BUSINESS PROCESS MANAGEMENT

MASTER DEGREE PROGRAM IN DATA SCIENCE AND ADVANCED ANALYTICS – MAJOR IN BUSINESS ANALYTICS

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1. Introduction

Caring Pharmacy is a well-known pharmacy in Portugal. This pharmacy is opened in Lisbon, Porto, Faro, Coimbra, Santarém, Torres Vedras, Braga, and Évora and it was founded in 1998. Nowadays, Caring pharmacy employs more than 80 people in several divisions.

The procedure of attending consumers will be the emphasis of this project. Customer and staff unhappiness, as well as an inability to handle part of the work, prompted the top managers to examine their processes to solve these challenges and increase efficiency.

Knowing all problems raised by Caring Pharmacy to our team, in this project, we will understand, model, analyse and redesign Caring Pharmacy Order-to-Cash (O2C) process, by making use of our knowledge about Business Process Management (BPM) and business processes. This framework will be addressed with the help of Bizagi Modeler, a software tool which uses BPM Notation (BPMN) to “create, interpret, and optimize workflow diagrams” and business processes, improving “organizational efficiency by eliminating unforeseen bottlenecks and identifying process improvement opportunities through Process Simulation.” [1]

2. Background

Being this project developed in the scope of the Business Process Management course, it is important to understand and state what this subject is about. “Business Process Management (BPM) is a discipline involving any combination of modelling, automation, execution, control, measurement and optimization of business activity flows, in support of enterprise goals, spanning systems, employees, customers and partners within and beyond the enterprise boundaries.” [2] Therefore, BPM is a discipline which tries to modify step by step and improve a business process, such as the Caring Pharmacy's Order-to-Cash process.

Additionally, it is also fundamental to perceive what is a business process in order to better understand the objective of this project. “A business process is a collection of linked tasks which find their end in the delivery of a service or product to a client. A business process has also been defined as a set of activities and tasks that, once completed, will accomplish an organizational goal.” [3]

Furthermore, being the analysis, modelling and redesign of an Order-to-Cash (O2C) process the main goals for this project, we also have to bear in mind the definition of an Order-to-Cash process. The O2C consists in four main steps: Order Management, Order Fulfillment and Shipping, Invoice Generation and Payment, as well as Account Receivables and Reporting:

- **Order Management:** When the system receives an order from a client, the Order-to-Cash cycle begins with the Order Management step. The order can take several forms, including an online order from a consumer directly on your website or an email sent to the sales staff.
- **Order Fulfillment and Shipping:** This stage of the O2C applies more to organizations that deal with physical items, where inventory workers should be advised of the order's exact specifics so that fulfillment and shipment may begin. This might entail allowing access to the product or service for which the order is placed in the case of digital services or Software as a Service (SaaS).
- **Invoice Generation and Payment**: In this stage, the consumer should get an order invoice that contains the whole order's data as separate line items, as well as supplementary information such as taxes and discounts, if appropriate. The consumer should also be able to pay the invoice that has been raised. In order to avoid delays and payment failures, it is important to offer several payment choices.
- **Account Receivables and Reporting:** At the end stage of the O2C, the payment is documented in the company’s accounting records as part of the accounts receivable against the raised order, being the process completed.

Bearing the definitions of BPM and business process in mind, our team is able to know how to attain the Caring Pharmacy’s goals which were proposed to us.

The process of attending clients is the subject of this Business Process Management (BPM) project, where its main aim is to redesign the Caring Pharmacy's Order-to-Cash process, since there are some issues within itself which must be solved. For instance, during working hours, an employee is unable to attend all clients and must make additional time to service them or does not attend them at all, rework due to poor process design or even handovers that generates inefficiency. Consequently, the aforementioned issues prompted senior executives to rethink and analyse their present Order-to-Cash in order to become more effective and having the challenges previously mentioned solved.

3. AS-IS Business Process Description

3.1 Receive Client

The Order-to-Cash process starts when the customer arrives at the pharmacy. Right after, the technician requests the order to the customer, which might have medical prescription or not. If he/she has, the customer shows the medical prescription, sent by phone message or in paper format to the customer, to the technician, who receives the order and proceeds to the registration of the order in the pharmacy IS to further be checked, fulfilled and delivered to the customer. If he/she does not have medical prescription, the technician takes note of the order and then checks in the Pharmacy IS if the ordered medicines can be picked up without a prescription and if not, the order is rejected. If they can be picked up, the order is registered in the pharmacy IS.

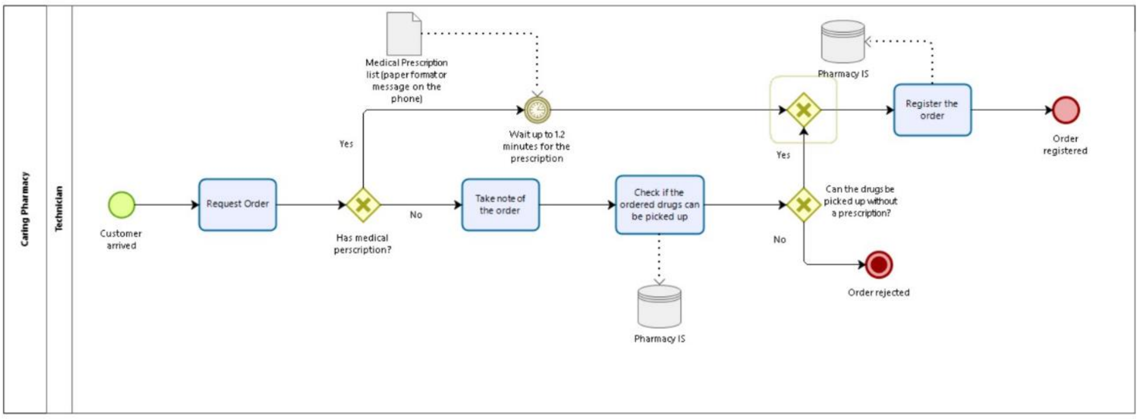

Figure 1 - AS-IS model – Receive Client

3.2 Enter and Check Prescription

The 'Enter and Check Prescription' process starts when the pharmacy's technician receives the medical prescription from the customer. Following this, the technician needs to enter the prescription details into the pharmacy's IS, to further proceed to the Drug Utilization Review (DUR) check, which will be carried out in an automated fashion by the same IS. If there are no alarms raised during this check, it is checked in the pharmacy IS if the customer has insurance for all or part of the ordered drugs.

On the other hand, if any alarms are raised during the automated DUR, then the pharmacist needs to review the alarms, which begins by checking the customer's record in order to assess if the prescribed drugs were ordered before by that customer and if their benefits are higher than the problems caused. If the benefits are higher, the pharmacist just needs to insert a note on the Pharmacy IS justifying why the drugs can be prescribed and the process continues to the insurance check. Otherwise, if the problems raised are higher than the benefits, then the pharmacist must call the customer's doctor when he finds no reason to deliver the ordered drugs to the client, aiming to understand why those medicines can be prescribed. However, sometimes the doctor does not answer the phone call, so the client is asked to return another day and leave without prescription, being that the order is cancelled. If the doctor does pick up the phone, the situation is discussed between the pharmacist and the doctor. If the latter committed a mistake when prescribing the drugs and the customer has an electronic prescription, he is asked to send a new prescription to the client's phone, which will trigger the whole prescription verification process to be started all over again. When the customer does not possess an electronic prescription, the client is informed to return another day with the new prescription and the order is cancelled. On the other hand, if the doctor was not wrong, the pharmacist needs to insert a justification in the pharmacy IS following the rationale behind the doctor recommending the drugs, which must only occur when the customer is in extreme necessity of the specific drugs, later the order proceeds for the insurance policy check of the customer using the pharmacy IS.

After the insurance check, it is verified if the insurance pays for all costs associated with the drugs' purchase. If it does not cover any costs, the customer must be informed about the total costs he/she has to pay for the medicines and if he/she accepts to pay for the entire sum, the prescription is fulfilled. If not, the order is cancelled, and the customer leaves the pharmacy with no medicines.

Moreover, if the insurance covers all costs, the prescription is fulfilled. If it just covers part of the expenses, the customer can opt for replacing the drugs which are not covered by the insurance policy by another one(s) whose costs are supported by the same policy. Therefore, and accordingly with the **'Drugs Replacement'** sub-process, the pharmacist can discuss with the doctor, or the patient or both to discuss which drugs could be replaced. If only the customer is called, the patient discusses with the pharmacist which drugs to be replaced and which ones to substitute those ones, having the final prescription filled with the drugs chosen by the customer. On the opposite, if only the doctor is called and does pick up the phone, the situation about the drugs replacement is discussed and the final decision about the drugs to be prescribed is taken solely by the doctor and the drugs are replaced. If the doctor does not pick up the phone, the client is asked to decide upon which drugs he/she wants to replace and which ones to be included in her/his prescription, having to agree upon paying for the medicine(s), being the drugs replaced, or, otherwise, he must return another day and the order is cancelled. Additionally, when both doctor and patient are contacted, the process is carried out in the same way as if both were to be contacted alone. After the drugs replacement, the prescription is fulfilled.

