GRACE HOSPITAL

Nurturing Health Since 1998

Business Process Analysis

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1. INTRODUCTION

Grace Hospital, located in Lisbon, Portugal, is a well-established healthcare institution founded in 1998. It boasts a dedicated staff of over 800 professionals and offers a diverse range of medical services across approximately 30 specialties.

Our objective is to refine the consultation process, aiming for greater efficiency and simplicity. To achieve this goal, we will identify and address existing challenges that contribute to patient and staff dissatisfaction, mitigating specific issues related to patient dissatisfaction and time consumption, optimizing appointment scheduling and punctuality, addressing communication failures and information gaps, minimizing patient errors in managing appointments, reducing costs and supporting the hospital in becoming more sustainable.

This involves a comprehensive review of our current 'As-Is' process model and will entail an examination of each phase, setting the stage for the development of an improved 'To-Be' process model. In this model, we will outline potential benefits and drawbacks, and consider various scenarios for implementation. Further, we will use a combination of quantitative and qualitative techniques, investigating aspects such as lengthy procedures, delays in scheduled appointments, and communication gaps between the hospital and patients.

2. BACKGROUND

Grace Hospital is a renowned medical institution with more than 800 employees spread across 30 departments. The hospital's current focus is to improve the patient experience in the medical consultation process.

To do this, we will design the actual business process model based on the process description, understanding the process problems and inefficiencies, and which activities in the current process can be improved or even excluded. After identifying the main problems and designing the business process As-Is model, we will apply a qualitative and quantitative analysis to understand the origin of Grace Hospital's problems, which activities add value to the process, and which activities delay the process.

After identifying the problems, we will carry out What-If simulations, where we hope to achieve an optimal result after some attempts and tests. After achieving the ideal result, we will redesign the As-Is model of the business process to create a To-Be model - the best and most efficient business process model - that solves the current problems of Grace Hospital's process. After creating a To-Be model of the business process, we will compare the changes made to the process, as well as the improvements and their implementation costs, according to their limitations.

3. PROCESS DESCRIPTION

There were many options when we selected one business model for our project. After analyzing all of them, we finally decided to choose Grace Hospital. Our objective is to achieve both academic and professional goals by analyzing and optimizing the processes in the Grace Hospital.

Grace Hospital is a big institution with complex and diverse processes, which corresponds with our ideal business model profile. This choice enables us to address real-world challenges using practical and theoretical insights gained from our Business Process Management (BPM) course.

Furthermore, the existing problems at Grace Hospital are very common in the real world. For this reason, we aim to provide some solutions and heuristics to healthcare institutions through our analysis, which will optimize patient experience and improve efficiency.

Ultimately, we aspire to reshape hospital processes in Portugal by organizing, identifying, and simplifying tasks.

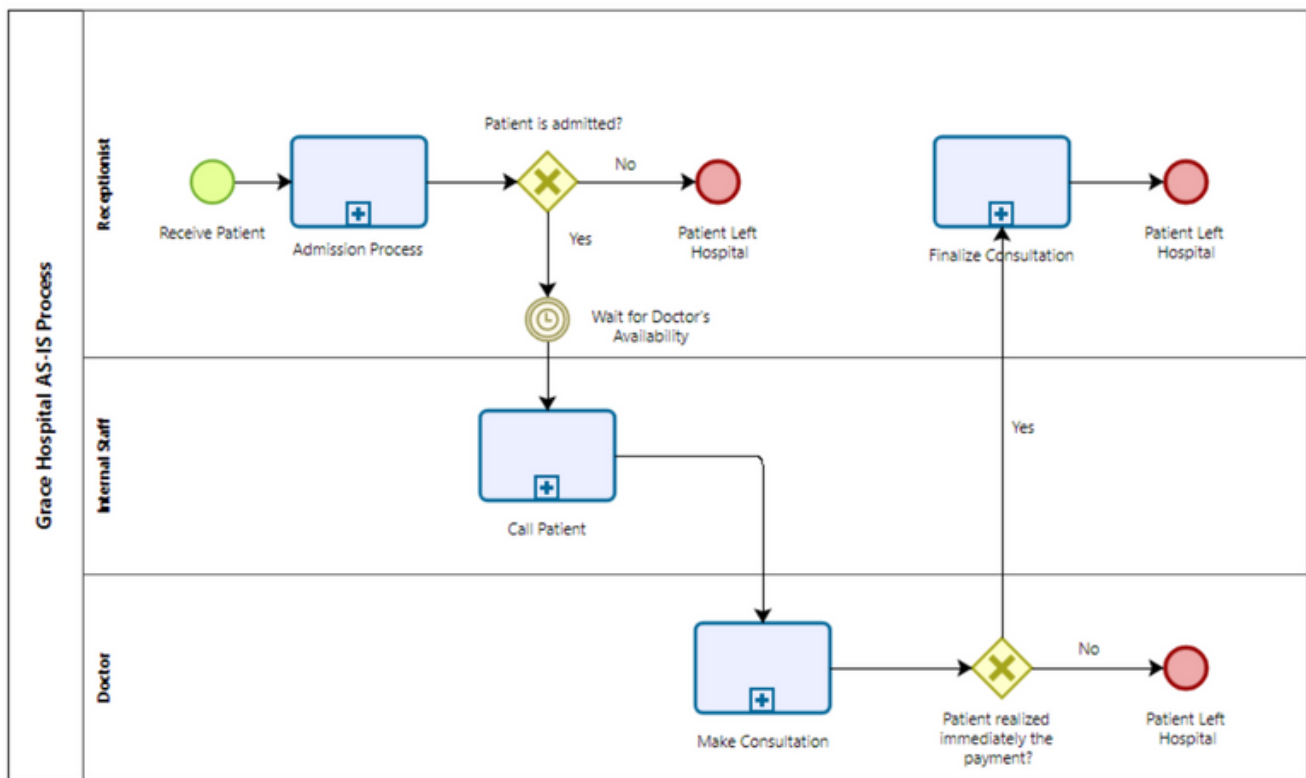GRACE HOSPITAL

4. AS-IS PROCESS MODEL

Figure 1: Grace Hospital Overall AS-IS (Process Level 1)

The process begins with the Receptionist receiving the Patient at Grace Hospital. The first subprocesses emerge during the Admission Process performed by the Receptionist, which will validate all the necessary documents and confirm the appointment day for a doctor consultation. Here, there are two potential paths: in 8% of cases, the patient is not admitted, requiring rescheduling, while in 92% of cases, the patient waits approximately 10 minutes for the doctor's availability.

The next subprocess is Call Patient, where the Internal Staff checks and directs the patient to the doctor's office when available.

The third subprocess, Make Consultation, involves the doctor conducting a thorough examination, providing medical advice, and prescriptions, or recommending additional tests.

Following the consultation, there are two potential outcomes: in 10% of cases, patients don't pay immediately and leave, while in 90% of cases, they move on to the fourth subprocess, Finalize Consultation. Here, the receptionist ensures payment, verifies documents, and schedules new appointments if needed, concluding the process as the patient leaves Grace Hospital.

4.1 ADMISSION PROCESS
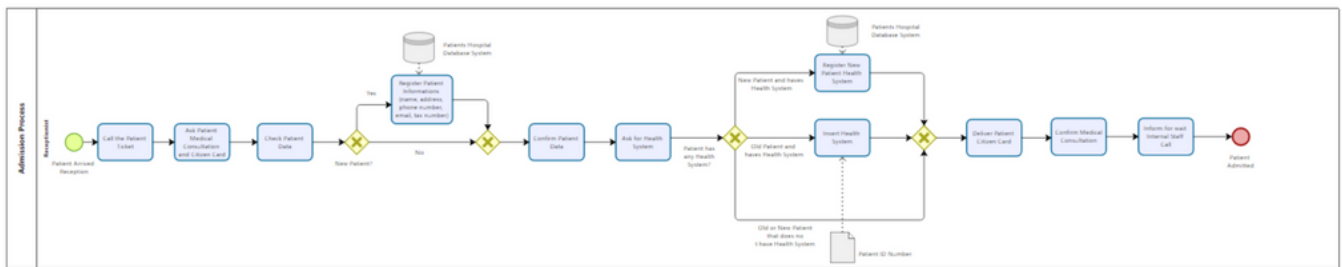
Figure 2: Admission Process AS-IS (Process Level 2)

The Admission sub-process at Grace Hospital begins with the receptionist collecting the Patient's Ticket, Citizen Card, and Medical Consultation request. The receptionist confirms the Medical Consultation in the system, distinguishing between new patients (25%) and returning patients (75%). For new patients, the receptionist registers personal information, checks the Patient's status with the Health System, and records the Health System details if applicable. For returning patients with a Health System, the receptionist updates information in the system. Patients without a Health System require no system input. After this, the receptionist returns the Citizen Card, confirms the Medical Consultation, and directs the patient to wait for the Internal Staff.

4.2 CALL PATIENT

Figure 3: Call Patient AS-IS (Process Level 2)

After admission, the Call Patient subprocess involves Internal Staff monitoring the Medical List and Doctor's availability in the system. Continuously refreshing the system, they wait for the moment the Doctor becomes available. Once notified, the sub-process ends with Internal Staff calling the Patient and guiding them to the available Doctor's Office.

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4.3 MAKE CONSULTATION
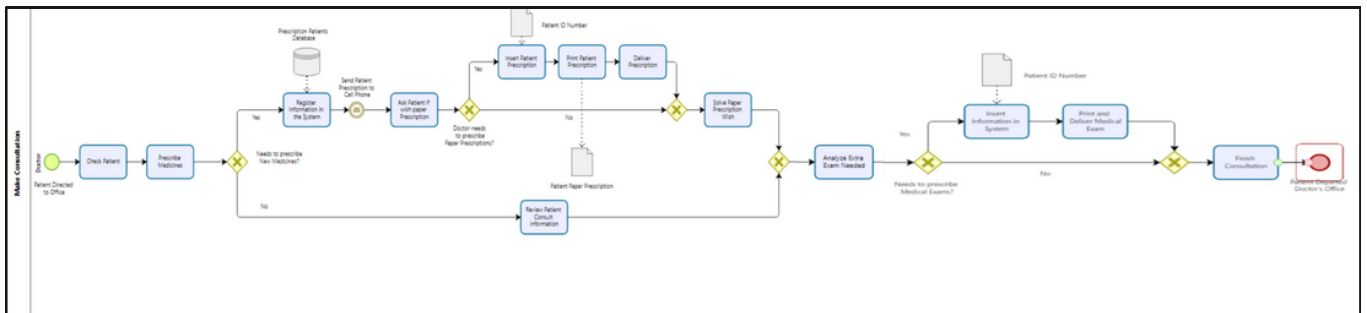
Figure 4: Make Consultation AS-IS (Process Level 2)

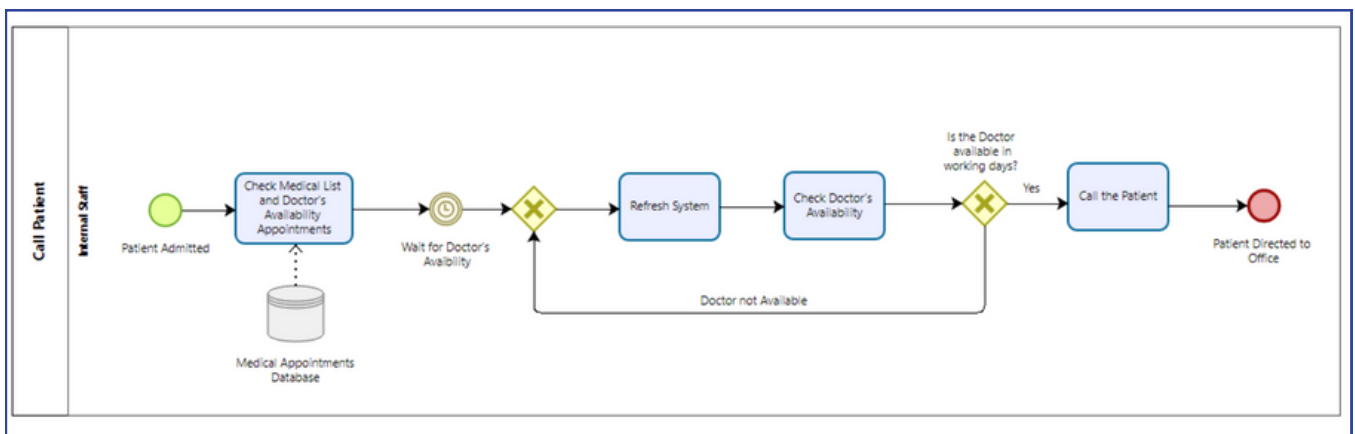Following the Call Patient subprocess and the Patient's direction by Internal Staff to the Doctor's Office, the Make Consultation subprocess initiates with the Doctor examining the Patient. In cases where no new medicines are prescribed (10%), the Doctor reviews the Patient's information. When new medicines are prescribed (90%), the Doctor enters the details into the System. When patients request a paper prescription (50%), the Doctor prints it and delivers it. The electronic prescription (50%), is sent to the patients' cell phone. After prescribing new medicines, the Doctor assesses the need for additional medical exams, leading to two scenarios.: if exams are necessary (40% of cases), the Doctor records the information, prints, and delivers the prescription. If no exams are required (60% of cases), no new prescriptions are issued. The Doctor concludes the consultation, and the Patient leaves the office. All activities in this subprocess are performed by the Doctor.

