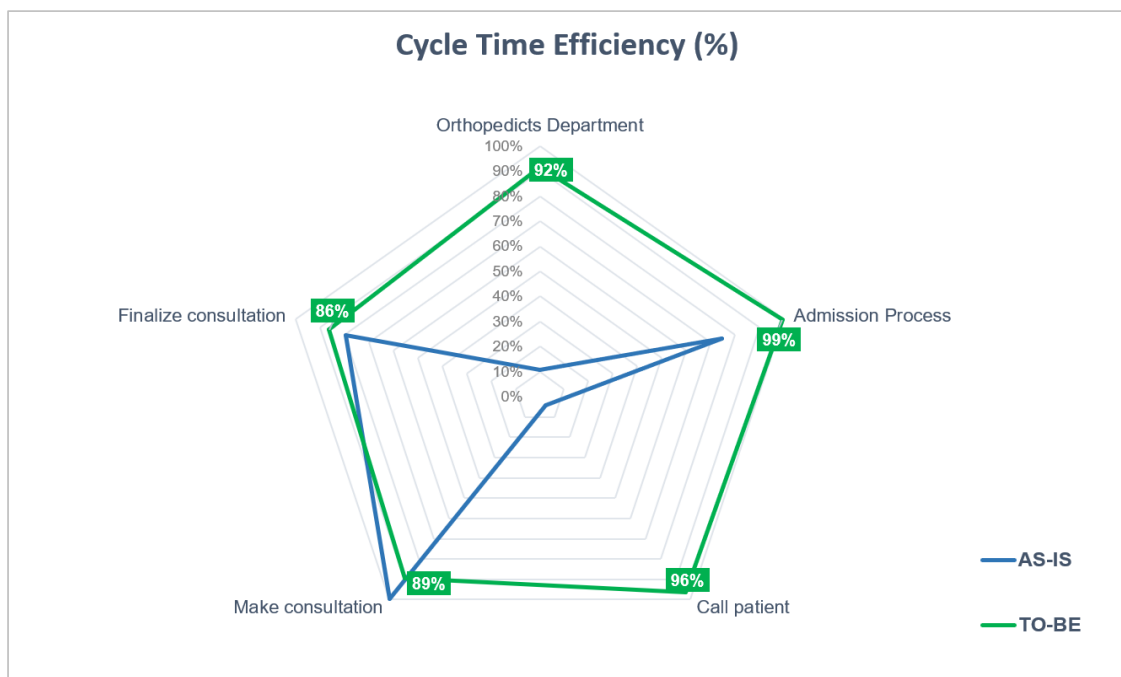


Figure 22: Cycle Time Efficiency To-Be vs As-Is

The chart below illustrates the number of cases that are running but not completed yet, also known as the Work in Progress (WIP). It is possible to see the huge improvement when comparing the To-Be model with the prior model.

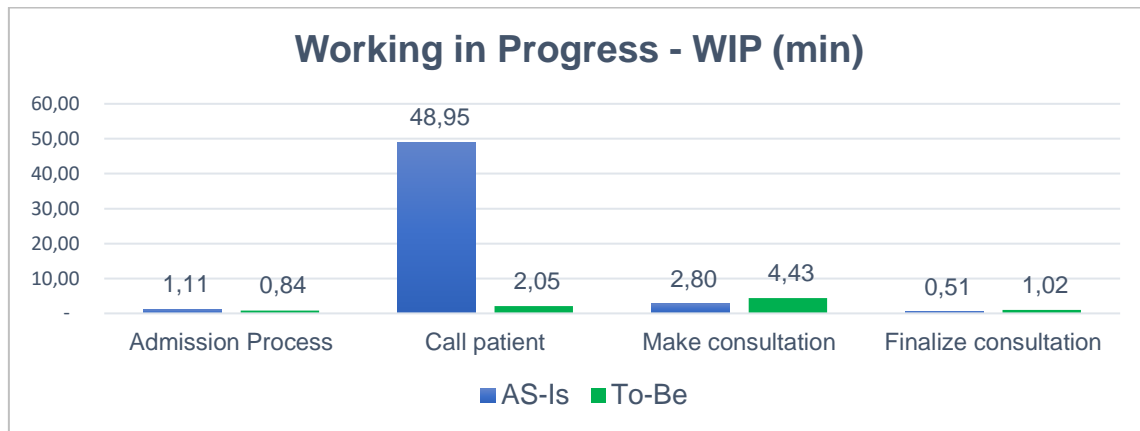


Figure 23: Work in Progress To-Be vs As-Is

Queuing Analysis

Flow analysis does not consider waiting times due to resource contention, therefore a queuing analysis was made to overcome these limitations and give a broader solution.