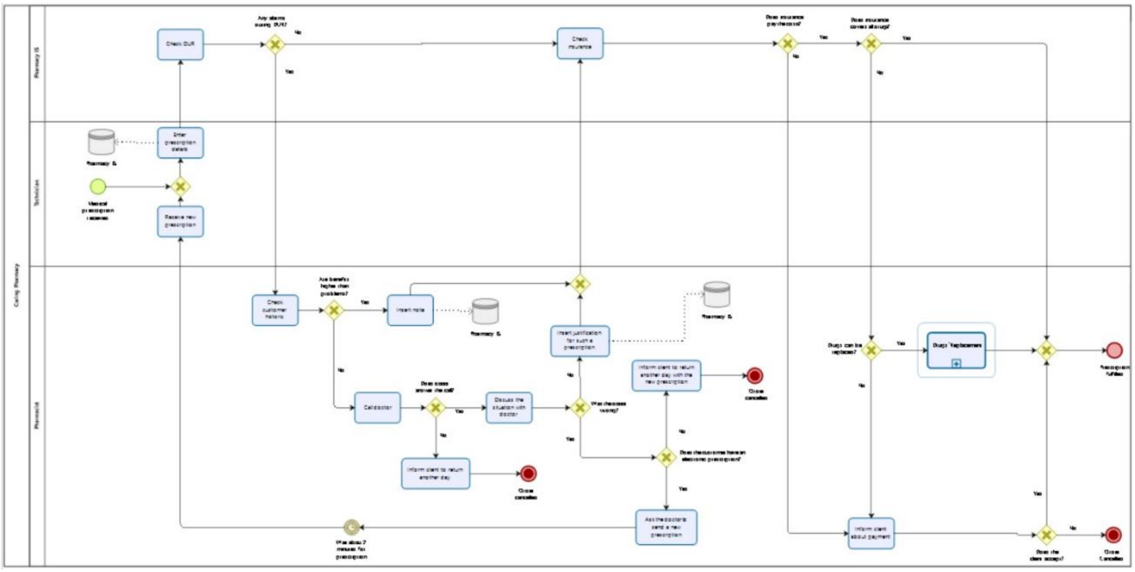

Figure 2 - AS-IS model – Enter and Check Prescription

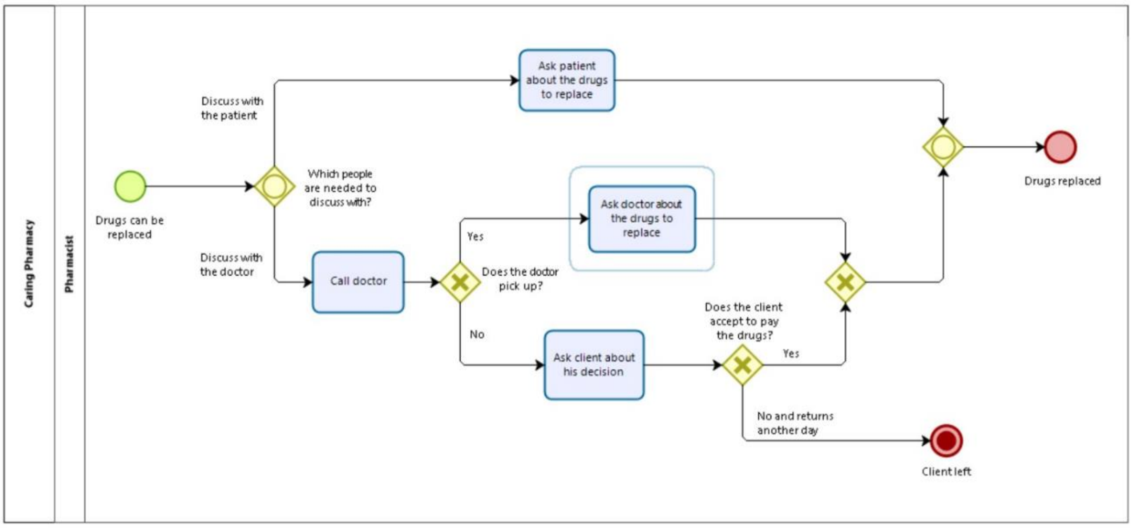

Figure 3 - AS-IS model – Drugs Replacement Sub-Process

3.3 Fulfill Order

After the prescription was checked or the order without prescription is ready to be fulfilled, the pharmacy technician must check if the prescribed medicines are in stock or not in the pharmacy's IS. If they are available in stock, the technician needs to get the medicines and check if they are the correct ones. If they are, then the pharmacist package them rapidly and the order is fulfilled. If they are not, the mistaken drugs must be replaced by the right ones in the order and the whole order fulfillment is started again with the correct medicines.

Coming back to the availability check, if they are not available, the technician must inform the pharmacist that the drugs are not available in stock, which forces the latter to choose alternative drugs. If there are no other alternatives, the pharmacist informs the technician and the latter notifies the customer of non-availability of both the original drugs and the alternative ones and orders the missing drugs from the supplier, which leads to the order being unfulfilled. If there are alternative medicines, the pharmacist needs to perform the **'Drugs Replacement'** sub-process, the same way it was carried out in the **'Enter and Check Prescription'** process, being this process proceeded as it is performed when the drugs are not available (explained in the previous paragraph).

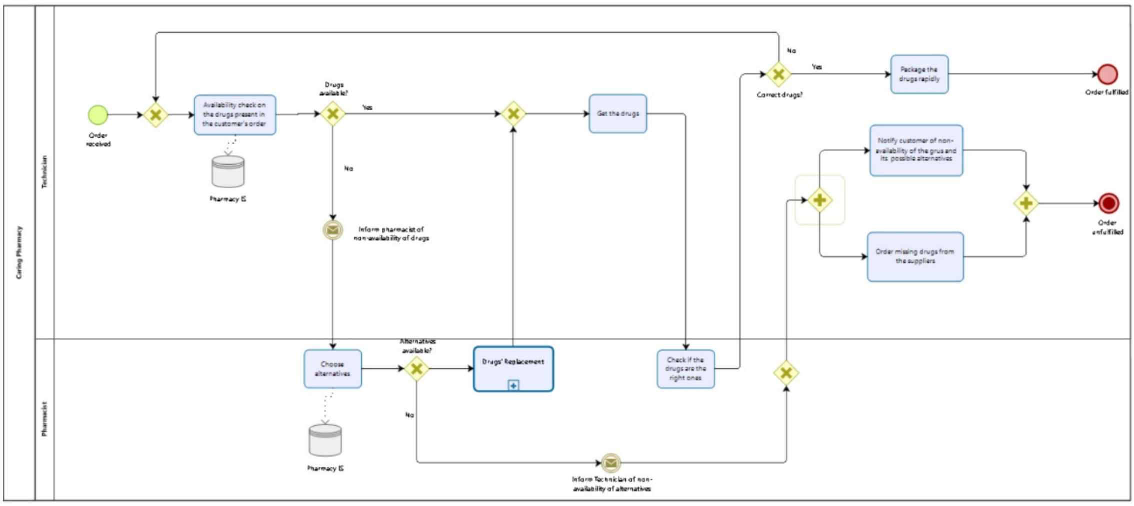

Figure 4 - AS-IS model – Fulfill Order

3.4 Deliver and Payment

After the order is fulfilled, it is packaged and the technician receives the payment and delivers the order to the customer, if his/her health insurance plan does not cover all costs related with purchasing the ordered drugs. Thus, the Order-to-Cash process is finalized.

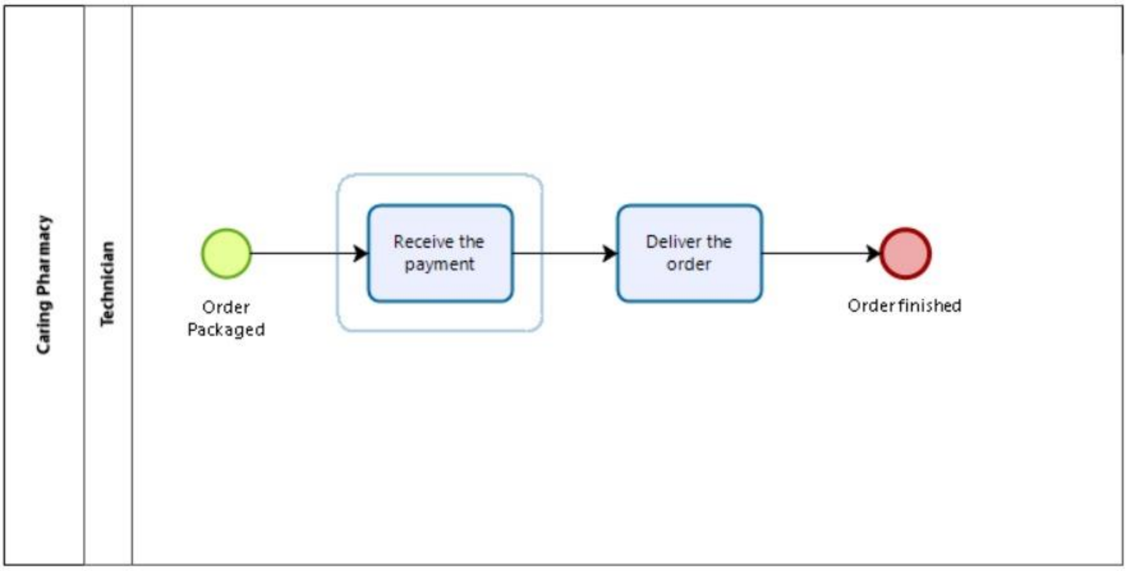

Figure 5 - AS-IS model – Delivery and Payment

4. Qualitative Analysis

After going through what the Order-to-Cash process is comprised of and which activities need to be performed to accomplish its goal, it is fundamental to identify valuable and non-valuable activities and waste (in terms of waiting time or existence of superfluous activities), to further improve the efficiency of the process. In this chapter, we address the two most used techniques in Qualitative Analysis: Value-Added Analysis and Waste Analysis.