4.4 FINALIZE CONSULTATION
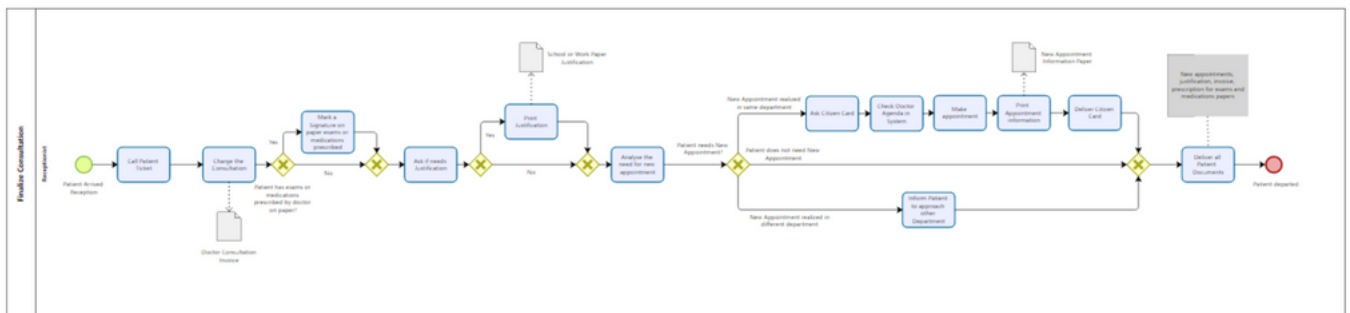
Figure 5: Finalize Consultation AS-IS (Process Level 2)

After leaving the doctor's office, the Finalize Consultation process begins at the reception. The receptionist charges the consultation fee, checks for any prescribed exams or medications on paper, and asks if a work or school justification is needed. If a Justification is required (35% of cases), the receptionist prints it. If the Patient requests a new appointment in the same department, the receptionist schedules it. If the appointment is in another department, the receptionist can't schedule it. Finally, the receptionist hands over all necessary documents (new appointments, justification, invoice, prescriptions) and the Patient leaves Grace Hospital.

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5. QUALITATIVE ANALYSIS

After designing the AS-IS process, we started applying the Qualitative Analysis, to have a better perception and recognition of both unnecessary and essential activities. Our focus was on identifying and removing redundant tasks while emphasizing the pivotal ones. This approach allowed us to differentiate between value-added and non-value-added activities, aiding in decisions about which tasks to keep. .

The analysis aimed to bring clarity by organizing and restructuring qualitative data from the process. Techniques like Value Added Analysis, Waste Analysis, Issue Register, and Root Cause Analysis, complemented by Why-Why Diagrams, were employed for a comprehensive assessment.

5.1 VALUE-ADDING ANALYSIS

The value-adding analysis will be applied to detect unnecessary steps and remove them, which will optimize the process and improve efficiency. There is a classification of value-adding analysis which can be divided into 3 different groups (Value Adding, Business Value Adding, and Non-Value-Adding):

Value Adding (VA)

When we define an activity as Value-Adding, it means that the activity produces satisfaction and value to customers. Customers are happy to pay for this type of activity and removing the step would diminish the perceived value of the result from the customer's perspective.

Business Value Adding (BVA)

Activities that help businesses to run efficiently and collect revenue are defined as Business value-adding. They do not directly add value to the customer but can reduce the risk of business losses.

Non-Value-Adding (NVA)

Non-Value-Adding activities don't produce value for customers and should be eliminated. They don't fall into either of the two previous categories.

ADMISSON PROCESS

Steps	Classification
Call the Patient Ticket	BVA
Ask Patient Medical Consultation and Citizen Card	VA
Check patient data	BVA
Register patient information	VA
Confirm patient data	VA
Ask for health system	BVA
Register new patient health system	BVA
Insert health system	BVA
Deliver patient citizen card	VA
Confirm medical consultation	BVA
Inform for wait internal staff call	VA

Table 1: Value-Adding Analysis - Admisson Process

CALL PATIENT

Steps	Classification
Check medical list and doctor's availability	BVA
Refresh system	BVA
Check doctor's availability	VA
Call the patient	BVA

Table 2: Value-Adding Analysis - Call Patient

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MAKE CONSULTATION

Steps	Classification
Check Patient	VA
Prescribe Medicines	BVA
Register Information in the System	BVA
Ask patient if wish paper prescription	BVA
Insert patient prescription	BVA
Print Patient Prescription	NVA
Deliver Prescription	VA
Inform patient on prescription completion	VA
Review patient consult information	BVA
Check Patient Medicines	BVA
Analyze extra exam needed	BVA
Insert information in system	BVA
Print and deliver patient prescription	NVA
Finish consultation	VA

Table 3: Value-Adding Analysis - Make Consultation

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FINALIZE CONSULTATION

Steps	Classification
Call the Patient	BVA
Charge the consultation	VA
Mark a Signature on prescription	VA
Ask if needs justification	BVA
Print justification	NVA
Analyze the need for new appointment	BVA
Ask citizen card	VA
Check doctor agenda in system	BVA
Make appointment	VA
Print appointment information	NVA
Deliver citizen card	VA
Inform patient to approach other department	VA
Deliver all patient documents	VA

Table 4: Value-Adding Analysis - Finalize Consultation

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5.2 WASTE ANALYSIS

After a comprehensive examination of the process and identification of challenges, the next step involves a Waste Analysis to pinpoint non-value-adding activities. This analysis categorizes wastes into three groups

Move: Related to movement, with two sub-types: transportation and motion.
Hold: Arising from holding or waiting, encompassing inventory and waiting.
Overdo: Resulting from unnecessary actions, with sub-types like defects, overprocessing, and overproduction

The analysis provides a structured framework for understanding and addressing inefficiencies in the process and aims the delivery of value to patients or the hospital:

Wastes	
Transportation	• System sends a message with prescription to the patient cell phone
Motion	• Patient goes to the receptionist desk • Internal Staff directs patient to doctors office • Doctor prints medicine prescription and /or exam prescription and gives it to patient • Receptionist prints and delivers work/school justification, appointment information, invoice, etc to patient • Patient goes to another department to book new appointment
Waiting	• Patient waits to be called for admission • Patient waits to be called and directed to the doctors office • Patient waits to be called for payment • Receptionist waits for patient to arrive after calling the ticket • Internal staff waits for doctor availability
Defect	• Receptionist has to call patient again for admission when he leaves the department • The doctor is called for emergencies, the appointments take longer than expected, the doctor is late, or the patient arrives late. • Patient leaves without paying
Over-processing	• Patient not admitted (after asking for citizen card and registering info. in the system) • Receptionist marks prescription with hospital signature • Receptionist asking again for citizen card in order to make new appointment
Over-production	• Patient not admitted (after asking for citizen card and registering all the info in the system)

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TRANSPORTATION WASTES

The identified transportation wastes in the medical consultation process at Grace Hospital underscore inefficiencies in the dissemination of critical information. The step where the system sends a prescription message to the patient's cell phone (during the consultation) can be a superfluous transfer of data. In the contemporary digital landscape, relying on such a method is deemed wasteful, as more streamlined alternatives could be employed.

This transportation waste highlights opportunities for process improvement within the medical consultation system, ensuring a more resource-effective and responsive approach to patient communication and billing procedures.

MOTION WASTES

The motion wastes identified reveal areas where unnecessary physical movements and activities contribute to inefficiencies.

Firstly, the requirement for a patient to physically go to the receptionist desk for admission introduces motion waste. This step could potentially be streamlined by implementing self-check-in kiosks or an online pre-registration system.

The internal staff directing patients to the doctor's office is an additional motion waste. The intervention of internal staff could be minimized through the implementation of a digital signage system or automated notifications.

The doctor's practice of printing medicine or exam prescriptions and personally handing them to the patient suggests an area for improvement. Transitioning to electronic prescription systems could eliminate the need for physical paperwork, ensuring a more efficient and eco-friendly approach to prescription delivery.

Similarly, the motion waste associated with the receptionist printing and physically delivering various documents could be addressed. Implementing digital document delivery systems or providing access to these documents through a patient portal could significantly reduce the need for manual document handling.

Lastly, the patient's physical presence (when they are already at the hospital) in another department to book a new appointment to a different specialty, introduces unnecessary motion waste as well. A centralized online appointment booking system accessible to patients could mitigate the need for patients to physically navigate the hospital for appointment scheduling.

These motion wastes collectively pinpoint areas where process optimization could enhance the overall efficiency of the medical consultation process at Grace Hospital.

WAITING WASTES

Waiting wastes within Grace Hospital's medical consultation process manifest at various stages, impacting the overall efficiency and patient experience. Patients waiting to be called for admission, for payment or to enter the doctor's office present instances of waiting waste. During these periods, patients are not actively progressing in their care journey.

Waiting waste becomes more pronounced when the waiting time to be called into the doctor's office is influenced by specific situations. For instance, the doctor may be called for emergencies, and such cases consistently take precedence over scheduled appointments. Additionally, appointments may take longer than expected, the doctor may be running late, or the patient may arrive late, further contributing to prolonged waiting times

Likewise, the receptionist waiting for the patient to arrive after calling the ticket (sometimes the patient leaves the department) introduces unproductive time in the workflow, impeding the efficiency of the admission process. Moreover, internal staff waiting for doctor availability indicates a congestion point in scheduling. Strategies to minimize waiting waste could involve optimizing appointment scheduling, leveraging digital tools for timely notifications, and implementing efficient payment systems.

DEFECT WASTES

Defect wastes arise from instances where the ideal workflow is disrupted, such as emergencies requiring the doctor's immediate attention, appointments exceeding anticipated durations, tardiness on the part of the doctor, or delays caused by patients arriving late, introducing inefficiencies and potential errors.

The need for the receptionist to call a patient again for admission when they leave the department while waiting, points to a defect in communication or patient awareness, resulting in deviations from the intended process.

Similarly, when a patient leaves without completing the payment, it indicates a breakdown in the transactional workflow, impacting both the hospital's financial processes and the completion of the patient's journey. These defect wastes underscore the importance of addressing communication gaps and process shortcomings to ensure a smoother and error-free patient experience throughout the medical consultation process.