AS-IS			
Activity	Avg. time (m)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
Orthopedicts Department	135,17		11.479,35
Admission Process	2,34	0,34	67,25
Call patient	133,10	125,11	11.385,00
Make consultation	15,05	0,03	2,31
Finalize consultation	2,82	0,32	24,79
TO-BE			
Activity	Avg. time (m)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
Orthopedicts Department	19,12		178,55
Admission Process	2,01	0,00	0,87
Call patient	5,00	0,18	35,07
Make consultation	10,61	0,58	109,44
Finalize consultation	2,70	0,20	33,18
Improvement Rate %			
Activity	Avg. time (m)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
Orthopedicts Department	↑ -85,86%		↑ -98,44%
Admission Process	↑ -14,19%	↑ -98,71%	↑ -98,71%
Call patient	↑ -96,24%	↑ -99,85%	↑ -99,69%
Make consultation	↑ -29,51%	↓ 2118,44%	↓ 4635,99%
Finalize consultation	↑ -4,37%	↑ -38,24%	↓ 33,82%

Figure 24: Queue Analysis in a View To-Be vs As-Is

Cost-benefit Analysis

Cost-benefit is a financial metric that is widely used to measure the probability of gaining a return from an investment. It is a ratio that compares the gain or loss from an investment relative to its cost. It is as useful in evaluating the potential return from a stand-alone investment as it is in comparing returns from several investments. In this case, a comparison of the As-Is and To-Be model is going to be placed, considering all the modifications in the second model, acquisition of new technologies, processes performance and opportunities improvements. More detailed information about the assumptions and the source used to calculate the return on investment can be obtained in the references.

AS-IS Yearly Direct and Indirect Costs					
Staff and Over Head Cost	Resource	Number of services	Cost per Unit		Total Cost
	Receptionist	2	€	1.000,00	€ 28.000,00
	Internal Staff	2	€	750,00	€ 21.000,00
	Doctor	6	€	2.000,00	€ 168.000,00
	Total	10	€	3.750,00	€ 217.000,00
Direct Cost	Printing Documents per Year per patient (Nr of Patients per day*30 *12)	6.000	€	0,13	€ 9.360,00
Opportunity Cost	Lost per Year (Nr of patient not attended * price per consult * 365)	Instances not served	Cost per specialist consult		Total Opportunity Cost
		113	€	70,00	€ 2.887.150,00
TOTAL COST PER YEAR (AS-IS)					€ 3.113.510,00

TO-BE Yearly Direct and Indirect Costs					
Staff and Over Head Cost	Resource	Number of services	Cost per Unit		Total Cost
	Receptionist	2	€	1.000,00	€ 28.000,00
	Internal Staff	2	€	750,00	€ 21.000,00
	Doctor	6	€	2.000,00	€ 168.000,00
	Total	10	€	3.750,00	€ 217.000,00
Technology Cost	Additional Number of Services				
	Recepcionist Machine (Acquisition)	3	€	598,60	€ 1.795,80
	Internal machine (Acquisition)	2	€	278,58	€ 557,16
	Equipment Assembly and Maintenance		€	400,00	€ 400,00
	Total	5	€	1.277,18	€ 2.752,96
Opportunity Cost	Lost per Year (Nr of patient not attended * price per consult * 365)	Instances not served	Cost per specialist consult		Total Opportunity Cost
		10	€	70,00	€ 255.500,00
TOTAL COST PER YEAR (TO-BE)					€ 475.252,96
COST SAVING PER YEAR AFTER IMPLEMENTING TO-BE MODEL					€ 2.638.257,04
% OF COST REDUCTION TO-BE VS AS-IS					-85%

Figure 25: Cost-benefit Analysis

By implementing the improvements addressed in the To-Be model, they could get a cost reduction of 85%, compared to the current state. The opportunity cost of patients leaving the Hospital without making a consultation seems the biggest problems, which affects potentially the Hospital finances.