4.1 Value-Added Analysis

The main goal of Value-Added Analysis is to identify and eliminate superfluous steps/activities in a process, decomposing the tasks inside a process. Following this, the next step is to classify each step/activity in terms of outcomes as follows:

- **Value Adding** (VA) steps/activities are those that directly contribute to good outcomes delivering value and satisfaction to the end customer. Therefore, these are activities for which the customer is willing to pay for and that produce enough satisfaction so the customer keeps doing business with the company;
- **Business Value Adding** (BVA) steps/activities are those that do not directly offer value to the customer but are important for the business to run efficiently. In other words, these are activities which are needed for collecting revenue and expand the business and whose removal could possibly harm the firm in the long run, leading to business failures;
- **Non-Value Adding** (NVA) steps/activities are those that are neither VA nor BVA.

After steps/activities classification, the aim of Value-Added Analysis is to figure out how to reduce BVA and remove NVA.

Relatively to this O2C specifically, we were able to identify various activities which fell within each of the previously stated categories in each of the processes that pertain to the O2C of Caring's Pharmacy:

4.1.1 Receive Client

Activity	Performer	Classification
Request order	Technician	NVA
Wait up to 1.2 minutes for the prescription	Technician	NVA
Take note of the order	Technician	BVA
Check if the ordered drugs can be picked up	Technician	BVA
Register order	Technician	VA

Figure 6 - Receive Client Value-Added Analysis

4.1.2 Enter and Check Prescription

Activity	Performer	Classification
Enter prescription details	Technician	BVA
Check DUR	Pharmacy IS	BVA
Check Insurance	Pharmacy IS	BVA
Check customer historic	Pharmacist	BVA
Insert note	Pharmacist	NVA
Call doctor	Pharmacist	BVA
Inform client to return another day	Pharmacist	NVA
Discuss the situation with doctor	Pharmacist	BVA
Insert justification for such a prescription	Pharmacist	NVA
Inform client to return another day with the new prescription	Pharmacist	NVA
Ask the doctor to send a new prescription	Pharmacist	BVA
Wait about 2 minutes for prescription	Pharmacist	NVA
Receive new prescription	Technician	NVA
Inform client about payment	Pharmacist	BVA

Figure 7 - Enter and Check Prescription Value-Added Analysis

4.1.3 Drugs Replacement Sub-Process

Activity	Performer	Classification
Ask patient about the drugs to replace	Pharmacist	BVA
Call doctor	Pharmacist	BVA
Ask doctor about the drugs to replace	Pharmacist	BVA
Ask client about his decision	Pharmacist	VA

Figure 8 - Drugs’ Replacement Sub-Process Value-Added Analysis

4.1.4 Fulfill Order

Activity	Performer	Classification
Availability check on the drugs present in the customer's order	Technician	VA
Get the drugs	Technician	BVA
Check if the drugs are the right ones	Pharmacist	VA
Choose alternatives	Pharmacist	VA
Package the drugs rapidly	Technician	NVA
Notify customer of non-availability of the drugs and its possible alternatives	Technician	BVA
Order missing drugs from suppliers	Technician	NVA

Figure 9 - Fulfill Order Value-Added Analysis

4.1.5 Deliver and Payment

Activity	Performer	Classification
Receive the payment	Technician	BVA
Deliver the order	Technician	VA

Figure 10 - Deliver and Payment Value-Added Analysis

4.2 Waste Analysis

The main goal of waste analysis is to detect "waste" throughout processes. Which might occur not just inside the activities themselves, but also between them (e.g. handovers between resources). The major difference between waste analysis and value-added analysis is that the first one examines activities from a positive viewpoint while the latter examines them from a negative one.

Now just focusing into the Waste Analysis, this qualitative technique is split up in three categories:

- **Move:** Waste related to movement. This category is subdivided in two categories: **Transportation**, which encompasses sending or receiving items or documents (including electronic ones) that are used as inputs or outputs by process activities; **Motion**, meaning internal motion of resources inside the process.
- **Hold:** Waste generated as a result of holding something. It is also subdivided in two categories: **Inventory** (accumulation of inventory and work-in-process (WIP), which stands for the number of cases that have started and have not yet completed) and **Waiting** (it occurs when an activity is awaiting supplies or input data, a resource or work).
- **Overdo:** Waste that results from doing more than is required to provide value to the client or the business. This category is divided in three subcategories: **Defects**, which consists of all work done in order to correct, repair, or compensate for a defect in a process, meaning a rework as to be performed due to a defect spotted at the first time

an activity was done. The second category is **Over-Processing**, which happens when work is done even though it isn't required given the output of a process instance, leading to unnecessary perfectionism. The last category is **Over-Production**, comprising unnecessary process instances that are run, but result in outcomes that do not add any value once they're finished.

Bearing in mind, the definition and division of Waste Analysis, our group decided to identify and explain the causes of the different sources of waste within the O2C process of Caring Pharmacy, dividing them in the various categories of Waste Analysis:

4.2.1 Receive Client

- **Waiting:**
  Technician waiting for the next customer to arrive, therefore a resource is waiting for work.

- **Over-Processing:**
  The technician takes note of the order for customers who do not have prescription is being performed unnecessarily, because one or more drugs happen to not being possible to be bought without description, which causes the order to be rejected for 15% of the customers.

- **Over-Production:**
  About 15% of the customers have their order rejected due to the impossibility of buying the drugs asked by the customer without being prescribed by a doctor. Consequently, some process instances are performed unnecessarily, for then not being completed until the end of the process.

4.2.2 Enter and Check Prescription

- **Transportation:**
  After being asked to send a new prescription to the customer, the doctor sends it and it will be taken as an output of the activity of receiving new prescription, which fits into the transportation type of waste.

- **Waiting:**
  When the doctor sends a new prescription, the technician must wait for it to reach the customer's mobile phone, which can be identified as a waiting type of waste, because a resource (technician, in this case) is waiting for work.

- **Defects:**
  When the doctor is wrong about the prescribed drugs and if the customer has an electronic prescription, the doctor sends a new electronic prescription, which leads the technician to start the Enter and Check Prescription all over again due to a defect detected during the process (doctor was wrong about the prescribed drugs).

- **Over-Processing:**
  Inserting a note into the pharmacy's IS about the benefits of taking the prescribed drugs being more than the problems caused by them, as well as inserting a justification into the pharmacy's IS after the checking the problems were higher than the benefits, but

the doctor did not commit any mistake when prescribing the drugs, are examples of Over-Processing, being unnecessary activities denoting too much perfectionism, leading to the same outcome as if they were not performed.

4.2.3 Fulfill Order

- **Motion:**
  Informing the non-availability of drugs could be interpreted as a simple handoff, seeming that it could be done through sending a simple notification to the PoA (Point of access of the pharmacy IS) of the pharmacist, maybe through the Pharmacy's Information System. Additionally, this notification could easily substitute this activity altogether and avoid this type of waste.
  Informing the non-availability of alternatives is carried out in the same fashion as informing the non-availability of drugs and it could be improved with the same solution provided previously.

- **Over-Processing:**
  Checking if a drug is the correct one could be identified as being obsolete altogether, even if it is performed by a machine. Even if one looks at the AS-IS model, it seems that if all activities are performed correctly, this activity could be interpreted as a waste.
  Another situation where it is possible to identify an Over-Processing type of waste is when the Pharmacist performs the activity of choosing the alternatives and later the doctor cannot be reached through phone call, leading to the order not being fulfilled. In that case, the activity of choosing alternatives to the prescribed drugs could be interpreted as an Over-Processing type of waste.

4.2.4 Deliver and Payment

There was no waste spotted in the Deliver and Payment process.

5. Quantitative Analysis: WHAT-IF Analysis

Following the modelling phase of the Order-to-Cash process, the evaluation of activities in terms of value added to the business, through Value Added Analysis, and the assessment of the existence of waste within the process, it is fundamental to resort to Quantitative Analysis, namely What-If Analysis. This technique enables the identification of activities or set of activities on top of the AS-IS model which we built previously, in order to know what could be improved in terms of cycle time, with the goal of boosting the overall efficiency of the O2C process, through the construction of different simulation scenarios.

In What-If Analysis, there are several phases which need to be followed to set those definitions. Hence, in Bizagi Modeler, there are four levels for defining the simulation scenarios, namely **Process Validation**, **Time Analysis**, **Resource Analysis** and **Calendar Analysis**.

In Process Validation, our team needed to set the statistical distribution assigned to the Start Event of each process (Receive Client, Enter and Check Prescription, Fulfill Order, Deliver and Payment). The chosen distribution was the Poisson distribution, because the AS-IS model needs to be fed with the number of expected customer arrivals per hour, so it can be known how many units of each resource can be assigned to perform the tasks of the O2C process. Consequently, the mean arrival time (λ) was calculated, which corresponds to the total number of orders received (number of process instances) per day at Caring Pharmacy, divided by the number of hours the pharmacy is open per day and 60 minutes to know the number of orders received per minute, as well as the maximum arrival count of instances per working day. In each process section, we explain the rationale behind each number of instances entered at the start event and the calculations made to know the mean arrival rate and the mean inter-arrival rate (1/λ). Furthermore, in each gateway, the probabilities of a process instance to follow each branch were arranged, being the Process Validation completed.

Secondly, we moved on to the Time Analysis stage, which consists in stablishing the statistical distributions that each activity follows. We opted to assign to each activity the Truncated Normal Distribution, since the events for each one is evenly distributed around the mean, not varying much, and the times cannot be negative.

Following that, Resource Analysis was performed, comprising the assignment of each resource (Technician, Pharmacist and Pharmacy IS, in this case) to each activity. Moreover, we decided that each activity was to be performed by a single unit of a single resource.

Finally, Calendar Analysis was carried out, meaning working schedules/calendars had to be defined, as well as how many units of each resource to be attached to each calendar.