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OVER-PROCESSING WASTES

Over-processing wastes are evident in situations where redundant steps contribute to inefficiencies. The instance where a patient is not admitted indicates the need to reassess the admission criteria and scheduling procedures to prevent unnecessary steps when patients inadvertently arrive on non-scheduled days.

Similarly, the repetition of steps, such as the receptionist marking a prescription with the hospital signature and asking again for the citizen card to make a new appointment, suggests opportunities to streamline processes and reduce redundancy in information gathering. Addressing these over-processing wastes involves refining procedures to ensure that each step contributes directly to the efficient flow of the medical consultation process.

OVER-PRODUCTION WASTES

The scenario where a patient is not admitted, after presenting the citizen card and completing the information registration process in the system, embodies both over-processing and over-production wastes. This situation indicates an excess in the effort invested in the admission process, as the patient's completion of necessary steps should ideally result in successful admission.

The repetition or continuation of the admission process despite the patient not being eligible for admission on that particular day signifies over-production, as the system unnecessarily proceeds with steps that do not contribute to the desired outcome.

5.3 ISSUE REGISTER

After analyzing the as-is process of Grace Hospital, we have gained a deep understanding of the existing process and became aware of the current problems, which could have a bad impact on patient experience and reduce efficiency in the hospital. The purpose of an issue register is to track the issues that arise in a project and prioritize a response to them.

Name	Explanation	Priority	Assumptions	Qualitative Impact
Unclear Waiting Time	Patients don't know how much they must wait, and medical consultations do not take place at the scheduled time	1	Not having the estimated time, how much time the patient needs to wait for the medical consult, the patient might leave the Hospital	Customer dissatisfaction
Lack of Efficiency in Admission of Patients for Consults	Patients go to the hospital on the wrong day, so the admission is not confirmed	2	Not having a efficient process for admisson of the patients in consults, leads to patient dissatisfaction about Hospital services	Customer dissatisfaction
Impossibility to make all types of appointment in one department	If the patient wants to make a new appointment after payment, they may need to go to another department.	4	Lack of efficiency in Hospital processes, leads to a unsatisfied Patient because of Hospital services	Waste of time, Inefficiency of making appointment
Waste of Environmental Resources and money on supplies	Spends a lot of money on supplies (papers, printer toners)	3	By using papers, and printer tones they are wasting money and environment resources	Decrease Sustainability of the Company, and their costs increase

Table 11: Grace Hospital Issue Register

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5.4 ROOT CAUSE ANALYSIS

Root cause analysis using "Why-Why" diagrams is a technique employed to delve into the underlying causes of issues within a business process. This method emphasizes tracing the cause-to-effect relationships systematically by recursively asking the question "Why?". The goal is to uncover factors perceived as root causes by stakeholders. By visually representing the cause-and-effect relationships in a structured manner, "Why-Why" diagrams not only prevent hasty conclusions but also facilitate collaborative efforts, providing a comprehensive understanding of the issues. This understanding serves as a foundation for developing effective and targeted solutions during the process redesign.
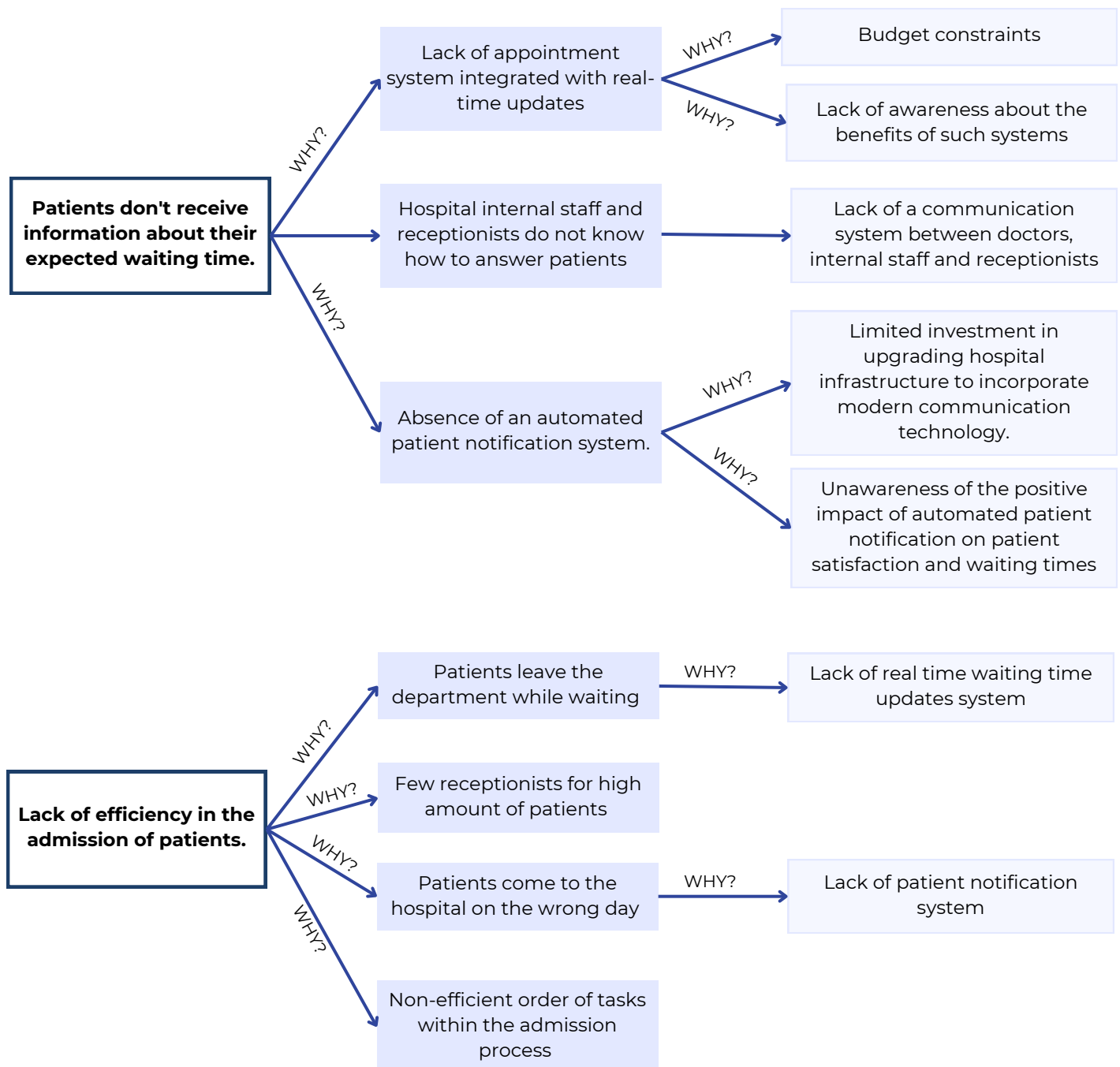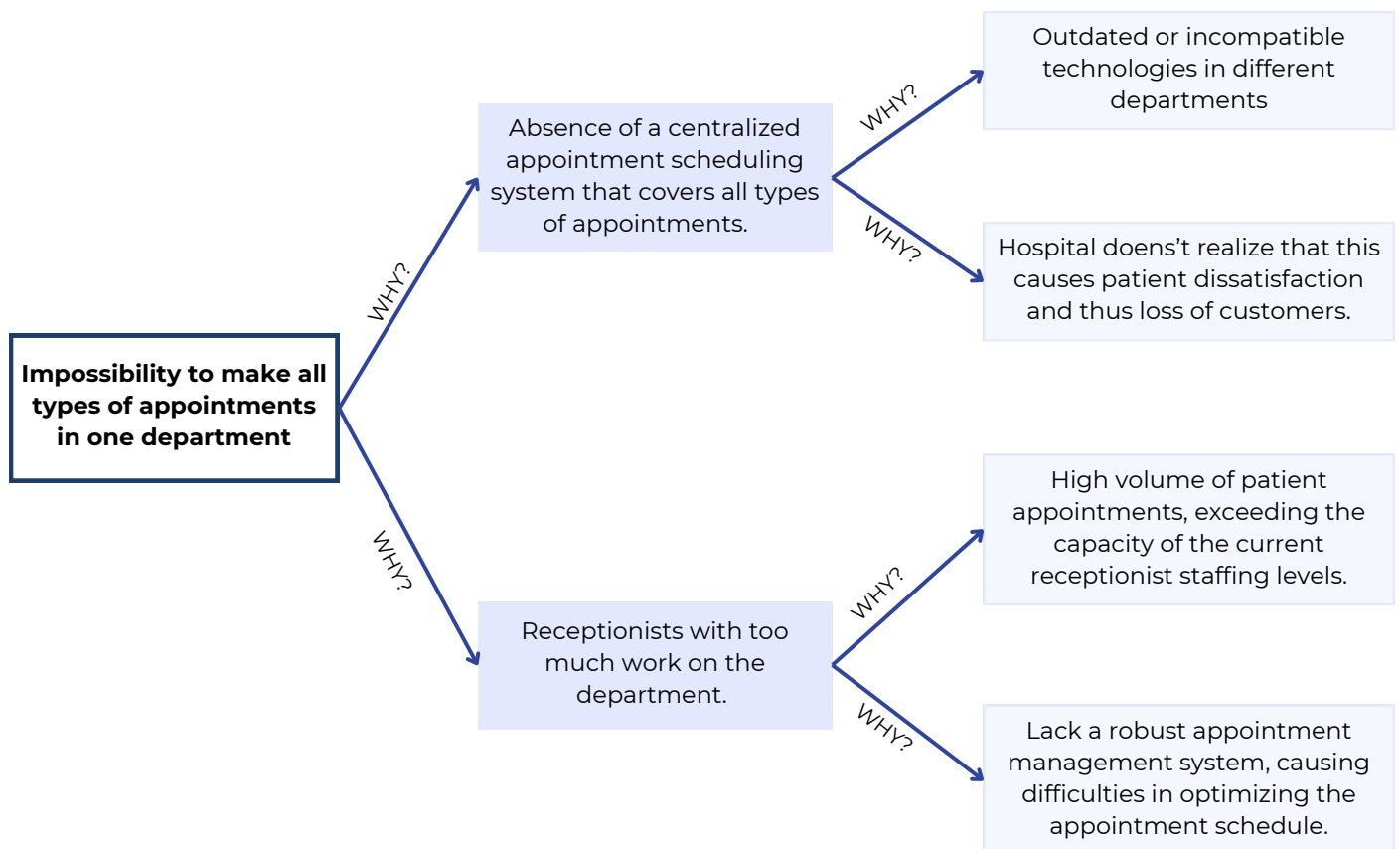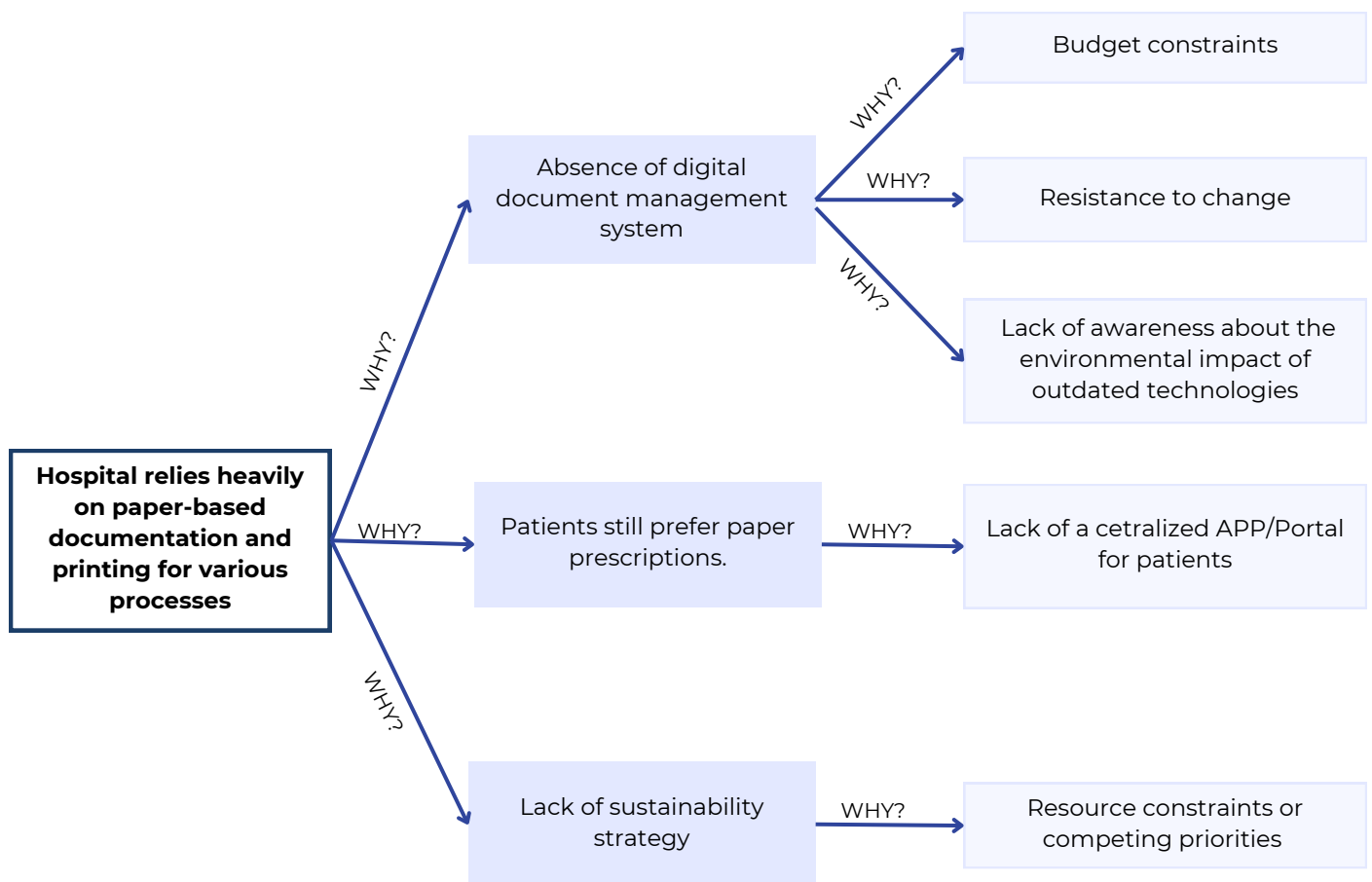