Limitations

The project was developed using information from the Grace Hospital project guideline, and several other information have been taken from external sources, and it can add a theoretical effect in the project. The assumptions used was based on the experience of the group participants, trying to focus on a business perspective and more technical expertise. It is known that this kind of project demands field experience, observation, interviews, and research to achieve a top-of-mind impact using the Business Process Management. However, the project did not use any further research or field information to direct the BPM roadmap that could helped to obtain more assertive results, or still could allowed to have more sources of inspiration to create different scenarios or explore further analysis that could be made.

Future Work and Conclusion

The project followed a full BPM lifecycle methodology, which provided a clear guide to identify, understand, model, analyze, and redesign the process in the Grace Hospital, of attending patients in a regular medical consultation. Although the Process Implementation and Process Monitoring and Controlling phases were not part of the scope of this project, the developed work can be widely explored to direct the business on the next steps towards the implementation of quick wins and robust changes in the company.

After all the many analyses that helped understanding the opportunities, and the process redesign phase, the To-Be model demonstrated a large advantage against the current model (As-Is), not only because of the efficiency in the optic of Time, Quality, but also under the financial perspective, which was reinforced by the Cost-benefit analysis. Also, the Ambiental impact was considered in the project, considering the paper and print toner that can be avoided if the Hospital decides on moving with the implementation.

The next step is to create an implementation and monitoring plan, which may help to identify other relevant costs or constraints before making the chances become real. All the steps need to be performed and reviewed during the

implementation, since there are many factors that can ease or difficult the success of the implementation.

References

Dumas, M., Rosa, M. L., Mendling, J., & Reijers, H. A. (2018). Fundamentals of Business Process Management 2 nd Edition. Springer Berlin Heidelberg;

W.M.P. van der Aalst, Business process simulation survival guide, in Handbook of Business

M. Hammer, J. Champy, Reengineering the Corporation: A Manifesto for Business Revolution (Harpercollins, New York, 1993)

Process Management 1, ed. by J. vom Brocke, M. Rosemann (Springer, Berlin, 2015), pp. 337–370

<https://static.staples.pt/resources/medias/mediamanagement/medias/copia-impressao-P-B-3.pdf>

[https://www.pccomponentes.pt/wacom-signature-set-stu-540-capturador-de-firmas-electronicas?codesf=153164983&utm_medium=cpc&utm_campaign=Shopping-feed&utm_term=Wacom+Signature+Set+STU-540+Capturador+de+Assinaturas+Eletr%C3%B3nicas&utm_source=googleShopping\(via+Shopping+Feed\)&gclid=CjwKCAjwkYGVbArEiwA4sZLuCl5apl9IajlN8zbc7aQeVB4v_pYEsTqJQUmlzlsQvDaA_bGHCx3FBoCKmkQAvD_BwE](https://www.pccomponentes.pt/wacom-signature-set-stu-540-capturador-de-firmas-electronicas?codesf=153164983&utm_medium=cpc&utm_campaign=Shopping-feed&utm_term=Wacom+Signature+Set+STU-540+Capturador+de+Assinaturas+Eletr%C3%B3nicas&utm_source=googleShopping(via+Shopping+Feed)&gclid=CjwKCAjwkYGVbArEiwA4sZLuCl5apl9IajlN8zbc7aQeVB4v_pYEsTqJQUmlzlsQvDaA_bGHCx3FBoCKmkQAvD_BwE)

<https://fr.aliexpress.com/item/4000070753699.html?spm=a2g0o.detail.1000023.11.17bc33f7GK4xsZ&gatewayAdapt=glo2fra>

<https://www.hospitaldaluz.pt/agueda/pt/para-clientes/precos-e-faturas>

ANNEXES

Scenario AS-IS							
Name	Type	Instances completed	Instances started	Difference	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Orthopedicts Department	Process	97	200	103	135,17		11.479,35
Patient arrived	Start event	200					
Consultation confirmed?	Gateway	200	200	0			
Patient leaves the hospital	End event	10					
Patient leaves the hospital	End event	78					
Patient leaves the hospital	End event	9					
Patient paying at the time?	Gateway	87	87	0			
Admission Process	Task	200	200	0	2,34	0,34	67,25
Call patient	Task	89	91	2	133,10	125,11	11.385,00
Make consultation	Task	87	89	2	15,05	0,03	2,31
Finalize consultation	Task	78	78	0	2,82	0,32	24,79