These previously mentioned analyses were performed for each scenario. These simulation scenarios differ from each other, essentially, in terms of the number of resources used, calendars assigned to each one and number of instances started, depending upon the operation hours of the pharmacy. In the table below, we can see the main differences between the four considered scenarios:

Scenario	Number of Units for each Resource	Calendar
Scenario 1	4 technicians and 3 pharmacists	8 operation hours
Scenario 2	4 technicians and 3 pharmacists	8 operation hours
Scenario 3	3 technicians and 2 pharmacists	12 operation hours and 2 shifts
Scenario 4	3 technicians and 2 pharmacists	12 operation hours and 2 shifts

Figure 11 - Different Scenarios Defined

5.1 Receive Client

Activity/Event	Distribution	Mean	Standard Deviation	Min	Max
Customer arrived	Poisson	2.18	-	-	220
Receive order	Truncated Normal	0.2	0.05	0.1	0.3
Receive the prescription	Truncated Normal	1.2	0.3	0.5	1.5
Take note of the order	Truncated Normal	0.4	0.2	0.2	0.75
Check if the ordered drugs can be picked up	Truncated Normal	0.85	0.15	0.5	1.25
Register order	Truncated Normal	0.2	0.1	0.1	0.3

Figure 12 - Receive Client Distributions and Values

The Receive Client process with 8 operation hours per day, corresponding to the scenarios 1 and 2, has a mean arrival time calculated as the following:

$$\text{Mean arrival time} = \lambda = 220 / 8 / 60 = 0.458$$

Then, we calculated the mean inter-arrival time to know the time between customer arrivals at the pharmacy:

$$\text{Mean inter-arrival time} = 1 / \lambda = 1 / 0.458 = 2.18$$

The values for λ and $1/\lambda$ are still valid for all the other 3 scenarios in the Receive Client process, as the number of instances started at the start event grow proportionally to the number of operation hours.

Scenario 1:

Scenario	Resource	Utilization
Scenario 1	Technician	7.96%

Figure 13 - Resource Utilization Scenario 1 – Receive Client

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
220/215	1.59	142.09	-	0

Figure 14 - Analysis Scenario 1 – Receive Client

Relatively to the resource utilization, we can assess that it is extremely low, meaning the technician can perform other activities, although the Receive Client process does not comprise much more than what is described in the AS-IS model.

When it comes to the results of the scenario 1, they lead us to conclude that the Receive Client process takes, on average, 1m35s, being the total time equal to 2h22m, existing no resource waiting for work, due to the scarce utilization that the technician has.

Scenario 2:

Scenario	Resource	Utilization
Scenario 2	Technician	10.61%

Figure 15 - Resource Utilization Scenario 2 – Receive Client

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
220/215	1.59	142.31	-	0

Figure 16 - Analysis Scenario 2 – Receive Client

The utilization of the technician in the scenario 2 increased a few points, yet its utilization is still low and can still be augmented.

The results of this scenario were almost the same as the scenario 1, as the reduction in 1 technician proved to be insufficient to reduce the average time and the total time of the Receive Client process, due again to the low amount of work the technicians have to perform.

Scenario 3:

Scenario	Resource	Utilization
Scenario 3	Technician	10.33%

Figure 17 - Resource Utilization Scenario 3 – Receive Client

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
330/322	1.58	213.93	-	0.26

Figure 18 - Analysis Scenario 3 – Receive Client

As we can see, the introduction of 2 shifts, meaning the operation hours of the pharmacy increased from 8 hours to 12 hours, did not change much the resource utilization (from 10.61% in the scenario 2 to 10.33%), as well as the average time. On the other hand, the total time increased from 2h22m to 3h33m, due to the higher number of operation hours per day but in proportion it remained the same, as well as the total time waiting for resource (from 0 seconds to 15 seconds), which is very insignificant.

Scenario 4:

Scenario	Resource	Utilization
Scenario 4	Technician	10.20%

Figure 19 - Resource Utilization Scenario 4 – Receive Client

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
275/263	1.61	176.66	-	0

Figure 20 - Analysis Scenario 4 – Receive Client

When looking at the previous tables, the introduction of three shifts and the implementation of 10 operating hours per day, impacted very slightly the results of this process, remaining in line with all the other described scenarios, just increasing the average time to 1m37s and decreasing the utilization at a very low level.

Overall, all the 4 scenarios managed to keep the average time of the Receive Client close to what was described in the project description, compared to 1m30s written in the project description.

5.2 Enter and Check Prescription

Activity/Event	Distribution	Mean	Standard Deviation	Minimum	Maximum
Medical prescription received	Poisson	2.793	-	-	172
Enter prescription details	Truncated Normal	0.7	0.2	0.3	1
Check DUR	Uniform	-	-	0.1	0.2
Check Insurance	Uniform	-	-	0.15	0.5
Check customer historic	Truncated Normal	1	0.2	0.6	1.2
Insert note	Truncated Normal	0.2	0.1	0.1	0.4
Call doctor	Truncated Normal	0.2	0.1	0.1	0.3
Inform client to return another day	Truncated Normal	0.2	0.1	0.1	0.4
Discuss the situation with doctor	Truncated Normal	5	2.5	2	8
Insert justification for such a prescription	Truncated Normal	0.3	0.1	0.1	0.5
Inform client to return another day with the new prescription	Truncated Normal	0.15	0.1	0.1	0.3
Ask the doctor to send a new prescription	Truncated Normal	0.2	0.1	0.1	0.3
Wait about 2 minutes for prescription	Truncated Normal	2	0.4	1	2.5
Receive new prescription	Truncated Normal	0.05	0.02	0.02	0.1
Inform client about payment	Truncated Normal	0.4	0.2	0.1	0.6
Ask patient about the drugs to replace	Truncated Normal	2	0.4	1	2.5
Call doctor	Truncated Normal	0.2	0.1	0.1	0.4
Ask doctor about the drugs to replace	Truncated Normal	5	2.5	2	8
Ask client about his decision	Truncated Normal	0.4	0.2	0.1	0.7

Figure 21 - Enter and Check Prescription Distributions and Values

Scenario 1:

Regarding the first scenario, with 8 working hours starting at 10AM, 4 and 3 technicians and pharmacists, respectively, we calculated the maximum arrival rate by multiplying the number of instances completed in scenario 1 from the Receive Client with the probability of having a medical prescription, as shown below:

Maximum Arrival Date = Instances completed from Receive Client * Prob. of having medical prescription

= 215 * 0.8 = 172

Then, we calculated the mean arrival rate and the mean inter-arrival time:

Mean arrival rate (λ) = 172 / 8 / 60 = 0.358

Mean inter-arrival time = 1 / 0.358 = 2.791

Scenario	Resource	Utilization
Scenario 1	Technician	5.97%
	Pharmacist	26.94%
	PoA Pharmacy IS	5.52%

Figure 22 - Resource Utilization Scenario 1 – Enter and Check Prescription

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
172/132	4.59	605.06	-	0.25

Figure 23 - Analysis Scenario 1 – Enter and Check Prescription

In scenario 1, we obtained an average time of 4m35s and a waiting time of 15s, due to the low utilization of the existing resources, being the pharmacist the one with the highest utilization (26.94%). Therefore, in future simulations, it is a good option to make use of less resources in order to lower the costs with personnel, as the efficiency of the Enter and Check Prescription process will not be hugely affected, as we assessed in the next scenarios presented in the report.

Scenario 2:

Regarding scenario 2, we decided to remove 1 pharmacist and 1 technician due to the low utilization in the previous scenario. Here, we did not need to perform any calculation since the values obtained in scenario 1 are also valid for this scenario.

Scenario	Resource	Utilization
Scenario 2	Technician	7.97%
	Pharmacist	40.40%
	PoA Pharmacy IS	5.52%

Figure 24 - Resource Utilization Scenario 2 – Enter and Check Prescription

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
172/132	4.75	626.85	-	22.04

Figure 25 - Analysis Scenario 1 – Enter and Check Prescription

For this scenario, the resources utilization increased significantly due to the reduction of the number of resources, however, the resources could have even more utilization. Still, the pharmacist, registers a mild utilization with 40.40%, being the highest among all resources.

Comparing with the previous scenario, the average time increased from 4m35s to 4m45s and the total time had a low increase of just 20 minutes. In this scenario, the Enter and Check Prescription registered a total time waiting for resource of 22.04 minutes, which shows a significant increment from the previous scenarios. Therefore, two less employees (1 technician and 1 pharmacist) could be beneficial for reducing the costs with personnel, while maintaining the efficiency of the Enter and Check Prescription process.

Scenario 3:

In scenario 3, we needed to perform the calculations once more, as the number of hours changed from 8 hours to 12 hours and the number of instances completed in the Receive Client process also changed. So, the calculations were done as shown below:

Maximum Arrival Date = Instances completed from Receive Client * Prob. of having medical prescription

= 322 * 0.8 = 257

As for the mean arrival rate and mean inter-arrival rate:

$$\text{Mean arrival rate } (\lambda) = 257 / 12 / 60 = 0.357$$

$$\text{Mean inter-arrival time} = 1/\lambda = 1 / 0.357 = 2.801$$

Scenario	Resource	Utilization
Scenario 3	Technician	8.03%
	Pharmacist	37.11%
	PoA Pharmacy IS	5.53%

Figure 26 - Resource Utilization Scenario 3 – Enter and Check Prescription

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
257/183	4.76	869.72	-	25.40

Figure 27 – Analysis Scenario 3 – Enter and Check Prescription

In this scenario, we obtained very similar results for both resources' utilization and average time in comparison with the previous scenario. The pharmacist is, once again, the resource with the highest utilization, although its utilization decreased.

Hence, it can be concluded that the introduction of two shifts, being the pharmacy opened for 12 hours per day, does not alter the efficiency of the process.