Diagram 1: Grace Hospital Why- Why Diagram

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                                                              ┌──────────────────────────┐
                                                      WHY?    │   Budget constraints     │
                                                    ┌────────▶└──────────────────────────┘
                          ┌──────────────────────┐ │
                          │  Absence of digital  │ │ WHY?   ┌──────────────────────────┐
                   WHY?   │ document management  │─┼───────▶│   Resistance to change   │
                ┌────────▶│       system         │ │        └──────────────────────────┘
                │         └──────────────────────┘ │
                │                                   │ WHY?   ┌──────────────────────────┐
                │                                   └───────▶│ Lack of awareness about  │
                │                                            │  the environmental       │
                │                                            │ impact of outdated       │
                │                                            │      technologies        │
                │                                            └──────────────────────────┘
┌─────────────────────┐
│ Hospital relies      │  WHY?   ┌──────────────────────┐  WHY?   ┌──────────────────────────┐
│ heavily on paper-    │────────▶│ Patients still prefer│────────▶│ Lack of a cetralized     │
│ based documentation  │         │ paper prescriptions. │         │ APP/Portal for patients  │
│ and printing for     │         └──────────────────────┘         └──────────────────────────┘
│ various processes    │
└─────────────────────┘  WHY?   ┌──────────────────────┐  WHY?   ┌──────────────────────────┐
                └───────────────▶│ Lack of sustainability│───────▶│ Resource constraints or  │
                                 │      strategy         │        │  competing priorities    │
                                 └──────────────────────┘         └──────────────────────────┘
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                                                              ┌──────────────────────────┐
                                                      WHY?    │ Outdated or incompatible │
                          ┌──────────────────────┐ ┌─────────▶│ technologies in          │
                          │ Absence of a         │ │          │ different departments     │
                   WHY?   │ centralized          │─┤          └──────────────────────────┘
                ┌────────▶│ appointment          │ │
                │         │ scheduling system    │ │ WHY?   ┌──────────────────────────┐
                │         │ that covers all      │ └───────▶│ Hospital doens't realize │
                │         │ types of appointments│          │ that this causes patient │
                │         └──────────────────────┘          │ dissatisfaction and thus │
                │                                            │ loss of customers.       │
┌─────────────────────┐                                     └──────────────────────────┘
│ Impossibility to     │
│ make all types of    │                                    ┌──────────────────────────┐
│ appointments in one  │                            WHY?    │ High volume of patient   │
│ department           │         ┌──────────────────┐┌─────▶│ appointments, exceeding  │
└─────────────────────┘         │ Receptionists    ││      │ the capacity of the      │
                │         WHY?   │ with too much    │┤      │ current receptionist     │
                └───────────────▶│ work on the      ││      │ staffing levels.         │
                                 │ department.      ││      └──────────────────────────┘
                                 └──────────────────┘│
                                                     │ WHY?  ┌──────────────────────────┐
                                                     └──────▶│ Lack a robust appointment│
                                                             │ management system,       │
                                                             │ causing difficulties in  │
                                                             │ optimizing the           │
                                                             │ appointment schedule.    │
                                                             └──────────────────────────┘
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Diagram 2: Grace Hospital Why- Why Diagram

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6.QUANTITATIVE ANALYSIS

Quantitative analysis refers to the use of numerical data and statistical methods to assess, measure, and analyze various aspects of business processes. This approach involves the systematic collection and interpretation of quantitative data to gain insights into the efficiency, effectiveness, and overall performance of a business process.

The Grace Hospital receives around 200 patients per day who will make a medical consultation in the orthopedics department. The department is open from 10:00 am to 6:00 pm every day, total 8 working hours every day.

6.1 PERFORMANCE MEASURE

The Performance Measure Process, a method within Quantitative Process Analysis, is employed to assess the performance of each activity within the process model. Process Performance encompasses key metrics such as Time (including processing time, waiting time, and cycle time efficiency), Cost (comprising tangible and intangible costs, like material and resource costs), Quality (measured by customer feedback and effective waiting rates), and Flexibility.

6.1.1 RESOURCES COST ANALYSIS

Since we cannot analyze material costs (such as paper prescriptions, database systems, etc.) during the process, we will perform resource cost analysis. The only resource cost information we have from Grace Hospital's orthopedics department is the salary per employee and the number of employees per procedure:

The department has 2 receptionists, 2 internal staff members, and 6 doctors, receiving each 1000€, 750€, and 2000€ respectively, which takes a total of 15500€ per month in salaries.

Breaking it down per hour, the cost is 4.16 euros per receptionist, 3.13 euros per internal staff member, and 8.33 euros per doctor.

$$\text{Employees Cost per month} = (\text{\# of Emplyee per Process} \times \text{Salary per Month})$$

$$= (2 \times 1000) + (2 \times 750) + (6 \times 2000) = 15500\text{€ p/month}$$

$$\text{Receptionist Hourly Cost} = \frac{\text{Monthly Salary}}{\text{Days p/Month} \times \text{Hours Worked p/ Day}} = \frac{1000}{30 \times 8} \approx 4.16\text{€ p/hour p/receptionist}$$

$$\text{Internal staff Hourly Cost} = \frac{\text{Monthly Salary}}{\text{Days p/Month} \times \text{Hours Worked p/ Day}} = \frac{750}{30 \times 8} \approx 3.13\text{€ p/hour p/internal staff}$$

$$\text{Doctor Hourly Cost} = \frac{\text{Monthly Salary}}{\text{Days p/Month} \times \text{Hours Worked p/ Day}} = \frac{2000}{30 \times 8} \approx 8.33\text{€ p/hour p/doctor}$$

Figure 6: Recepcionist, Internal Staff, and Doctor costs per hour

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6.1.2 FLOW ANALYSIS

Flow analysis is a family of techniques that allow us to assess the global performance of a process given some knowledge about the performance of its activities. Flow analysis can be used to compute the average cost of a process instance - knowing the cost-per-execution of each activity, - or the error rate of a process - given the error rate of each activity. But only works in structured models and with fixed arrival rates.

We will start with two simple measures: the Total Cycle Time and the Arrival Time. In the Call Patient and Make Consultation processes, we used the average time per patient as Cycle Time, since we don't have information about the cost time of each activity:

$$Mean\ arrival\ rate(\lambda) = \frac{Patients\ p/day}{Hours\ Open \times Minutes\ in\ an\ hour} = \frac{200}{8 \times 60} \approx 0.42\ Paients\ p/minute$$

$$Mean\ inter-arrival\ time = \frac{1}{\lambda} \approx 2.4 minutes$$

Figure 7: Mean arrival rate and Mean inter-arrival time of patient

Grace Hospital attends to an average of 200 patients daily during its eight-hour operational period. This translates to a patient arrival rate of 25 patients per hour or approximately 0.42 patients per minute. On average, one patient arrives every 2.4 minutes. The AS-IS model's lack of structure prevents the application of the Little Formula, and due to the limitations of queuing analysis, including basic theory models like m/m/1 and m/m/c, such analysis is not being applied in this case.

6.2 SIMULATION

Simulation is a quantitative process analysis technique used to enhance the existing process model (AS-IS). It involves exploring various What-If scenarios until an optimal state for one of the What-If processes is identified. This identified state is then utilized to build a future model (TO-BE).

6.2.1 PARAMETERS

Before diving into the Grace Hospital Simulation with the current AS-IS model, we first need to define the parameters for each event and sub-process in our AS-IS Level 1 model. This involves choosing suitable distributions based on the characteristics of each sub-process or event and specifying their values, such as mean, standard deviation, minimum, and maximum. Once that's done, we can assess the present performance of Grace Hospital, providing us with the final output of the AS-IS Model

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As we could see previously in the Flow Analysis, Grace Hospital is open from 10:00 am to 6:00 pm every day (8 hours per day), and receives 200 patients per day, with an arrival rate time of 2.40 minutes.

After choosing the distributions and determining the parameters for each sub-process and event, we decided to represent these values based on the estimated time for each process. To facilitate understanding, all values have been converted to minutes.

Events/Sub-Process	Distribution	Mean	Standard Deviaton	Maximum	Minimum
Receive Patient	Poisson	2.4 minutes	-	200 patients	-
Admission Process	Truncated Normal	2 minutes	1 minute	2.583 minutes	1.667 minutes
Wait for Doctor's Availability	Negative Exponential	10 minutes	-	-	-
Call Patient	Truncated Normal	0.5 minutes	0.05 minutes	10 minutes	0 minutes
Make Consultation	Negative Exponential	15 minutes	-	-	-
Finalize Consultation	Truncated Normal	2.5 minutes	1.5 minutes	5 minutes	1 minutes

Table 10: Distributions and Parameter Values of Grace Hospital AS-IS (Level 1)

In our worst-case scenario, where all entering patients are served, the process begins when a patient arrives at the hospital, for a total of 8 hours. With an expected average of around 200 patients per day, the arrival time is approximately 2.4 minutes. This specific event follows a Poisson distribution, as the probability of a patient arriving at any given moment is independent of the arrival of the previous patient

For every sub-process in Model AS-IS Level 1, we determined their distribution based on complexity and potential variation. The Admission Process, Call the Patient, and Finalize Consultation were assigned a Truncated Normal Distribution because these sub-processes involve repetitive tasks and are relatively straightforward.