Figure 26: Annex 1

What-IF 1							
Name	Type	Instances completed	Instances started	Difference	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Orthopedicts Department	Process	184	200	16	41,28		3.851,50
Patient arrived	Start event	200					
Consultation confirmed?	Gateway	200	200	0			
Patient leaves the hospital	End event	10					
Patient leaves the hospital	End event	153					
Patient leaves the hospital	End event	21					
Patient paying at the time?	Gateway	175	175	0			
Admission Process	Task	200	200	0	3,04	1,03	206,78
Call patient	Task	190	190	0	15,12	10,31	1.958,20
Make consultation	Task	175	181	6	23,33	8,49	1.536,55
Finalize consultation	Task	153	154	1	3,49	0,97	149,97

Figure 27: Annex 2

What-IF 2							
Name	Type	Instances completed	Instances started	Difference	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Orthopedicts Department	Process	193	200	7	31,34		2.692,21
Patient arrived	Start event	200					
Consultation confirmed?	Gateway	200	200	0			
Patient leaves the hospital	End event	10					
Patient leaves the hospital	End event	162					
Patient leaves the hospital	End event	21					
Patient paying at the time?	Gateway	184	184	0			
Admission Process	Task	200	200	0	3,66	1,66	331,28
Call patient	Task	190	190	0	15,08	10,26	1.949,82
Make consultation	Task	184	190	6	10,64	0,68	129,57
Finalize consultation	Task	162	163	1	4,24	1,73	281,54

Figure 28: Annex 3

What-IF 3							
Name	Type	Instances completed	Instances started	Difference	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Orthopedicts Department	Process	194	200	6	29,01		2.217,21
Patient arrived	Start event	200					
Consultation confirmed?	Gateway	200	200	0			
Patient leaves the hospital	End event	10					
Patient leaves the hospital	End event	163					
Patient leaves the hospital	End event	21					
Patient paying at the time?	Gateway	184	184	0			
Admission Process	Task	200	200	0	2,00	-	-
Call patient	Task	190	190	0	15,68	10,87	2.064,44
Make consultation	Task	184	190	6	10,65	0,69	130,69
Finalize consultation	Task	163	163	0	2,64	0,14	22,08

Figure 29: Annex 4

What-IF 4							
Name	Type	Instances completed	Instances started	Difference	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Orthopedicts Department	Process	200	200	0	19,12		178,55
Patient arrived	Start event	200					
Consultation confirmed?	Gateway	200	200	0			
Patient leaves the hospital	End event	10					
Patient leaves the hospital	End event	169					
Patient leaves the hospital	End event	21					
Patient paying at the time?	Gateway	190	190	0			
Admission Process	Task	200	200	0	2,01	0,00	0,87
Call patient	Task	190	190	0	5,00	0,18	35,07
Make consultation	Task	190	190	0	10,61	0,58	109,44
Finalize consultation	Task	169	169	0	2,70	0,20	33,18

Figure 30: Annex 4

AS IS								
Name	Type	Instances completed	Instances started	Difference	Min. time (m)	Max. time (m)	Avg. time (m)	Total time (m)
Orthopedicts Department	Process	97	200	103	1,96	245,05	135,17	13.843,81
Patient arrived	Start event	200						
Consultation confirmed?	Gateway	200	200					
Patient leaves the hospital	End event	10						
Patient leaves the hospital	End event	78						
Patient leaves the hospital	End event	9						
Patient paying at the time?	Gateway	87	87	0				
Admission Process	Task	200	200	0	1,87	5,19	2,34	467,79
Call patient	Task	89	91	2	5,53	253,24	133,10	11.846,22
Make consultation	Task	87	89	2	13,38	16,84	15,05	1.309,57
Finalize consultation	Task	78	78	0	2,39	4,80	2,82	220,23

Figure 31: Annex 5

TO BE								
Name	Type	Instances completed	Instances started	Difference	Min. time (m)	Max. time (m)	Avg. time (m)	Total time (m)
Orthopedicts Department	Process	200	200	0	1,95	48,93	19,12	3.824,03
Patient arrived	Start event	200						
Consultation confirmed?	Gateway	200	200					
Patient leaves the hospital	End event	10						
Patient leaves the hospital	End event	169						
Patient leaves the hospital	End event	21						
Patient paying at the time?	Gateway	190	190	0				
Admission Process	Task	200	200	0	1,87	2,96	2,01	401,41
Call patient	Task	190	190	0	0,03	30,50	5,00	950,40
Make consultation	Task	190	190	0	8,38	16,96	10,61	2.015,90
Finalize consultation	Task	169	169	0	2,34	5,03	2,70	456,32