Scenario 4:

Regarding scenario 4, we had to do the calculations once more, the number of instances completed in the previous process changed, as well as the number of hours related with the alteration of the shifts. So, the calculations were done as shown below:

Maximum Arrival Date = Instances completed from Receive Client * Prob. of having medical prescription

= 263 * 0.8 = 210

The mean arrival rate and the mean inter-arrival rate were also recalculated:

Arrival rate (λ) = 263 / 10 / 60 = 0.35

Mean inter-arrival time = 1 /0.35 = 2.857

Scenario	Resource	Utilization
Scenario 4	Technician	8.82%
	Pharmacist	35.77%
	PoA Pharmacy IS	5.32%

Figure 28- Resource Utilization Scenario 4 – Enter and Check Prescription

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
210/141	5.12	720.78	-	66.73

Figure 29 – Analysis Scenario 4 – Enter and Check Prescription

In scenario 4, the utilization rates obtained were somewhat similar to the ones of the two previous scenarios, registering a slight decrease, and the pharmacist still shown to be resource with the highest utilization rate with 35.77%.

However, when comparing this scenario with the others, it shows a higher average time, with 5m07s, and consequently, the highest total time in proportion to the number of operating hours. Additionally, the time waiting for resource is also the highest among all scenarios, even though the utilization rates were lower than in the previous scenarios. Therefore, it should be a good solution to introduce three shifts per working day, being the pharmacy to operate for 10 hours daily.

In the end of the simulation with the different scenarios, we were not able to comply with the average time of 3m30s, as written in the project description, although we tried to minimize as possible the average, maximum and minimum times for each activity (but still setting reasonable values to each of the parameters), as well as the standard deviation. Consequently, in the TO-BE process, our team will try to commit to this average time of 3m30s in the Receive Client process.

5.3 Fulfill Order

Activity/Event	Distribution	Mean	Standard Deviation	Minimum	Maximum
Order received	Poisson	2.74	-	-	175
Availability check on the drugs present in the customer's order	Truncated Normal	0.5	0.1	0.1	2.0
Get the drugs	Truncated Normal	0.75	0.375	0.375	4
Check if the drugs are the right ones	Truncated Normal	0.5	0.15	0.25	2
Choose alternatives	Truncated Normal	1.0	0.25	0.25	4.0
Notify customer of non-availability of the drugs and its possible alternatives	Truncated Normal	1.5	0.225	0.5	5.0
Order missing drugs from the suppliers	Truncated Normal	1.5	0.225	0.5	5.0
Ask patient about the drugs to replace	Truncated Normal	2	0.4	1	2.5
Call doctor	Truncated Normal	0.2	0.1	0.1	0.4
Ask doctor about the drugs to replace	Truncated Normal	5.0	2.5	2.0	8.0
Ask client about his decision	Truncated Normal	0.4	0.2	0.1	0.7
Package the drugs rapidly	Truncated Normal	0.25	0.1	0.1	0.5

Figure 30 - Fulfill Order Distributions and Values

Scenario 1:

Regarding the first scenario of the Fulfill Order process, the maximum arrival rate was calculated the same way as in the previous processes presented:

Maximum Arrival Date = Instances completed from Enter and Check Prescription + Instances completed from Receive Client * Prob. of having medical prescription

= 132 + 215 * 0.2 = 175

Then, we calculated the mean arrival rate and the mean inter-arrival time:

Mean arrival rate (λ) = 175 / 8 / 60 = 0.365

Mean inter-arrival time = 1 / 0.365 = 2.74

These values are also applicable for the scenario 2.

Scenario	Resource	Utilization
Scenario 1	Technician	20.20%
	Pharmacist	9.08%

Figure 31 - Resource Utilization Scenario 1 – Fulfill Order

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
175/131	3.40	500.74	-	0.10

Figure 32 - Analysis Scenario 1 – Fulfill Order

The simulation results for the scenario 1 for the AS-IS modelling phase makes clear that both resources technician and pharmacist display a low level of resource utilization, being respectively, 20.20% and 9.08%. Consequently, these resource utilization levels depict a situation where some efficiency gains should be achieved and sought after.

When assessing the average time, it is close to some extent to the described average value of the process as described in the project description, being 1m24s above it. Additionally, there is almost no waiting time for resource, therefore we can infer with extremely strong confidence that queues are mostly inexistent.

Scenario 2:

Scenario	Resource	Utilization
Scenario 2	Technician	24.58%
	Pharmacist	13.62%

Figure 33 - Resource Utilization Scenario 2 – Fulfill Order

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
175/131	3.15	470.74	-	3.07

Figure 34 - Analysis Scenario 2 – Fulfill Order

In scenario 2, resource utilization rates increased, as expected, and total time increased very slightly, therefore this scenario for the AS-IS design seems promising with respects to efficiency gains. One Technician and one Pharmacist were removed and despite the waiting time increased quite a bit, the proportional increase in total time was insignificant.

Overall, decreasing the number of technicians and pharmacists by 1 each proves to boost the efficiency of the Fulfill Order process. At the same time, it helps Caring Pharmacy to support lower personnel costs, reaching the yearly reduction toll more than 30,000 euros.

Scenario 3:

Now, considering the third scenario of the Fulfill Order process, the maximum arrival rate was calculated the same way as in the previous processes presented, with the exception that the operation hours are 12, so the number of instances entered in this process also have to grow proportionally:

Maximum Arrival Date = Instances completed from Enter and Check Prescription + Instances completed from Receive Client * Prob. of having medical prescription

= 183 + 322 * 0.2 = 247

Then, we calculated the mean arrival rate and the mean inter-arrival time:

Mean arrival rate (λ) = 247 / 12 / 60 = 0.343

Mean inter-arrival time = 1 / 0.365 = 2.915

Scenario	Resource	Utilization
Scenario 3	Technician	22.12%
	Pharmacist	12.66%

Figure 35 - Resource Utilization Scenario 3 – Fulfill Order

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
247/192	2.97	646.54	-	3.78

Figure 36 - Analysis Scenario 3 – Fulfill Order

As for the scenario 3, there were some minor changes from the previous scenario. Resource utilization stayed more or less the same (the pharmacist rate decreased 2.5% and the technician rate 1%), the average time of the process diminished from 3m9s to 2m58s and the waiting time registered a slight increase, which tells that introducing 2 shifts did not result in great outcomes in the efficiency of the Fulfill Order process.

Scenario 4:

Once again, the maximum arrival rate has to be re-calculated and it is done in the same fashion as in the previous processes and scenarios presented. Despite this, and considering the fourth scenario of the Fulfill Order process, the operation hours are 10 different, being 10 in total, thus leading to different values for the maximum arrival rate, mean arrival rate and mean inter-arrival rate:

Maximum Arrival Date = Instances completed from Enter and Check Prescription + Instances completed from Receive Client * Prob. of having medical prescription

= 141 + 263 * 0.2 = 193

Then, we calculated the mean arrival rate and the mean inter-arrival time:

Mean arrival rate (λ) = 193 / 10 / 60 = 0.322

Mean inter-arrival time = 1 / 0.322 = 3.106

Scenario	Resource	Utilization
Scenario 4	Technician	16.73%
	Pharmacist	19.22%

Figure 37 - Resource Utilization Scenario 4 – Fulfill Order

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
193/183	2.86	537.44	-	3.50

Figure 38 - Analysis Scenario 4 – Fulfill Order

Relatively to the scenario 4, the resource utilization altered in a very significant way, as the pharmacist is the resource with the highest utilization rate (19.22%), having the technician just 16.73%, which is completely the opposite to what occurs in the other scenarios. The average time decreased once again, being now at 2m52s, along with the total time and the waiting time, which is now 3m30s. Therefore, in the end, this scenario with 3 shifts, 3 technicians, 2 pharmacists and 10 operation hours per day seems to be the one which is more suited to improve the efficiency of the Fulfill Order process.

5.4 Deliver and Payment

Activity/Event	Distribution	Mean	Standard Deviation	Min	Max
Order Packaged	Poisson	3.663	-	-	131
Receive the payment	Truncated Normal	0.5	0.1	0.2	0.7
Deliver the order	Truncated Normal	0.1	0.02	0.02	0.15

Figure 39 – Deliver and Payment Distributions and Values

Scenario 1:

Considering the scenario 1 of the Deliver and Payment process, the maximum arrival rate was calculated the same way as in the previous processes presented:

Maximum Arrival Date = Instances completed from Fulfill Order = 131

Then, we calculated the mean arrival rate and the mean inter-arrival time:

Mean arrival rate (λ) = 131 / 8 / 60 = 0.273

Mean inter-arrival time = 1 / 0.365 = 2.663

These values are also applicable for the scenario 2.

Scenario	Resource	Utilization
Scenario 1	Technician	4.06%

Figure 40 - Resource Utilization Scenario 1 – Deliver and Payment

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
131/131	0.59	76.79	-	0

Figure 41 - Analysis Scenario 1 – Deliver and Payment

In the scenario 1, the resource utilization stays extremely low, at just 4.06%, as the same happens in the Receive Client process.

Considering the results, it can be concluded that the Deliver and Payment process takes, on average, 35s, existing no resource waiting for work, due to the scarce utilization that the technician has. In the next scenarios, it could be tried to reduce the number of technicians allocated to this process.

Scenario 2:

Scenario	Resource	Utilization
Scenario 2	Technician	5.41%

Figure 42 - Resource Utilization Scenario 2 – Deliver and Payment

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
131/131	0.59	76.78	-	0

Figure 43 - Analysis Scenario 2 – Deliver and Payment

The utilization of the technician in the scenario 2 increased at a very low level, from 4.06% to 5.41%, meaning firing 1 technician does not increase the utilization of the other 3 technicians.

As for the average time, total time and total time waiting for resource values, they remained exactly the same, meaning one less technician does not impact in any matter those values in the Deliver and Payment process, meaning just one or two technicians could be allocated to this process in order to increase the efficiency of this process.