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Finally, we opted for a Negative Exponential Distribution for the Make Consultation sub-process, considering the unpredictable nature of consultation times and the analytical nature of these activities.

Once the distributions were chosen for each sub-process and event, we specified a standard deviation, minimum, and maximum values based on the provided mean and our understanding of the process.

6.2.2 OUTPUT

Name	Type	Instances started	Instances completed	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Grace Hospital AS-IS Process	Process	200	195	32.49		1667.15
Receive Patient	Start event		200			
Admission Process	Task	200	200	5.12	2.97	594.40
Patient is admitted?	Gateway	200	200			
Patient Left Hospital	End event		21			
Wait for Doctor's Availability	Intermediate event	179	179			
Call Patient	Task	179	179	0.51	0.01	1.23
Make Consultation	Task	179	176	16.24	3.13	559.71
Patient payed immediately?	Gateway	176	176			
Patient Left Hospital	End event		15			
Finalize Consultation	Task	161	159	5.95	3.18	511.82
Patient Left Hospital	End event		159			

Table 11: Output of Simulation of Grace Hospital AS-IS Process (Level 1)

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Resource	Utilization
Receptionist	90.08%
Internal Staff	9.33%
Doctor	81.43%

Table 12: Output of Simulation of Grace Hospital AS-IS (Level 1) Resources Utilization

Observing the results of the AS-IS Grace Hospital Simulation (Level 1), it is evident that out of the 200 patients initially present, only 159 completed all required procedures. This implies a loss of 41 patients for various reasons:

- 21 patients left the hospital because they were not admitted;
- 3 patients skipped the consultation with the doctor;
- 15 patients did not pay immediately to the receptionist;
- 2 patients did not finalize the consultation process with the receptionist.

In terms of the average time for each sub-process, a patient undergoing the entire consultation process at Grace Hospital takes approximately 32.49 minutes:

- The average time of the admission process is 5.12 minutes;
- The average time of calling the patient is 0.51 minutes;
- The average appointment time with the doctor is 16.24 minutes;
- The average time to finalize the consultation is 5.95 minutes.

Concerning waiting times:

- 2.97 minutes for the admission process;
- 0.01 minutes to call a patient;
- 3.13 minutes for making the consultation;
- 3.18 minutes to finalize the consultation.

Notably, the sub-process that consumes the highest total waiting time is "make consultation" with 559.71 minutes, while the fastest is "call patient" with 1.23 minutes.

Analyzing resource utilization in the AS-IS (Level 1), it is evident that the receptionist role has the highest utilization at 90.08%. The doctor follows with a utilization rate of 81.43%, while the internal staff exhibits the lowest utilization across all processes, standing at 9.33%.

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6.2.3 FINAL IDEAS

After a comprehensive examination of the Grace Hospital AS-IS Simulation Process output and the corresponding resource utilization percentages, we arrived at important conclusions, particularly in terms of resource allocation and efficiency.

The utilization of Internal Staff stands at 9.33%, indicating a potential for optimization in this role within the process. In contrast, both Doctor and Receptionist utilizations exceed 80%, signaling a state of overutilization.

To address the underutilization of Internal Staff, several strategic options are available:

- Reallocation to other departments where their skills and capacities are more aligned;

- Enhance their workload within the current department;

- Dismiss internal staff elements (this option must be approached with careful consideration of overall organizational needs and the potential impact on employee morale).

Moreover, the overutilization of Doctors and Receptionists, coupled with substantial waiting times in key sub-processes, highlights a critical need for workload redistribution:

- Specifically, the Admission sub-process, with a waiting time of 594.40 minutes, and the Finalize Consultation sub-process, with 511.82 minutes, managed by the Receptionist, indicate potential bottlenecks.

- Additionally, the Make Consultation sub-process, handled by the Doctor and taking 559.71 minutes, states the overutilization of this role.

To achieve better outcomes for every patient and the overall process, a reevaluation of the resource allocation is imperative. This may involve reducing the workload on Doctors and Receptionists and redistributing certain responsibilities to the Internal Staff.

Such strategic adjustments aim to strike a balance in resource utilization, minimize waiting times, and enhance overall process efficiency.

6.3 WHAT IF ANALYSIS

After observing the outputs of the AS-IS Simulation, it is evident that improvements are necessary. To do that, we will conduct a What-If Analysis, which involves iterative attempts to optimize resource allocation. This approach allows for systematically exploring potential adjustments to identify the most effective configuration for the hospital's processes.

The process requires allocating resources (receptionist, doctor, and Internal Staff) to specific sub-processes to assess their impact on reducing waiting times, achieving lower average times in sub-processes, and optimizing resource utilization.

WHAT-IF SCENARIO 1

Given the low utilization of Internal Staff in the previous output, our initial What-If Scenario involves the removal of one Internal Staff member across all resources:

Name	Type	Instances started	Instances completed	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Grace Hospital AS-IS Process	Process	200	195	32.52		1672.42
Receive Patient	Start event		200			
Admission Process	Task	200	200	5.13	2.99	597.33
Patient is admitted?	Gateway	200	200			
Patient Left Hospital	End event		21			
Wait for Doctor's Availability	Intermediate event	179	179			
Call Patient	Task	179	179	0.56	0.06	10.81
Make Consultation	Task	179	175	16.25	3.10	554.79
Patient payed immediately?	Gateway	175	175			
Patient Left Hospital	End event		15			
Finalize Consultation	Task	160	159	5.94	3.18	509.48
Patient Left Hospital	End event		159			

Table 13: Scenario 1 Grace Hospital - Process Time and Waiting Time

Resource	Utilization
Receptionist	90.07 %
Internal Staff	18.66 %
Doctor	81.44 %

Table 14: Scenario 1 Grace Hospital - Resource Utilization

The outputs of Scenario 1 in the What-If Analysis, where we **reduced the number of Internal Staff resources by one**, provide valuable insights for the hospital. Having only one Internal Staff member yields very similar results compared to having two Internal Staff members dedicated to the Call Patient sub-process.

Examining the changes in the resource utilization before and after the adjustment:

- Recepcionist Utilization: **90.08%** → 90.07%;
- Internal Staff utilization: **9.33%** → 18.66%;
- Doctor Utilization: **81.43%** → 81.44%.

The increase in Internal Staff utilization is evident due to the staff reduction. Consequently, the remaining Internal Staff at Grace Hospital will experience a higher workload and utilization.

Observing the Process Time and Cycle in the Scenario 1 table, we find that the results are consistent with the previous output. The average time for all sub-processes remains very similar before and after the adjustment:

- Average time of overall Grace Hospital process: **32.49 minutes** → 32.52 minutes;
- Average time of the Admission Process: **5.12 minutes** → 5.13 minutes;
- Average time of Call Patients: **0.51 minutes** → 0.56 minutes;
- Average time of Make Consultation: **16.24 minutes** → 16.25 minutes;
- Average time of Finalize Consultation: **5.95 minutes** → 5.94 minutes.

Regarding the average waiting time before and after the adjustment:

- Average time waiting in the Admission Process: **2.97 minutes** → 2.99 minutes;
- Average time waiting in Call Patients: **0.01 minutes** → 0.06 minutes;
- Average time waiting in Make Consultation: **3.13 minutes** → 3.10 minutes;
- Average time waiting in Final Consultation: **3.18 minutes** → 3.18 minutes.

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In terms of Total Waiting Time before and after the adjustment:

- Total Waiting Time for the Grace Hospital process: **1667.15 minutes** → 1672.42 minutes;
- Total Waiting Time for the Admission Process: **594.40 minutes** → 597.33 minutes;
- Total Waiting Time for the Call Patient: **1.23 minutes** → 10.81 minutes;
- Total Waiting Time for Make Consultation: **559.71 minutes** → 554.79 minutes;
- Total Waiting Time for Finalize Consultation: **511.82 minutes** → 509.48 minutes (only 159 instances completed).

This indicates that the presence of Internal Staff is not a critical factor in the overall process, and the hospital may be incurring unnecessary salary costs for this role. Consequently, the analysis highlights that reducing Internal Staff does not significantly impact the reduction of processing time and waiting time for the majority of processes, except for the waiting time associated with the Call Patient sub-process.

WHAT-IF SCENARIO 2

In this analysis, we **introduced a new element by hiring an additional Receptionist**. This Receptionist is specifically responsible for handling the Call Patient sub-process, while our Internal Staff is redirected to assist in other sub-processes, excluding the Call Patient sub-process. This decision was made based on the belief that the Receptionist can perform tasks similar to those of the Internal Staff. The Receptionist's role includes monitoring the doctor's availability in the system and allowing patients to proceed to the doctor's office. We anticipate seeing incremental improvements with this adjustment.

Name	Type	Instances started	Instances completed	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Grace Hospital AS-IS Process	Process	200	196	25.53		269.73
Receive Patient	Start event		200			
Admission Process	Task	200	200	2.36	0.21	42.49
Patient is admitted?	Gateway	200	200			
Patient Left Hospital	End event		21			
Wait for Doctor's Availability	Intermediate event	179	179			
Call Patient	Task	179	179	0.84	0.34	60.24
Make Consultation	Task	179	176	13.77	0.70	124.68
Patient payed immediately?	Gateway	176	176			
Patient Left Hospital	End event		15			
Finalize Consultation	Task	161	160	3.00	0.26	42.33
Patient Left Hospital	End event		160			

Table 15: Scenario 2 Grace Hospital - Process Time and Waiting Time

Resource	Utilization
Receptionist	63.89 %
Internal Staff	85.59 %
Doctor	68.90 %

Table 16: Scenario 2 Grace Hospital - Resource Utilization

After analyzing the outcomes of Scenario 2, significant improvements are evident across all metrics compared to Scenario 1. The only exception is the Call Patient sub-process, where utilizing Internal Staff for the Admission and Finalize Consultation sub-processes may have impacted Call Patient outcomes, now handled by the Receptionist. Consequently, improvements in other sub-processes are slightly less pronounced for Call Patients.

Examining resource utilization before and after:

- Receptionist Utilization: 90.07% → 63.89%;
- Internal Staff utilization: 18.66% → 85.59%;
- Doctor Utilization was 81.44% → 68.90%;

Receptionist utilization decreases as Internal Staff now assists with their tasks, while Internal Staff utilization increases due to additional responsibilities in the Admission Process, Finalize Consultation, and Make Consultations with the Doctor. Doctor utilization decreases as Internal Staff support is introduced.

Analyzing Process Time and Cycle Time in Scenario 2, notable differences from Scenario 1 are observed.

Regarding average time before and after:

- Average time of Grace Hospital process: **32.52 minutes** → 25.53 minutes;
- Average time of the Admission process: **5.13 minutes** → 2.36 minutes;
- Average time of Call Patients: **0.56 minutes** → 0.84 minutes;
- Average time of Make Consultation: **16.25 minutes** → 13.77 minutes;
- Average time of Finalize Consultation: **5.94 minutes** → 3 minutes.

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Observing the average waiting time before and after:

- Average time waiting in the Admission Process: **2.99 minutes** → 0.21 minutes;
- Average time waiting in Call Patients: **0.06 minutes** → 0.34 minutes;
- Average time waiting in Make Consultation: **3.10 minutes** → 0.70 minutes;
- Average time waiting in Final Consultation: **3.18 minutes** → 0.26 minutes.

Analyzing the Total Waiting Time before and after:

- Total Waiting Time for the Grace Hospital process: **1672.42 minutes** → 269.73 minutes;
- Total Waiting Time for the Admission Process: **597.33 minutes** → 42.49 minutes;
- Total Waiting Time for the Call Patient: **10.81 minutes** → 60.24 minutes;
- Total Waiting Time for Make Consultation: **554.79 minutes** → 124.68 minutes;
- Total Waiting Time for Finalize Consultation: **509.49 minutes** → 42.33 minutes (only 160 instances completed).