Figure 32: Annex 6

AS-IS					
Name	Avg Processing Time	Waiting Time	Cycle Time	Theoretical circle time (m)	CTE (Circle Time Efficiency) (m)
	Avg. time (m)	Avg. time waiting for resource (m)			
Orthopedicts Department	135,17	143,93	279,11	30,00	11%
Admission Process	2,34	0,34	2,68	2,00	75%
Call patient	133,10	125,11	258,21	10,50	4%
Make consultation	15,05	0,03	15,08	15,00	99%
Finalize consultation	2,82	0,32	3,14	2,50	80%

TO-BE					
Name	Avg Processing Time	Waiting Time	Circle Time	Theoretical circle time (m)	CTE (Circle Time Efficiency) (m)
	Avg. time (m)	Avg. time waiting for resource (m)			
Orthopedicts Department	19,12	2,16	21,28	19,50	92%
Admission Process	2,01	0,00	2,01	2,00	99%
Call patient	5,00	0,18	5,19	5,00	96%
Make consultation	10,61	0,58	11,19	10,00	89%
Finalize consultation	2,70	0,20	2,90	2,50	86%

Figure 33: Annex 7

AS-IS				
Name	Instances started	Lambda	Cycle Time	WIP(Working in Progress)
Admission Process	200	0,42	2,68	1,11
Call patient	91	0,19	258,21	48,95
Make consultation	89	0,19	15,08	2,80
Finalize consultation	78	0,16	3,14	0,51

TO-BE				
Name	Instances started	Lambda	Cycle Time	WIP(Working in Progress)
Admission Process	200	0,42	2,01	0,84
Call patient	190	0,40	5,19	2,05
Make consultation	190	0,40	11,19	4,43
Finalize consultation	169	0,35	2,90	1,02

Figure 34: Annex 8

		AS-IS			Lambda	μ Mean Services rate
	Avg Processing Time	Waiting Time				
Name	Avg. time (m)	Avg. time waiting for resource (m)	Number of services	Cycle Time		
Admission Process	2,34	0,34	2	2,68	0,42	0,43
Call patient	133,10	125,11	2	258,21	0,19	0,02
Make consultation	15,05	0,03	6	15,08	0,19	0,07
Finalize consultation	2,82	0,32	2	3,14	0,16	0,35

Figure 35: Annex 9

AS-IS					
L Average Customers in System	Lq Average Customers in Queue	W Average Time Spent in System	Wq Average time Waiting in Line	ρ Server Utilization	
1,2827	0,3059	3,054	0,7284	0,4884	
1,2268	0,2768	6,4568	1,4568	0,475	
2,7693	0,055	14,5752	0,2894	0,4524	
0,4823	0,0252	3,0146	0,1575	0,2286	

Figure 36: Annex 10

		TO-BE				Lambda	μ Mean Services rate
	Avg Processing Time	Waiting Time					
Name	Avg. time (m)	Avg. time waiting for resource (m)	Number of services	Cycle Time			
Admission Process	2,01	0,00	5	2,01	0,42	0,50	
Call patient	5,00	0,18	4	5,19	0,40	0,20	
Make consultation	10,61	0,58	6	11,19	0,40	0,09	
Finalize consultation	2,70	0,20	2	2,90	0,35	0,37	

Figure 37: Annex 11

TO-BE					
L Average Customers in System	Lq Average Customers in Queue	W Average Time Spent in System	Wq Average time Waiting in Line	ρ Server Utilization	
0,8404	0,0004	2,0009	0,0009	0,168	
2,1739	0,1739	5,4348	0,4348	0,5	
5,6016	1,1571	14,0039	2,8928	0,7407	
1,2185	0,2726	3,4815	0,7788	0,473	

