Medication Distribution Process Improvement of the Pharmaceutical Services of Hospital Beatriz Ângelo

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September 2020

Abstract

The medication distribution in a hospital environment, as a logistical activity, is one of the most important responsibilities of the Pharmaceutical Services and it is an essential factor in the process of meeting patients' needs. This process ensures the validation of prescriptions with verification of drug interactions, dose adjustment, drug changes, among others. Additionally, this activity also guarantees the delivery of drugs in the services where they are needed and, subsequently, the retrieval of those that were not used. Currently, the Pharmaceutical Services of Hospital Beatriz Ângelo consider that the distribution of medication in unit dose is a system that can be changed or improved to ensure the use of medication in a safe and effective way. It is important for this service, and globally for the hospital, the optimization of processes that reduces costs and improve the satisfaction of its users. To study the Pharmaceutical Services operations, a conceptual simulation model was constructed in which the entities involved in the system and their respective activities were defined. Later, a computer model was created in Simul8, which allows the analysis of the effect of certain alterations. It was possible to conclude that some changes in the process have direct impacts on the use of their resources and the safety of the drug circuit. In particular, the change in the number of daily deliveries from one to three, shows itself as a structural change in the drug distribution, which increases the use of Pharmacy Technicians from 7% to 9% and Pharmacy Assistants from 2.5% to 5%, but it makes the circuit much safer. This safety is confirmed by the reduction of 60% of the time that each unit spends outside the pharmaceutical services.

Keywords: *Medication, Distribution, Dispensing, Unit dose, Hospital logistics, Discrete-event simulation, Healthcare simulation.*

1. Introduction

From 2007 to 2017, the percentage of gross domestic product spent on the healthcare industry by countries from the Organization for Economic Cooperation and Development (OECD) rose by almost 12%, and for Portugal, these expenditures remain in OECD's average, at approximately 9%. In 2013, OECD indicators showed that hospital centers are responsible for 29% of total spending on healthcare (OECD Health at a glance, 2013) and approximately 30% of these spending's are directly associated with logistic activities (Dacosta-Claro, 2002).

The medication distribution in a hospital environment, as a logistics activity, is one of the major responsibilities of the Pharmaceutical Services and is an essential factor in the process of meeting patients' needs. This process is a sequence of several activities and involves a high number of human resources which increases the risk of medication errors and, consequently, adverse reactions (Noparatayaporn et al., 2017).

The Pharmaceutical Services of Hospital Beatriz Ângelo (HBA) is responsible for the execution of crucial activities that are related to good operation of the Hospital. These include the validation and daily distribution of drugs to about 435 hospitalized patients and the follow-up and dispensing of drugs to approximately 1000 patients per month at the Ambulatory Hospital Pharmacy (Hospital Beatriz Ângelo, 2019). Considering this complex infrastructure, the Pharmaceutical Services want to adopt an adequate and optimized medication distribution system that translates into a safe and effective use of medication.

The objective of the Pharmaceutical Services of Hospital Beatriz Ângelo is to improve the distribution of medication for the different services of the Hospital to guarantee the use of medication in a safe and effective way. Thus, the objective of this work will be to propose and analyze alternatives to the current process, using a methodology that is appropriate. In this sense, the objectives are the following:

- describe the drug dispensing operations and identify their current inefficiencies;
- review scientific studies and methodologies based on the literature in order to understand what methods are available to solve the problem in question;

- build a model that is close to the reality of HBA Pharmaceutical Services;
- analyze possible changes in the current distribution process.

2. Case study

HBA's Pharmaceutical Services are responsible for the execution of activities crucial to the proper operation of the Hospital. These services are located on the 1st underground floor and have an area of approximately 840 square meters. This area includes: Pharmacotechnic; Distribution Area; 3 drug warehouses. The team has 3 Administrative members, 14 Diagnosis and Therapeutical Technicians (hereby referred has Technicians), 8 Medical Auxiliaries (hereby referred has Assistants) and 16 Pharmacists.