Scenario 3:

Considering the scenario 3, the maximum arrival rate was calculated as the following:

Maximum Arrival Date = Instances completed from Fulfill Order = 192

Then, we calculated the mean arrival rate and the mean inter-arrival time:

Mean arrival rate (λ) = 192 / 12 / 60 = 0.267

Mean inter-arrival time = 1 / 0.267 = 3.745

Scenario	Resource	Utilization
Scenario 3	Technician	5.45%

Figure 44 - Resource Utilization Scenario 3 – Deliver and Payment

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
192/192	0.59	113.15	-	0

Figure 45 - Analysis Scenario 3 – Deliver and Payment

In this scenario, the results were the same as in the previous scenario. Therefore, implementing two shifts of 12 operation hours does not improve the efficiency of the Deliver and Payment process.

Scenario 4:

As for the fourth scenario, the maximum arrival rate was calculated as the following:

Maximum Arrival Date = Instances completed from Fulfill Order = 183

Then, we calculated the mean arrival rate and the mean inter-arrival time:

Mean arrival rate (λ) = 183 / 10 / 60 = 0.305

Mean inter-arrival time = 1 / 0.305 = 3.279

Scenario	Resource	Utilization
Scenario 4	Technician	6.24%

Figure 46 - Resource Utilization Scenario 4 – Deliver and Payment

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
183/183	0.59	108.11	-	0

Figure 47 - Analysis Scenario 4 – Deliver and Payment

As for the scenario 4, the results were again almost the same comparing with the three previous assessed scenarios, except for the resource utilization, which raised at a very low degree (just a 0.79% increase).

Therefore, in future scenarios, we could try to allocate even less resources to this process, for instance, just 2 technicians and 1 pharmacist.

6. TO-BE Process Model

After resorting to the Qualitative and Quantitative Analyses, we were able to advance to the TO-BE modelling, based on the scenarios we designed for getting all the needed values of the metrics constructed to evaluate the efficiency of the Order-to-Cash process of Caring Pharmacy. Consequently, we used again the same scenarios used in the assessment of the AS-IS model, due to not being clear which scenario was the best one. For instance, we concluded that in the Receive Client and Deliver and Payment processes the four scenarios did not differ from each other in terms of resource utilization, average time, total time and average time waiting for resource. For the Enter and Check Prescription, the scenario 1 was deemed to be the best one, while in the Fulfill Order process, it was the scenario 4.

Therefore, our team decided to adjust some parameters, such as the number of technicians and pharmacists needed, due to the implementation of a new Information System (described below) and test again the four scenarios with 3, 2 and 1 technicians, keeping the number of pharmacists as 2. We tried these approaches because the new IS enabled to relieve the technicians from doing some activities which could be automated by the system, which meant that Caring Pharmacy could get rid off one or two technicians. For instance, in the Enter and Check Prescription, the technician lane was deleted, and in the Fulfill Order, some activities performed by the technician passed to be carried out by the IS, due to the reason explained in the last sentence.

Finally, when looking at the results of the different scenarios, it became clear which scenario led to the best results, which was the Scenario with 2 technicians, 2 pharmacists and 3 Points of Access for the IS (PoA), being the pharmacy open for 8 hours daily, with no shifts. These settings permit Caring Pharmacy to enhance the efficiency of the Order-to-Cash process, while sparing 3300€ per month on personnel costs.

Relatively to the proposal of the implementation of a Pharmacy Information System to Caring Pharmacy, Pharmacy Information Systems (PIS) are computer software systems that have been built to accomplish the numerous tasks needed to run a pharmacy. They improve the efficiency of the business and allow for the storage of digital records and quick retrieval of information. The uses for a PIS include:

- Prescription management;
- Patient personal profiles and medication history;
- Consultation documentation;
- Inventory management;
- Purchasing management;
- Billing and insurance management;
- Clinical screening (allergies, drug interactions, warnings and patient education);
- Drug interaction monitoring, among others. [5]

The PIS proposed by our team is the one provided by Interactive Business Systems, named as WinPharm. “WinPharm is a full featured hospital pharmacy drug distribution and control system, and Electronic Medication Administration Record (EMAR) System. WinPharm is operational at approximately 100 hospitals world-wide in local and internet hosted environments, is multi-lingual, and provides for both inpatient and outpatient operations.” [6]

Furthermore, we consider this Pharmacy Information System to be the perfect IS for the Order-to-Cash process of Caring Pharmacy because it has many features that fit into the operations and activities described in the AS-IS model and many others that can be incorporated into the TO-BE model of this O2C, which can improve its efficiency. Some of the most important characteristics of this IS are:

- Registration of an order and its full details;
- Registration of transaction logs, allowing to have in the system an History of transactions for each customer and medicine;
- Incorporated Inventory System which allows to automate the processes of ordering and receiving the medicines;
- Registration of current and historical DURs, allowing for checking previous adverse reaction between prescribed drugs, their interaction between them and with alcohol, as well as checking for contraindication of the drugs when the patient suffers from a particular disease;
- Check for recommended doses for each prescribed drug;
- Registration and lookup of each drug entered into the system by brand, generic name, NDC number or ID;
- Registration of new drugs while entering orders.

Unfortunately, our team was not able to disclose the costs of purchasing the Winpharm IS, although this can be done by Caring Pharmacy if they find this Information System interesting and useful for their Order-to-Cash process.

6.1 Receive Client

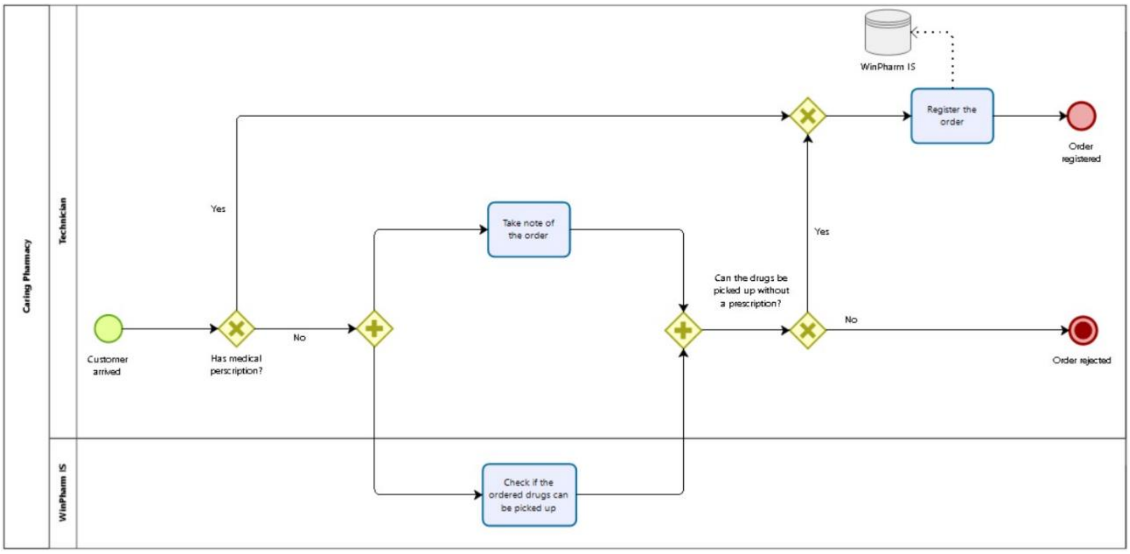

Figure 48 - TO-BE model - Receive Client

Activity/Event	Distribution	Mean	Standard Deviation	Min	Max
Customer arrived	Poisson	2.18	-	-	220
Take note of the order	Truncated Normal	0.4	0.2	0.2	0.75
Check if the ordered drugs can be picked up	Truncated Normal	0.85	0.15	0.5	1.25
Register order	Truncated Normal	0.2	0.1	0.1	0.3

Figure 49 - TO-BE Receive Client Distributions and Values

The Receive Client process was targeted with various modifications from the original one modelled in the AS-IS process.

Firstly, it is worthy to note that a new lane was added to the pool 'Caring Pharmacy', named as 'WinPharm IS', the proposed Information System to be implemented in Caring Pharmacy, in order to introduce some automation into this process, where a task ('Check of the ordered drugs can be picked up') before was performed manually by the technician.

Now looking more in depth into the Receive Client process, it begins when the customer arrives at the pharmacy. Then, if he/she brings a medical prescription, the order is registered by the technician into the WinPharm IS, otherwise, the technician needs to take note of the ordered drugs and the WinPharm IS automatically retrieves if the ordered drugs can be picked up or not without a prescription. If so, the order is registered into the IS, but if not, the order is rejected, and the customer must return another day.

Scenario	Resource	Utilization
TO-BE	Technician	6.38%
	PoA WinPharm IS	2.69%

Figure 50 - TO-BE Resource Utilization – Receive Client

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
220/213	0.39	104.06	-	0.21

Figure 51 - TO-BE Analysis – Receive Client

Level	Heuristic	Time	Cost	Quality	Flexibility
Task	1 – Task Elimination	Improves	Ambiguous	Worsens	No effect
Flow	5 - Parallelism Enhancement	Improves	Ambiguous	No effect	No effect
Process	9 - Automation	Improves	Ambiguous	Ambiguous	Worsens

Figure 52 - TO-BE Heuristics – Receive Client

Heuristics used to redesign the Receive Client process:

Heuristic 1 – **Task Elimination** was used to eliminate two activities identified as Non-Value Adding in the Value Added Analysis, namely 'Request Order' and 'Wait up to 1.2 minutes for the prescription'. Accordingly, the cycle time of the Receive Client will decrease, although the quality of the model decreases, being the flexibility not affected.