Figure 38: Annex 12

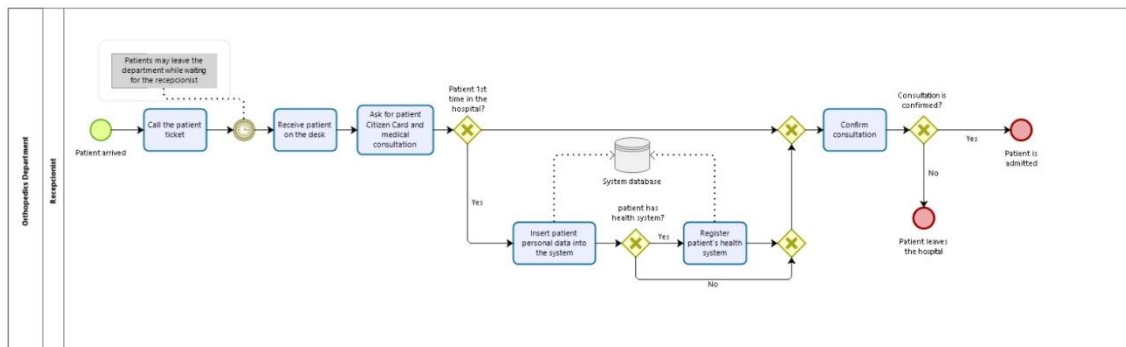


Figure 39: Annex 13

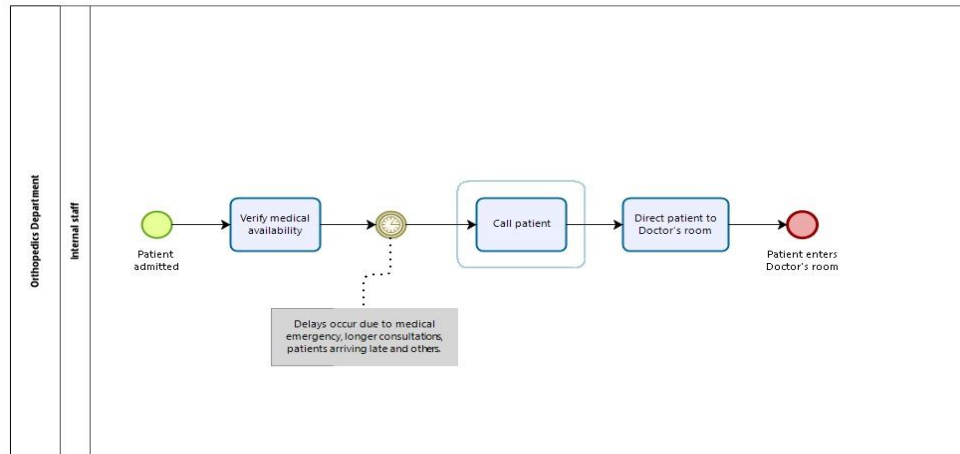


Figure 40: Annex 14