Regarding efficiency, the incremental cost of 250 euros, incurred by reallocating one internal staff member to the receptionist role, results in slight improvements in waiting and processing times for various activities and resources. This strategic investment aims to boost patient satisfaction and enhance the overall quality of hospital services.

WHAT-IF SCENARIO 3

In Scenario 3, our analysis involves the hiring of only one additional doctor specifically assigned to the Make Consultation sub-process. This strategic decision is aimed at minimizing waiting times associated with this particular resource.

Name	Type	Instances started	Instances completed	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Grace Hospital AS-IS Process	Process	200	196	24.96		156.84
Receive Patient	Start event		200			
Admission Process	Task	200	200	2.36	0.21	42.37
Patient is admitted?	Gateway	200	200			
Patient Left Hospital	End event		21			
Wait for Doctor's Availability	Intermediate event	179	179			
Call Patient	Task	179	179	0.80	0.30	53.52
Make Consultation	Task	179	176	13.20	0.14	24.31
Patient payed immediately?	Gateway	176	176			
Patient Left Hospital	End event		15			
Finalize Consultation	Task	161	160	2.96	0.23	36.65
Patient Left Hospital	End event		160			

Table 17: Scenario 3 Grace Hospital - Process Time and Waiting Time

Resource	Utilization
Receptionist	63.87 %
Internal Staff	85.21 %
Doctor	59.12 %

Table 18: Scenario 3 Grace Hospital - Resource Utilization

Regarding the resource utilization before and after:

- Receptionist Utilization: **63.89%** → 63.87%;
- Internal Staff utilization: **85.59%** → 85.21%;
- Doctor Utilization was **68.90%** → 59.12%;

We observe similar utilization rates for Receptionists and Internal Staff in Scenario 2 and Scenario 3, as we have only hired one additional doctor who does not contribute to the tasks of Internal Staff and Receptionists. In terms of Doctor utilization, there is a decrease due to the hiring of a new doctor. Reviewing the Process Time and Cycle of Time table for Scenario 3, we find results comparable to those of Scenario 2.

The average times before and after the changes are as follows:

- Average time of Grace Hospital process: **25.53 minutes** → 24.96 minutes;
- Average time of the Admission Process: **2.36 minutes** → 2.36 minutes;
- Average time of Call Patients: **0.84 minutes** → 0.80 minutes;
- Average time of Make Consultation: **13.77 minutes** → 13.20 minutes;
- Average time of Finalize Consultation: **3 minutes** → 2.96 minutes.

In terms of average waiting times before and after the adjustments:

- Average time waiting in the Admission Process: **0.21 minutes** → 0.21 minutes;
- Average time waiting in Call Patients: **0.34 minutes** → 0.30 minutes;
- Average time waiting in Make Consultation: **0.70 minutes** → 0.14 minutes;
- Average time waiting in Final Consultation: **0.26 minutes** → 0.23 minutes.

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Concerning the Total Waiting Time before and after the adjustments:

- Total Waiting Time for the Grace Hospital process: **269.73 minutes** → 156.84 minutes;
- Total Waiting Time for the Admission Process: **42.49 minutes** → 42.37 minutes;
- Total Waiting Time for the Call Patient: **60.24 minutes** → 53.52 minutes;
- Total Waiting Time for Make Consultation: **124.68 minutes** → 24.31 minutes;
- Total Waiting Time for Finalize Consultation: **42.33 minutes** → 36.65 minutes (only 160 instances completed).

After the analysis, it becomes evident that we have effectively reduced waiting times, particularly for the resources involved in the "Make Consultation" by the Doctor. The final results in waiting and processing times are notably improved. However, it is important to note that the added cost of hiring a doctor for Grace Hospital in Scenario 3 is significantly higher, amounting to an extra 2250 Euros per month compared to Scenario 2, which achieves nearly identical results. Therefore, after evaluating these three If-Scenarios, we conclude that Scenario 2 yields better results.

7. PROCESS REDESIGN

Process redesign is the purposeful restructuring of current business processes to boost efficiency, effectiveness, and overall performance. It involves rethinking how tasks are carried out, and transitioning from the existing AS-IS model to a desired TO-BE model. This strategic approach aligns business processes with organizational goals, adapts to change, and leverages technology for optimal results.

7.1 SOLUTIONS & HEURISTICS

In the existing process, automation is an excellent method to solve issues involving self-service development, information system optimization, and data sharing.

Starting with the admission process, the hospital can improve patient experience by providing estimated waiting times and queue information. Streamlining the ticket system is a logical step. When patients obtain a ticket, they can input essential information, such as their name, desired department, and phone number. Afterward, the patient receives a mobile notification when it's their turn. To ensure efficiency, patients must arrive at the reception within a specified time. If they fail to do so, they will need to obtain a new ticket.

According to the description of the admission process, 8% of patients come to the hospital on the wrong day. Implementing an appointment system can solve this problem. This system would display available days and times for appointments, sending reminders to patients one day in advance.

The hospital can also enhance efficiency by implementing automation in the admission process. Instead of relying on a receptionist or an internal staff member to call patients, an **automated system, such as SMS notifications or a display screen, can inform patients when it's their turn.** This reduces waiting and admission times, though initial automation costs should be considered against long-term savings. We must keep in mind that automation means a certain loss of flexibility in the process.

Task elimination, coupled with automation, can further improve efficiency. In processes like Make Consultation and Finalize Consultation, tasks involving paper documents can be eliminated (Printing Prescription, Asking Patients about the need for a paper Prescription, and Deliver Prescriptions), cutting costs and speeding up consultations. However, this may impact the quality of the patient experience.

To address delays caused by paper prescriptions, a digital prescription system can be implemented. Patients can access paper prescriptions through self-service machines by entering personal information. Automation ensures this information is available across all departments, eliminating the need for doctors to print every prescription during the consultation and for patients to carry paper prescriptions to do medical exams. Moreover, automating the process of getting certain documents, like justifications, will save the hospital money on supplies and reduce waiting times during the Finalize Consultation task.

In resource optimization, the Call Patient process can benefit from removing the receptionist's manual calling and directing tasks, and replacing them with an automated system. Categorizing doctors into emergency and regular roles helps manage treatment time effectively. This optimization improves time and cost management without compromising service quality. In addition, the flexibility will improve.

Issue	Sub-Process	Heuristics	Time	Cost	Quality	Flexibility
Uncertainty of Waiting Time	Admission Process	Automation	improves	Decreases (Long-Term)	No Affects	Decreases
Unnecessary tasks of receptionist	Call Patient	Automation	Improves	Decreases (Long-Term)	No Affects	Decreases
Low efficiency because of delivering paper documents	Make Consultation; Finalize Consultation	Task Elimination	improves	Decreases	Decreases	Improves
Patient can't be treated on time	Call Patient	Resource Optimization	improves	Decreases	No Affects	Improves

Table 19: Heuristics Solutions Grace Hospital
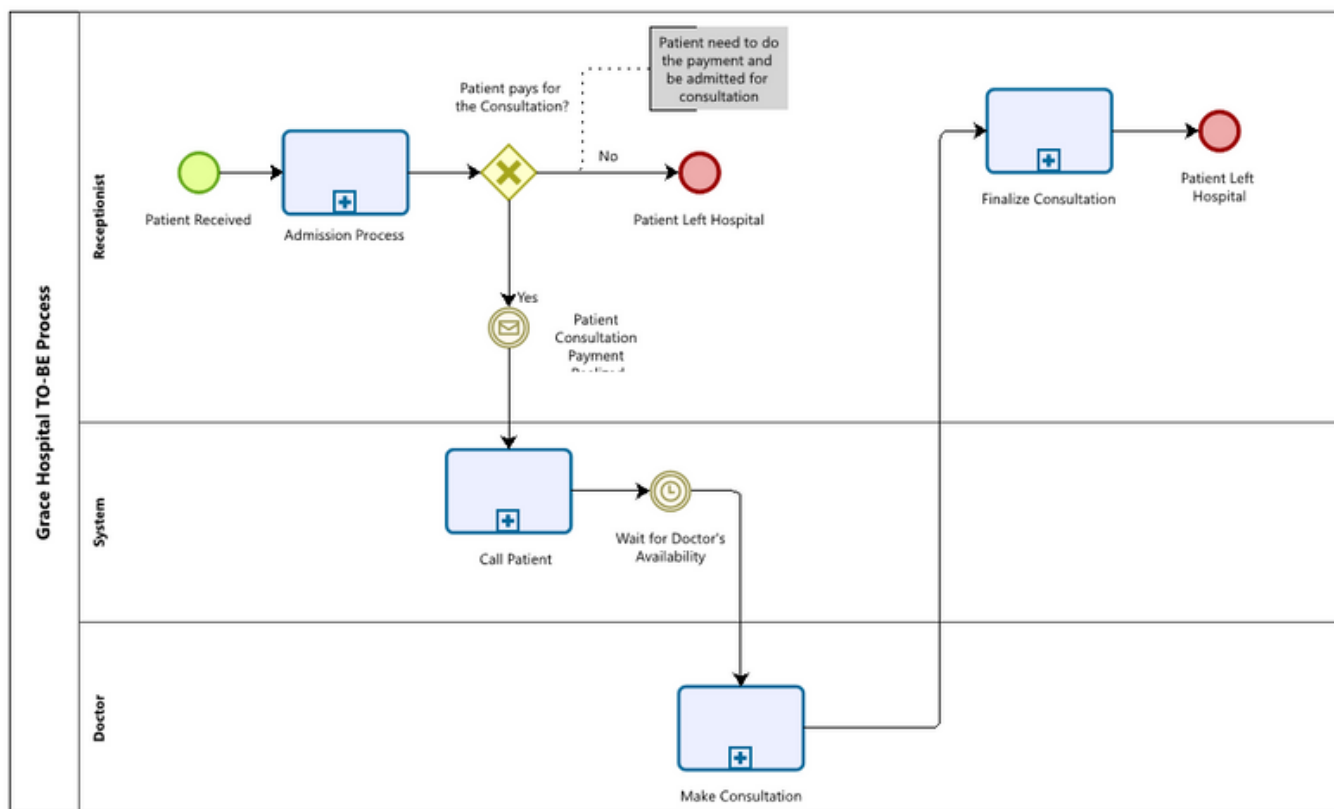
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7.2 TO BE PROCESS

Figure 8: Grace Hospital Overall TO-BE (Process Level 1)

In our conceptualization of the TO-BE model, we consider the worst-case scenario, addressing delayed payments and overprocessing issues.

The process initiates with the patient being received by the Receptionist, who registers and admits them, charges the consultation fee, and then branches into two paths:

- In 10% of cases, the patient doesn't pay or cannot afford the payment, leading them to leave the hospital.

- In the remaining 90%, the patient pays, gets admitted, and the system updates their payment status, displaying the estimated waiting time for the doctor on the Reception Screen.

After waiting, the patient is received by the doctor for consultation. Post-consultation, the receptionist provides necessary documents, reschedules appointments if needed, and the patient leaves the hospital.
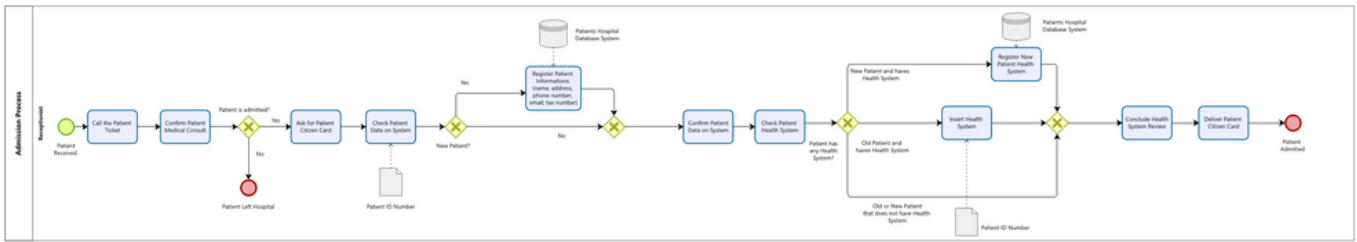
7.2.1 ADMISSION SUB-PROCESS

Figure 9: Admission Process TO-BE (Process Level 2)

The TO-BE Admission Process is very similar to the AS-IS Admission Process. The receptionist initiates the process by receiving the patient and using a system to call for the patient's ticket, displayed on the Reception Screen. After calling for the patient, the receptionist confirms the medical consultation using either the hospital system, email or paper confirmation).