On the other hand, we resorted to heuristic 5 – **Parallelism Enhancement** to redesign the flow of the Receive Client process. Therefore, we parallelized the activities 'Take note of the order' and 'Check of the ordered drugs can be picked up' aiming to reduce the cycle time.

Lastly, heuristic 9 – **Automation** turned the 'Check of the ordered drugs can be picked up' activity to be performed in automated fashion, in order to improve the cycle time, although the flexibility was affected negatively.

6.2 Enter and Check Prescription

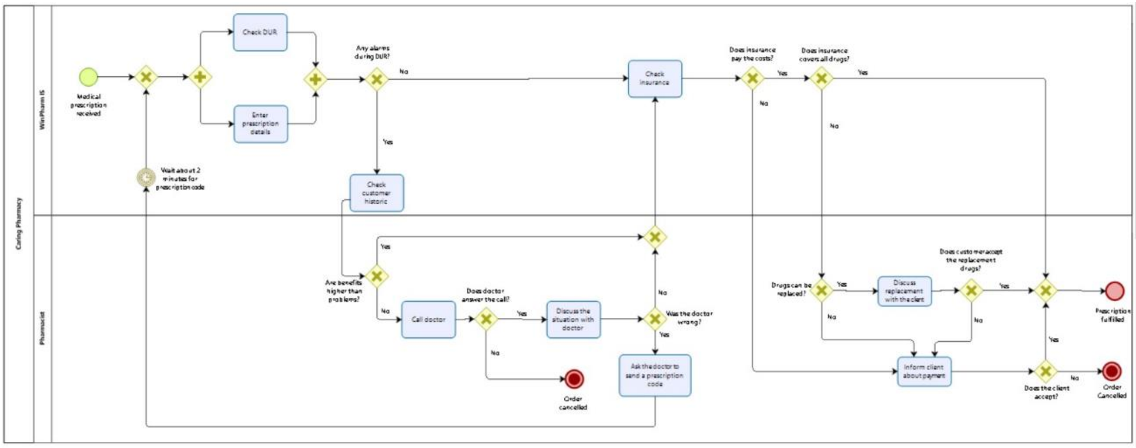

Figure 53 - TO-BE model – Enter and Check Prescription

Activity/Event	Distribution	Mean	Standard Deviation	Minimum	Maximum
Medical prescription received	Poisson	2.825	-	-	170
Enter prescription details	Uniform	-	-	0.2	0.3
Check DUR	Uniform	-	-	0.1	0.2
Check customer historic	Uniform	-	-	0.25	0.5
Check insurance	Uniform	-	-	0.15	0.5
Call doctor	Truncated Normal	0.2	0.1	0.1	0.3
Discuss the situation with doctor	Truncated Normal	5	2.5	2	8
Ask the doctor to send a new prescription	Truncated Normal	0.2	0.1	0.1	0.3
Wait about 2 minutes for prescription	Truncated Normal	2	0.4	1.0	2.5
Inform client about payment	Truncated Normal	0.4	0.2	0.1	0.6
Ask patient about the drugs to replace	Truncated Normal	2	0.4	1	2.5

Figure 54 - TO-BE Enter and Check Prescriptions Distributions and Values

In the proposed To-Be Enter and Check Prescription, we looked for decreasing the time of the subprocess by removing some Non-Value Adding activities, enhancing the performance and efficiency by automating some activities and applying resource optimization by removing the need for technicians in this process.

The Enter and Check Prescription process starts with the reception of the medical prescription by the WinPharm IS, the customer inserts the medical prescription's code number or scan its QRCode directly in the system through a tablet or a QRCode scanner while in parallel the system checks the DUR (Drug Utilization Review). If no alarm raises during the DUR checking, the system performs the insurance checking.

In the cases where any alarm raises during the DUR check, the system checks the customer historic and when the benefits are higher than the problems it can progress to check the insurance. Otherwise, if the benefits are not higher than the problems, the pharmacist has to call the doctor. If the doctor does not answer the call, the order is cancelled and the process ends, yet when the doctor answers the call, the pharmacist discusses the situation with him to assess if the doctor was wrong or not.

When the doctor was not wrong it proceeds to insurance checking by the system, in the cases that the doctor was wrong the pharmacist requests the doctor to send a new prescription through a code number or a QRCode. So, the customer and the system have to wait around 2 minutes for the new prescription, to enter again the prescription details in the system through the new code number or QRCode and perform the process once more.

Once the check insurance is made by the system, if the insurance does not cover any cost, the pharmacist informs the customer about the payment, otherwise, if the insurance covers all the costs the prescription is fulfilled. In the cases, that the insurance only covers a part of the costs and the drugs cannot be replaced, the pharmacist informs the customer about the payment, however in the cases that the drugs can be replaced by a generic drug that is covered by the insurance, it is discussed with the client. If the customer accepts the replacement, the prescription is fulfilled, but in the cases when the customer does not accept the replacement, the pharmacist informs him about the payment. After the pharmacist have informed the customer about the payment, the customer can accept it and the prescription is fulfilled or decline, being the order cancelled.

Scenario	Resource	Utilization
TO-BE	Pharmacist	26.58%
	PoA WinPharm IS	10.66%

Figure 55 - TO-BE Resource Utilization – Enter and Check Prescription

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
170/113	3.42	410.79	-	8.57

Figure 56 - TO-BE Analysis – Enter and Check Prescription

Level	Heuristic	Time	Cost	Quality	Flexibility
Task	1 – Task Elimination	Improves	Ambiguous	Worsens	No effect
Process	7 - Resource Optimization	Improves	Improves	No effect	Ambiguous
Process	9 - Automation	Improves	Ambiguous	Ambiguous	Worsens

Figure 57 - TO-BE Heuristics – Enter and Check Prescription

Heuristic 1 – **Task Elimination** was used to remove the activities 'Insert note', 'Insert justification for such a prescription', 'Inform client to return another day', 'Inform client to return another day with the new prescription' and 'Receive new prescription' as they were all classified as Non-Value Adding activities. The following activities from the drugs replacement were also removed: 'Ask client about his decision', 'Call doctor' and 'Ask doctor about the drugs to replace'. With these changes, the time will improve, mainly due the elimination of the discussion with the doctor as it was time consuming.

Heuristic 9 – **Automation** consists in the client inserting the prescription details directly in the systems through a code number or a QR code and the system automatically performing the DUR and customer historic checking. The waiting for a new prescription and its reception was also moved from the pharmacist to the WinPharm IS, since now the client can insert the prescription details directly in the system.

Heuristic 7 – **Resource Optimization** is a consequence from the last heuristic, where the only activity performed by the technician, 'Enter prescription details', in the Enter and Check Prescription was automated, so there is no need for a technician for this subprocess.

6.3 Fulfill Order

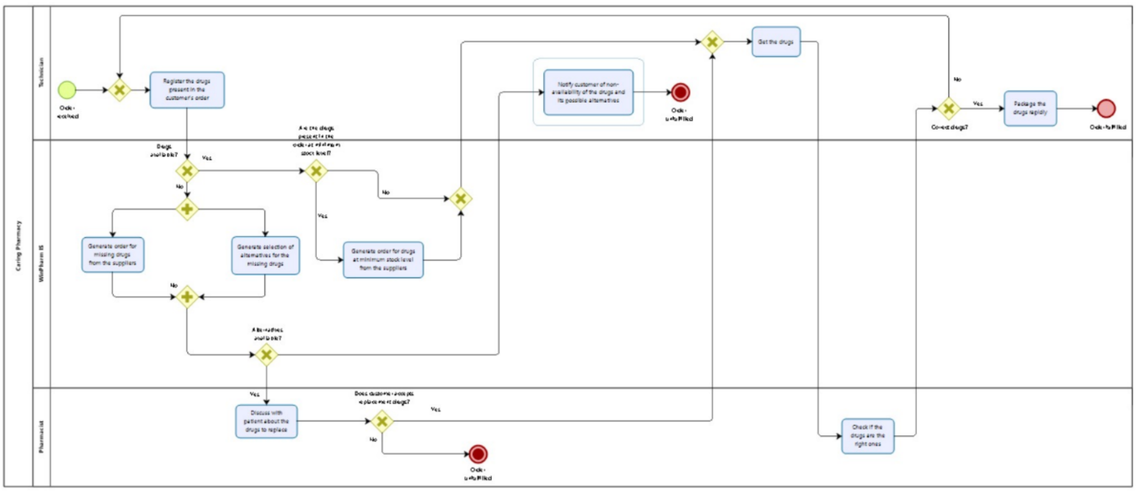

Figure 58 - TO-BE model – Fulfill Order

Activity/Event	Distribution	Mean	Standard Deviation	Minimum	Maximum
Order received	Poisson	3.096	-	-	155
Register the drugs present in the customer's order	Truncated Normal	0.5	0.2	0.2	1.0
Generate order missing drugs from the suppliers	Uniform Distribution	-	-	0.1	0.2
Generate selection of alternatives for the missing drugs	Uniform Distribution	-	-	0.1	0.2
Generate order for drugs at minimum stock level from the suppliers	Uniform Distribution	-	-	0.1	0.2
Notify customer of non-availability of the drugs and its possible alternatives	Truncated Normal	0.3	0.1	0.1	0.6
Discuss with patient about the drugs to replace	Truncated Normal	2	0.4	1.0	2.5
Get the drugs	Truncated Normal	0.75	0.375	0.375	1.25
Check if the drugs are the right ones	Truncated Normal	0.2	0.1	0.1	0.4
Package the drugs rapidly	Truncated Normal	0.25	0.1	0.1	0.5

Figure 59 - TO-BE Fulfill Order Distributions and Values

In the Fulfill Order, our rationale behind the new schematics was to reduce the cycle time of the whole process, reducing processing time and waiting time and increase efficiency.