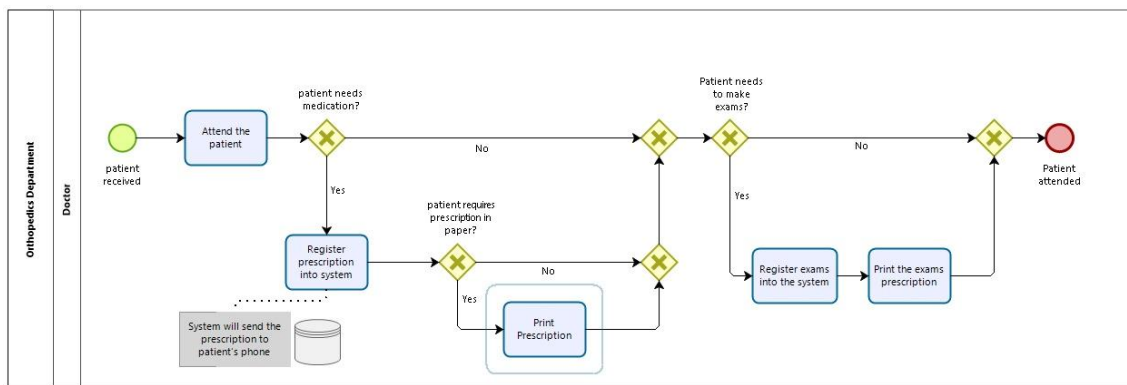


Figure 41: Annex 15

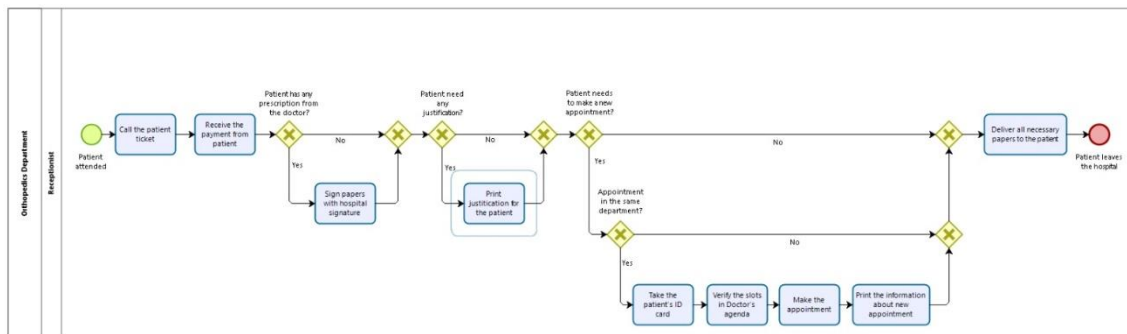


Figure 42: Annex 16

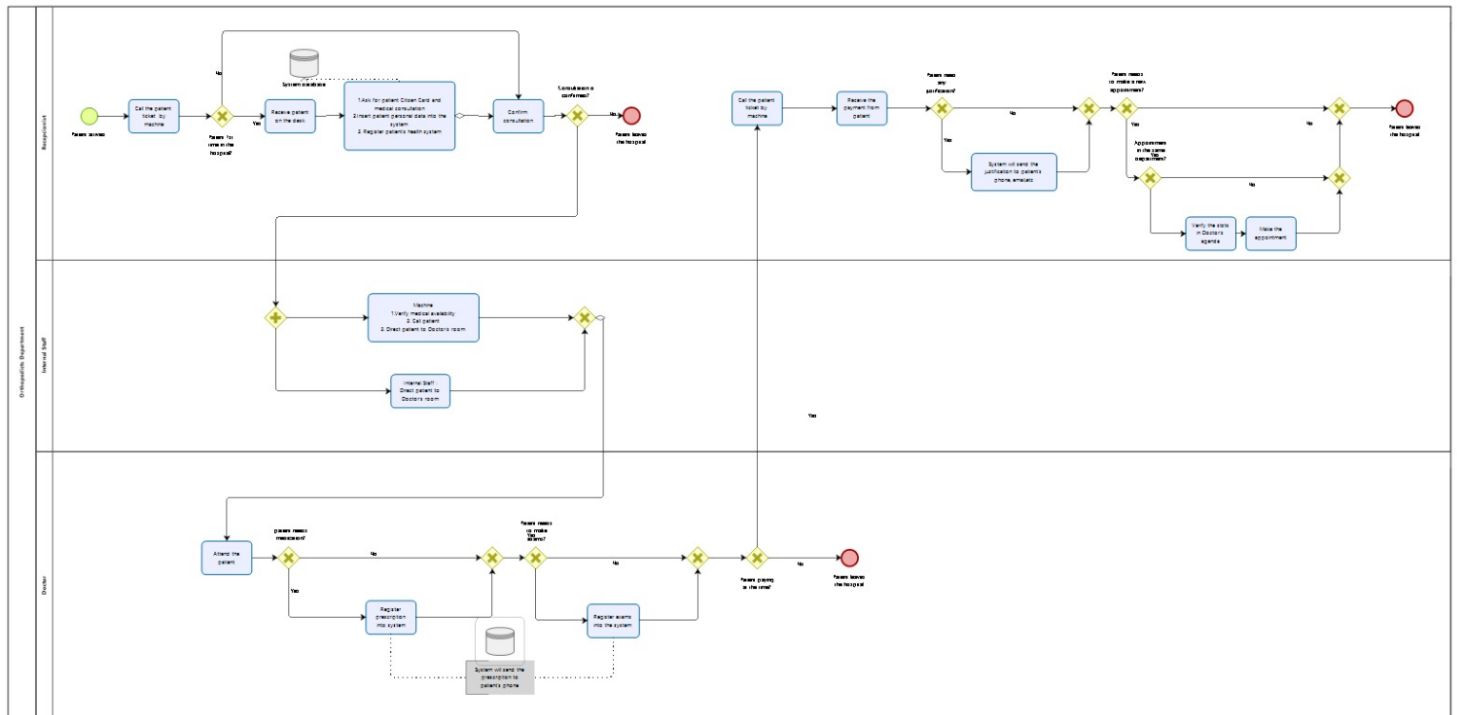


Figure 43: Annex 17