If the patient is not admitted (indicating they came on the wrong day), they are advised to leave and return on the correct day. If admitted, the receptionist proceeds by asking for the citizen card, registering patient information (name, address, phone number, email, and tax number), and confirming if the patient is new (25% of cases) or not (75% of cases). In the case of a new patient, the receptionist registers detailed information. The subsequent steps depend on the patient's health system status:

1. New patient with a health system: Register health system information in the hospital system.

2. Returning patient with a health system: Insert the patient ID and health system details into the system (90% probability for these scenarios).

3. Patient, new or returning, without a health system: No need for system entry.

After handling health system scenarios, the receptionist returns the citizen card to the patient, completing the admission process. All these steps are carried out by the receptionist

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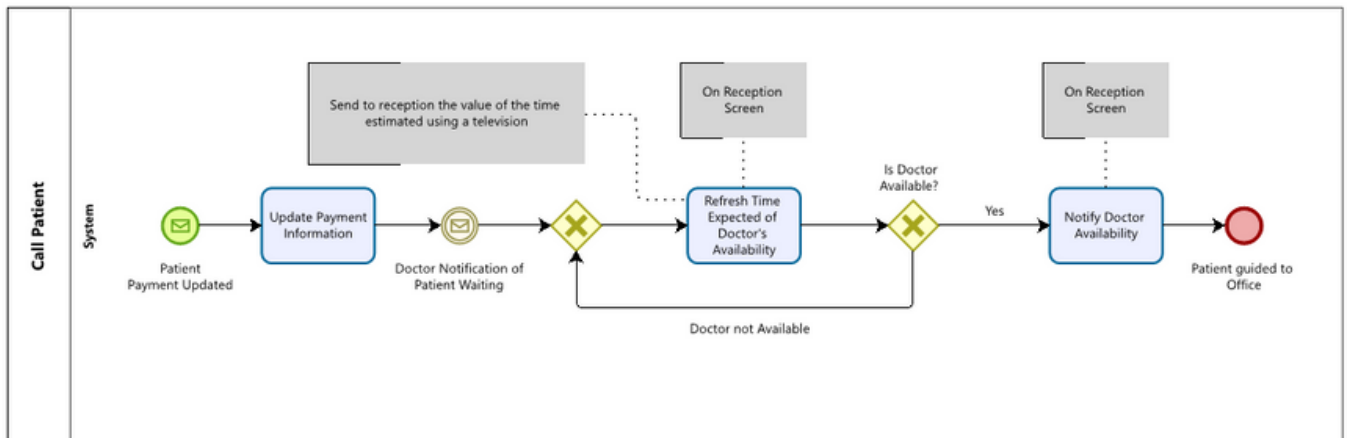
7.2.2 CALL PATIENT SUB-PROCESS

Figure 10: Call Patient Process TO-BE (Process Level 2)

The Call Patient sub-process is initiated by the system upon receiving payment from the patient. The system updates the patient's payment information and issues a notification for the patient who has paid and is awaiting doctor services in the reception area. In scenarios where the doctor is not immediately available, the system displays an average wait time on the reception screen. When the doctor becomes available, they inform the system, triggering a notification on the reception screen for the patient to proceed to the respective doctor's office. This entire sub-process is executed by the system.

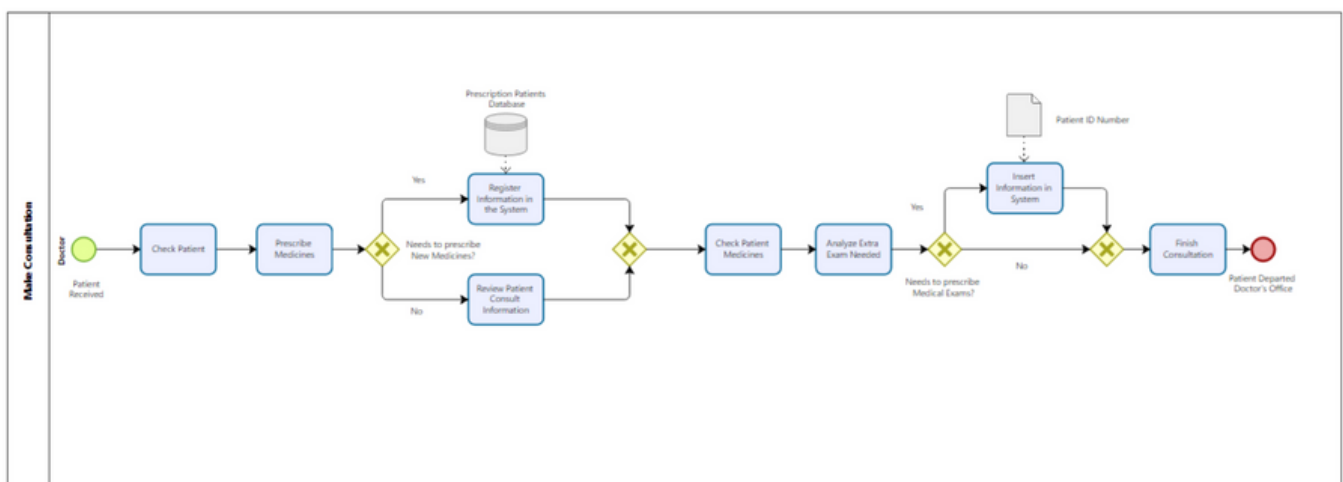## 7.2.3 MAKE CONSULTATION SUB-PROCESS

Figure 11: Make Consultation Process TO-BE (Process Level 2)

After receiving the notification from the Call Patient sub-process, the Make Consultation sub-process begins with the doctor examining the patient. In this sub-process, there are two possible scenarios:

- in 10% of cases, the doctor reviews the patient's information without prescribing new medicines;

- in 90% of cases, the doctor prescribes new medicines and registers the information in the system. Notably, the doctor no longer prints prescriptions and medical exams, as this is considered a motion waste; instead, these documents are virtually delivered by the receptionist.

Following the prescription of new medicines, the doctor assesses whether additional medical exams are necessary, resulting in two scenarios:

- If medical exams are required (40% of cases), the doctor registers the information in the System;

- If no medical exams are needed (60% of cases), the doctor concludes the consultation, and the patient leaves the doctor's office.

The entire sub-process is conducted by the doctor.

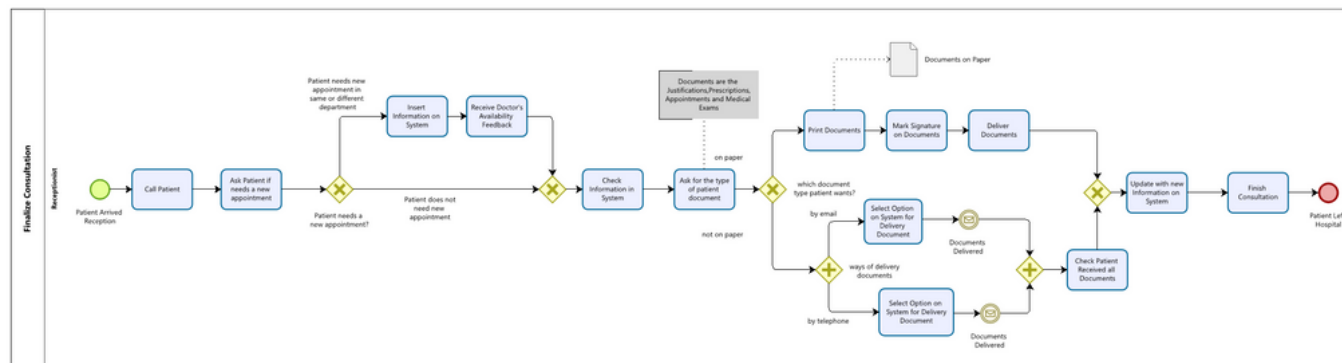## 7.2.4 FINALIZE CONSULTATION SUB-PROCESS

Figure 12: Finalize Consultation Process TO-BE (Process Level 2)

After the patient leaves the doctor's office, the Finalize Consultation sub-process starts with the patient returning to the reception, where the receptionist attends to them.

The receptionist initiates the process by calling for the patient's ticket through the system, visible on the Reception Screen. Subsequently, the receptionist inquires whether the patient requires a new appointment, leading to two paths. If the patient needs a new appointment in the same or a different department, the receptionist enters the information into the system, checks the doctor's availability, selects an available slot, and schedules the future appointment. If the patient does not want a new appointment, no further action is required.

The receptionist verifies the information in the system and then asks the patient about their preferred method of receiving documents (justifications, prescriptions, appointments, and medical exams), providing three options: by email, telephone SMS, or paper for those not using technology.

This leads to three possible scenarios. If the patient prefers receiving documents on paper, the receptionist prints, signs, and physically delivers the documents. If the patient prefers electronic delivery (email or telephone), the receptionist selects the respective option in the system, ensuring virtual document delivery. After document delivery, the receptionist updates the system, concludes the process, and the patient leaves the hospital. The entire sub-process is performed by the receptionist.

7.3 TO-BE PARAMETERS

After carefully selecting the distributions and parameter values for each sub-process and event, we decided to align these values with the estimated times from the AS-IS model. This strategic choice helps us to assess the feasibility and benefits of implementing a system to replace the Internal Staff, requiring minimal alterations to the existing values. The primary modification in our TO-BE model, compared to the AS-IS model, involved introducing the event "Patient Consultation Payment Realized." Furthermore, to ensure consistency and comparability, all values were scaled to minutes for their respective parameters

Events/Sub-Process	Distribution	Mean	Standard Deviaton	Maximum	Minimum
Receive Patient	Poisson	2.4 minutes	-	200 patients	-
Admission Process	Truncated Normal	2 minutes	1 minute	1.667 minutes	2.583 minutes
Patient Consult Payment Realized	Truncated Normal	0.5 minutes	0.05 minutes	0.3 minutes	1 minute
Wait for Doctor's Availability	Negative Exponential	10 minutes	-	-	-
Call Patient	Truncated Normal	0.5 minutes	0.05 minutes	10 minutes	0 minutes
Make Consultation	Negative Exponential	15 minutes	-	-	-
Finalize Consultation	Truncated Normal	2.5 minutes	1.5 minutes	5 minutes	1 minute

Table 20: Distributions and Parameter Values of Grace Hospital TO-BE (Level 1)

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7.4 TO-BE SIMULATION OUTPUT

Name	Type	Instances started	Instances completed	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Grace Hospital TO-BE Process	Process	200	188	30.16		313.59
Patient Received	Start event		200			
Admission Process	Task	200	198	2.71	0.59	118.59
Patient pays for the Consult?	Gateway	198	198			
Patient Left Hospital	End event		21			
Patient Consult Payment Realized	Intermediate event	177	177			
Call Patient	Task	177	176	0.52	0.02	3.8
Wait for Doctor's Availability	Intermediate event	176	174			
Make Consultation	Task	174	168	15.55	0.36	62.02
Finalize Consultation	Task	168	167	3.54	0.77	129.19
Patient Left Hospital	End event		167			

Table 21: Output of Simulation of Grace Hospital TO-BE Process (Level 1)

Resource	Utilization
Receptionist	75.28 %
Internal Staff	88.53 %
Doctor	66.98 %
System	18.39 %

Table 22: Output of Simulation of Grace Hospital TO-BE (Level 1) Resources Utilization

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Before doing the quantitative analysis, it's crucial to highlight a key change in the resources of Grace Hospital. We replaced Internal Staff resources with a System in the Call Patient sub-process. However, we retained the two Internal Staff members to support the remaining sub-processes within the Hospital. This strategic adjustment allows us to closely examine the implications of introducing a System to handle the Call Patient sub-process, observing its impact on efficiency and performance.