Moreover, one of the main issues in pharmacy management is the supply management part, more specifically on how to deal with stock management and the related procurement of drugs. Therefore, WinPharm IS, as a system developed for the daily management of a pharmacy, manages the product from its entry point to its end event, when the drug is handed to customers, with all the specificities of the pharmacy business. Additionally, this proposed IS generates proposed minimum and maximum stock levels for each product, according to the current demand of drugs, it suggests orders and can be automatized to do so contingent on some predefining criteria for the IS to do so. Thus, we decided to include some of these activities performed by the WinPharm IS in the TO-BE model, which followed this schematic:

First, technician receives the order and register the drugs in the WinPharm’s IS.

Secondly, WinPharm's IS proceeds to verify if there is any stock of the drug and if it is at the minimum stock level, if so, it generates the order for the drugs from the supplier, if there are not any stock, the proposed IS generates alternatives in parallel, as well as the order for more supplies to the corresponding suppliers.

Thirdly, either technician goes to pick the original drugs (if they are available) or notify the customer of non-availability of both original drugs and the alternative ones or even the pharmacist will discuss the alternatives with the patient (if the alternatives are available).

Following that, either the order is unfulfilled, in case the patient does not agree with the replacement, or the technician proceeds to get the alternative drugs selected by pharmacist and patient. Then, the pharmacist proceeds to check if the drugs picked by the technician are the right ones.

Lastly, either drugs are packed rapidly if they are the right ones or the order must be registered within the system and all process must be redone.

Scenario	Resource	Utilization
TO-BE	Technician	10.61%
	Pharmacist	26.85%
	PoA WinPharm IS	0.55%

Figure 60 - TO-BE Resource Utilization – Fulfill Order

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
155/154	2.39	369.76	-	4.37

Figure 61 - TO-BE Analysis – Fulfill Order

Level	Heuristic	Time	Cost	Quality	Flexibility
Task	1 – Task Elimination	Improves	Ambiguous	Worsens	No effect
Task	3 – Triage Specialization	Improves	Ambiguous	No effect	Worsens
Flow	4 – Re-sequencing	Improves	Improves	No effect	No effect
Flow	5 - Parallelism Enhancement	Improves	Ambiguous	No effect	No effect
Process	9 - Automation	Improves	Ambiguous	Ambiguous	Worsens

Figure 62 - TO-BE Heuristics – Fulfill Order

The TO-BE process model generated higher resource utilization rates for the pharmacists and lower resource utilization rates for the technicians compared to the AS-IS and all What-Ifs described in this report. Additionally, both total time and average time decreased significantly despite total time waiting for resource increased a bit.

The heuristics used and the redesign proposed generated cuts in costs, through less staff being employed in the operations (two less technicians and 1 less pharmacist), and higher efficiency regarding time spent generating better service for clients.

We used both Heuristic 1 - **Task Elimination** and Heuristic 3 - **Specialization** jointly, which remove the possibility of calling the doctor to discuss alternatives, due to the low likelihood of these event ending up happening (only in 0,57% of the orders). The main reason why the likelihood of these events ended up plummeting was due to adding the check gateway for low level of stock for products within the order and the corresponding procurement activity if the stock is low, which greatly diminishes the possibility of not having both the drugs and eventual alternatives. Additionally, now the task on discussing alternatives with patients became the only option for pharmacist to discuss alternative, therefore it is also a specialization, which naturally leads to better servicing.

Lastly, by jointly using Heuristics 4, 5 and 9, e.g., **Re-sequencing**, **Parallelism Enhancement** and **Process Automation,** the AS-IS model could be improved. Generating orders for drugs missing from the suppliers automatically is re-sequencing since in the previous model assessed this activity was done on the very end of the process. Additionally, this re-sequencing will have the activity of generating alternatives for the missing drugs, another re-sequenced activity, which will lead to a Parallel Enhancement. On that note, both these activities will be leveraged by the fact that they will me automated by the new proposed pharmacy's IS, WinPharm IS.

6.4 Deliver and Payment

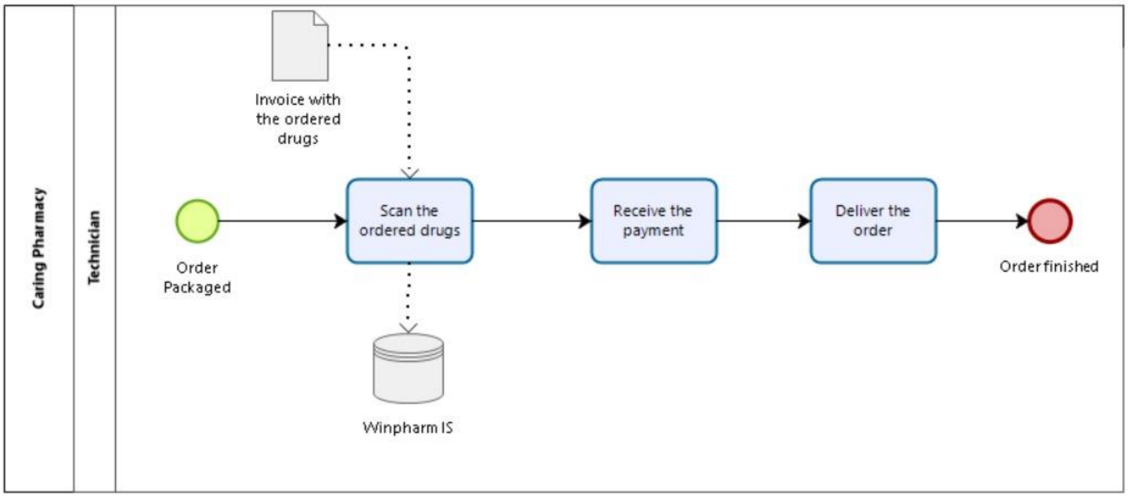

Figure 63 - TO-BE model – Deliver and Payment

Activity/Event	Distribution	Mean	Standard Deviation	Minimum	Maximum
Order Packaged	Poisson	3.115	-	-	154
Scan the ordered drugs	Truncated Normal	0.1	0.05	0.05	0.2

Receive the payment	Truncated Normal	0.5	0.1	0.2	0.7
Deliver the order	Truncated Normal	0.1	0.02	0.02	0.15

Figure 64 - TO-BE Deliver and Payment Distributions and Values

At last, in the Deliver and Payment process, we did not make major changes in the activities or in the sequence flow. Nevertheless, we introduced a new activity, right after the order is packaged, named 'Scan the ordered drugs', due to the implementation of the WinPharm IS. This activity consists in the technician scanning the barcode of the invoice containing the drugs list in order to be read by the IS and saved into it to be added to the customer history. Thus, in the future, it can save cycle time if the ordered drugs in the next time have been already ordered a previous time, being faster to check if the drugs could be ordered together or not. After this scan, the process is followed by the receival of the payment by the technician, who delivers the medicines to the customer, being both Deliver and Payment and Order-to-cash processes finished.

Moreover, there were no heuristics used to redesign the Deliver and Payment process.

Scenario	Resource	Utilization
TO-BE	Technician	1.66%

Figure 65 - TO-BE Resource Utilization – Deliver and Payment

Instances started/completed	Avg. time (min)	Total time (min)	Avg. time waiting for resource (min)	Total time waiting for resource (min)
154/154	0.71	109.41	-	0

Figure 66 - TO-BE Analysis – Deliver and Payment

7. Conclusions

In this project, our team was proposed with the challenge of improving the Order-to-Cash (O2C) process of Caring Pharmacy, in order to fight customer dissatisfaction, caused by the slowness and inefficiency of the process. This was achieved by understanding, modelling, analyzing and redesigning the O2C, as we went through all the steps needed to accomplish the proposed goals, namely the AS-IS Modelling and its description, Qualitative and Quantitative Analyses and the TO-BE modelling and corresponding description.

The Qualitative Analysis was fundamental to identify which activities and steps of the processes were more valuable to the business and the ones which were more regarded as being superfluous and unnecessary. On the other hand, Quantitative Analysis enabled to build several scenarios which took into account the amount of resources, working schedules, cycle time, statistical distributions followed by each activity and number of customers entered in each process, which, in turn, permitted to see if the processes were taking too long comparing with what was expected, which activities generated more waiting time, the resource utilization, among other technical aspects. After performing these two analyses, their inputs were combined to model the TO-BE process model, since our team already knew which activities could be removed, where could be some re-sequencing of the process, which resources could be targeted with more work, the amount of resources needed to perform each process of the O2C and which schedules suited the best to boost the efficiency of the O2C.

Considering the last assumptions, we opted to stand with a TO-BE process model which proposes Caring Pharmacy to keep just 2 technicians and 2 pharmacists, comparing with the initial 4 technicians and 3 pharmacists, allowing the pharmacy to save 3300€ per month on costs with employees, which could be regarded as capital to invest in the new WinPharm Information System proposed by our team. This IS could be of great help in handling the O2C process and the daily management of Caring pharmacy (purchase management, billing and insurance management, inventory management, drug interaction management, customer historic management, among other features), while, although not knowing the initial costs of acquiring this IS, we reckon that it could compensate a lot in the long term, considering the costs that Caring Pharmacy currently has with personnel. Despite making these changes, the initial schedule of 8 working hours per day was maintained, although there were some attempts to modify the working schedule (with shifts), which resulted in worse outcomes for the TO-BE model.

In the end, our group thinks that the proposed TO-BE model is able to end with customer dissatisfaction and the slowness and inefficiency of the process. Despite this, we advise Caring Pharmacy to put into practice this TO-BE model delivered in a Bizagi Modeler file to assess in a real-world scenario if it achieves the goals for which it was build.

8. References

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