Observing the results of the Simulation of the TO-BE Grace Hospital (Level 1), we can conclude that, from the 200 patients that we had in the hospital, only 167 patients finalized all procedures. This means that we lost 33 patients:

- 2 patients left the hospital because they were not admitted;
- 21 patients did not pay immediately to the receptionist;
- 1 patient didn't go to the consultation with the doctor because of the system;
- 2 patients did not wait for the doctor's availability;
- 6 patients didn't go to the consultation with the doctor;
- 1 patient did not finalize the consultation with the receptionist.

Concerning the average time of all sub-processes we can conclude that a patient who goes through all of the steps of the consultation process at Grace Hospital takes 30.16 minutes:

- The average time of the admission process is 2.71 minutes;
- The average time of calling the patient is 0.52 minutes;
- The average time for an appointment with the doctor is 15.55 minutes;
- The average time to finalize consultation is 3.54 minutes.;

Regarding the waiting average time:

- 0.59 minutes for the admission process;
- 0.02 minutes to call a patient;
- 0.36 minutes for making the consultation;
- 0.77 minutes to finalize the consultation.

Finally, the sub-process that consumed the most total waiting time was the "finalize consultation" with 129.19 minutes, while the quickest was the "call patient" with 3.8 minutes.

Analyzing the resource utilization results of the AS-IS Grace Hospital (Level 1), it is evident that the Internal Staff is the most utilized role in all processes, accounting for 88.53% of utilization. Following that, the receptionist has a utilization rate of 75.28%, followed by the Doctor with 66.98%. The System exhibits the lowest utilization across all processes, standing at 18.39%.

7.5 TO-BE VS AS-IS

Name	Type	Instances started	Instances completed	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Grace Hospital AS-IS Process	Process	200	195	32.49		1667.15
Receive Patient	Start event		200			
Admission Process	Task	200	200	5.12	2.97	594.40
Patient is admitted?	Gateway	200	200			
Patient Left Hospital	End event		21			
Wait for Doctor's Availability	Intermediate event	179	179			
Call Patient	Task	179	179	0.51	0.01	1.23
Make Consultation	Task	179	176	16.24	3.13	559.71
Patient realized immediately the payment?	Gateway	176	176			
Patient Left Hospital	End event		15			
Finalize Consultation	Task	161	159	5.95	3.18	511.82
Patient Left Hospital	End event		159			

Table 23: Output of Simulation of Grace Hospital AS-IS Process (Level 1)

Name	Type	Instances started	Instances completed	Avg. time (m)	Avg. time waiting for resource (m)	Total time waiting resource (m)
Grace Hospital TO-BE Process	Process	200	188	30.16		313.59
Patient Received	Start event		200			
Admission Process	Task	200	198	2.71	0.59	118.59
Patient pays for the Consult?	Gateway	198	198			
Patient Left Hospital	End event		21			
Patient Consult Payment Realized	Intermediate event	177	177			
Call Patient	Task	177	176	0.52	0.02	3.8
Wait for Doctor's Availability	Intermediate event	176	174			
Make Consultation	Task	174	168	15.55	0.36	62.02
Finalize Consultation	Task	168	167	3.54	0.77	129.19
Patient Left Hospital	End event		167			

Table 24: Output of Simulation of Grace Hospital TO-BE Process (Level 1)

Resource	Utilization
Receptionist	90.08%
Internal Staff	9.33%
Doctor	81.43%

Table 25: Output of Simulation of Grace Hospital AS-IS (Level 1) Resources Utilization

Resource	Utilization
Receptionist	75.28 %
Internal Staff	88.53 %
Doctor	66.98 %
System	18.39 %

Table 26: Output of Simulation of Grace Hospital TO-BE (Level 1) Resources Utilization

Regarding the resource utilization in AS-IS and in TO-BE:

	AS-IS	TO-BE
Receptionist Utilization:	90.08% →	75.28%;
Internal Staff utilization:	9.33% →	88.53%;
Doctor Utilization:	81.43% →	66.98%;
System Utilization:	-------- →	18.39%;

Now, observing the Process Time and Cycle of Time of the table of AS-IS, we can understand that we had different results from the TO-BE.

Regarding average time in AS-IS and in TO-BE:

	AS-IS	TO-BE
Average time of Grace Hospital:	32.49 minutes →	30.16 minutes;
Average time of the Admission Process:	5.12 minutes →	2.71 minutes;
Average time of Call Patients:	0.51 minutes →	0.52 minutes;
Average time of Make Consultation:	16.24 minutes →	15.55 minutes;
Average time of Finalize Consultation:	5.95 minutes →	3.54 minutes.

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Regarding the average time waiting in AS-IS and TO-BE:

	AS-IS	TO-BE:
Average time waiting in the Admission Process:	2.97 minutes →	0.59 minutes;
Average time waiting in Call Patients:	0.01 minutes →	0.02 minutes;
Average time waiting in Make Consultation:	3.13 minutes →	0.36 minutes;
Average time waiting in Final Consultation:	3.18 minutes →	0.77 minutes.

Regarding Total Time waiting in AS-IS and TO-BE:

	AS-IS	TO-BE:
Total Time waiting for the Grace Hospital process:	1667.25 minutes →	313.59 minutes;
Total Time waiting for the Admission Process:	594.40 minutes →	118.59 minutes;
Total Time waiting for the Call Patient:	1.23 minutes →	3.8 minutes;
Total Time waiting for Make Consultation:	559.71 minutes →	62.02 minutes;
Total Time waiting for Finalize Consultation:	511.82 minutes →	129.19 minutes

(only 160 instances completed).

Based on the analysis of TO-BE and AS-IS results, it is evident that implementing a system for the Call Patient subprocess is a favorable decision. The automation in this subprocess contributes to overall process efficiency, especially when considering the redistribution of Internal Staff to support other subprocesses. This approach enhances the performance of Grace Hospital, making it a more effective and streamlined operation.

8. FINANCIAL ANALYSIS

Alteration	Expected Effect	Cost/Gain
Device Implementation (Hospital HealthCare Medical Self-Service Kiosk) Hongzhou CO.,LT	Increase cost in short term, but decrease in the long term	$9500 One-time (10 devices for the hospital)
System Implementation (patient scheduling system) Booknetic CO.,LT	Increase cost in short term, but decrease in the long term	$79 One-time
Dismissing 1 Internal Staff	Decrease Costs	$750 per month
Reduction of Prints and paper	Decrease Costs	---

Table 27: Financial Analysis

For each of the Solutions & Heuristics mentioned above, we conduct Financial Analysis.

1) To tackle the issue of patients arriving at the wrong time, the implementation of Booknetic's patient scheduling system proves to be a cost-effective solution. This software, obtained at a one-time fee of $79, not only significantly reduces the number of patients with incorrect appointment times but also enhances the overall efficiency of the hospital's Admission Process. With built-in functions such as reminders, multi-booking features, and waiting lists, the software ensures a seamless patient experience. The potential value is substantial, as it is estimated to decrease the number of patients with wrong appointment times by 8% per day, equivalent to 16 patients (based on a daily intake of 200 patients)

2) In the Admission Process and Call Patient subprocesses, the integration of the Hospital HealthCare Medical Self-Service Kiosk, provided by Hongzhou, offers a more automated approach. These kiosks, priced at $950 each, are designed to replace one internal staff member. Through mobile phone text messages and loudspeakers, patients can efficiently obtain tickets and go to the relevant doctor's office.

In Scenario 2, where one internal staff member is dismissed, the hospital achieves a total monthly saving of $750. Despite an initial monthly increase in costs ($8,829 - 950*10 + 79 - 750) due to the acquisition of kiosks and scheduling software, the long-term benefits become evident.

Over a span of one year and two months, the dismissal of one internal staff member results in a total saving of $10,500 (750*14). Taking into account the costs of purchasing the kiosks and scheduling software, the net financial benefit amounts to $9,579 (950*10+79).

$$Return\ on\ Investment(ROI) = \left(\frac{Amount\ Gained\ -\ Amount\ spent}{Amount\ Spent} \right) \times 100 = \left(\frac{(750 \times 14) - (9500 + 79)}{9579} \right) \times 100 = 9.61\%$$

Table 28: Return on Investment (ROI)

Considering the conventional benchmark of an annual ROI of 7% or higher as a favorable investment, the proposed solutions for Grace Hospital exhibit not only financial viability but also potential hidden benefits. The implementation of a patient scheduling system not only addresses appointment-related issues but also contributes to increased efficiency and serves more "effective" patients.

3) In the Make Consultation and Finalize Consultation sub-processes, the integration of Self-Service Kiosks introduces further efficiency gains. Allowing patients to print prescriptions independently is anticipated to decrease paper costs and streamline the overall process.

In summary, the adoption of a patient scheduling system and the incorporation of Self-Service Kiosks emerge as pragmatic and economically advantageous measures. These actions not only cut down costs for the hospital but also elevate operational efficiency, aligning with the hospital's goals.

9. CONCLUSION

After finishing the analysis of the current Grace Hospital attendance of their Patients we can conclude that the company must improve its actual process. Although it can be costly, we strongly believe it will be a great investment.

To address the prevailing issues in the existing processes, such as patient check-in, doctor appointments, prescription handling, and administrative tasks, we propose strategic enhancements.*

Our recommendations include optimizing resource allocation, fostering improved communication channels between receptionists and doctors, and introducing software solutions for device implementation and scheduling. These changes aim to automate the processes, mitigate human errors, enhance communication, and foster sustainability within Grace Hospital. By streamlining operations, the hospital becomes more efficient, expedient, and environmentally conscious. Furthermore, these alterations are anticipated to elevate patient and employee satisfaction, potentially resulting in increased hospital consultations.

The implementation of this new approach is designed not only to address existing challenges but also to model various pathways an order can follow, ensuring a holistic and comprehensive solution.

10. LIMITATIONS

The development of the new business process faced certain limitations primarily due to the lack of detailed information on the existing process. We made assumptions that may not accurately reflect the real-time or cost implications.

Additionally, constraints related to the implementation of new ideas posed challenges to the success of our proposed process. These constraints encompassed the time requirements for new activities, adjustments in duration for modified processes, and the overall cost implications associated with each change.

The successful integration of software solutions, a key element in our proposal, remains subject to exploration and is dependent on the company's preferences and beliefs regarding the most suitable software.

Furthermore, limitations in testing were notable as we relied on simulations without direct real-world validation

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- Patient goes to the receptionist desk; Internal Staff directs patient to doctors office, Doctor prints medicine prescription and /or exam prescription and gives it to patient, Receptionist prints and delivers work/school justification, appointment information, invoice, etc to patient, Patient goes to another department to book new appointment, Patient waits to be called for admission, Patient waits to be called and directed to the doctors office, Patient waits to be called for payment, Receptionist waits for patient to arrive after calling the ticket, Internal Staff waits for doctor availability, Receptionist has to call patient again for admission when he leaves the department, Doctor is called for emergencies, the appointments take longer than expected, the doctor is late, or the patient arrives late, Patient leaves without paying, Patient not admitted (after asking for citizen card and registering info. in the system), Receptionist marks prescription with hospital signature , Receptionist asking again for citizen card in order to make new appointment, Patient not admitted (after asking for citizen card and registering info. in the system), Receptionist asking again for citizen card in order to make new appointment, Patient not admitted (after asking for citizen card and registering all the info in the system) of the employees and patients dissatisfaction and excessive use of paper.

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