2.1. Medication distribution

The medication distribution is the activity that has more visibility for the rest of the hospital. It ensures the validation of prescriptions with verification of drug interactions, dose adjustment due to renal or hepatic insufficiency, administration changes, among others. It also ensures the delivery of drugs to patients and the preparation of validated medication. The objectives of this distribution are to make the drugs available at the service so that it can administrate according to the prescriptions, allowing to reduce the time of drug manipulation and, as such, the risk of preparation and administration errors (Brou *et al.*, 2005).

This is a complex system for the pharmaceutical services that requires a high and constant level of control and management. This control is carried out over three types of distribution:

- Distribution to Inpatients:
  - Distribution System in Unitary Dose
  - Stock Replenishment system
- Distribution to Outpatients;
  - Distribution of drugs subject to restrictive legislation, such as:
    - Narcotics and Psychotropics
    - Hemoderivatives

For the purposes of this work, only the distributions to inpatients will be studied. In addition, the process of Urgent Medication which is intended to help those mentioned above will be described.

The distribution of medication includes their delivery in individualized dose and in unit dose. The individualized dose is related to the amount of drugs that exists in an individual package with the necessary information, while the unit dose corresponds to the dose of medication prescribed for a given patient, to be administered at once and at a certain time. In short, it is a matter of distributing medication to each patient, with the drugs being distributed individually and at particular time.

For this system to work, it is necessary to distribute medication daily, in individual unit dose, for a period of 24 hours. Since the Pharmaceutical Services do not work on weekends for Unit dose, medication sent on Friday will have to be distributed for a period of 72 hours. For some services, the unit dose is also prepared on Saturday, i.e. for a period of 48 hours. Similarly, on holidays during the week, the medication must be distributed according to patients' needs.

In order to ease the explanation and subsequent analysis of the process, it is divided into 4 sub-processes with the objective of isolating the activities that are executed by only one member of the team: Validation, Distribution, Transportation and Retrieval.

2.1.1. Validation

The Unit dose process begins with the generation of the unitary dose map which, for each service, indicates all the new prescriptions made for the patients of that service. The Pharmacist dedicated to this service will validate the prescription to guarantee that all the prescribed medication is in accordance with the clinical file of the patient. This activity begins in the morning and, until the end of validation of a given service, all prescriptions must be checked by the Pharmacist in charge of that service. After it is finished, the map for is sent to be prepared. For the 16 services that have Unit dose, there are between 7 and 8 Pharmacists responsible for this task.

2.1.2. Distribution

After receiving the map of the day, the Unit dose cars are prepared for the service to which they will be delivered. These cars consist of sets of drawers that are received by the services. Each drawer is assigned to a patient and properly identified with his/her information. At a set time, medication for the drawers is dispensed. To perform this task, Technicians have at their disposal two vertical carousels coordinated by a computer system that speeds up medicine picking and, both carousels can be used simultaneously. There are some drugs that cannot be packed in the vertical carousels and therefore are placed, by the computer system, in an area called *Estante*. The medication distribution must be performed by two Technicians. If it is executed by only one, the medication will have to be checked by another to minimize the probability of distribution errors.

2.1.3. Transportation

When the medication delivery time arrives, an Assistant will deliver the cars the service, a process that the duration depends on the distance between the services and the Pharmaceutical Services. Then, the cars of the previous day are collected and transported back to the Pharmaceutical Services. To perform this phase, a single Pharmacy Auxiliary is required.

2.1.4. Retrieval

Back in the Pharmaceutical Services, the medication not administered is taken from the car's drawers of the previous day and these are cleaned and sanitized. The reverted medications are accounted for, organized in an auxiliary car, and introduced into the computer system by an Assistant. At the end of the working day, when the deliveries to all the services are fulfilled, a Technician reintroduces the reverted medication in the vertical carousels.

2.1.5. Urgent Medication Circuit

The urgent medication circuit is an auxiliary process to those described above and it is used to meet extraordinary medication needs that, for some reason, are not available in the service. These requests occur in cases such as a new patient entering the service after delivery of the Unit dose, the need for medication that is not available in stock, or unfilled stock replacements.

To make an urgent medication request, the services' nurse makes a written request with the patient information and the medication needed, following a medical prescription. This order is either delivered by hand in the Pharmaceutical Services or arrives via a pneumatic tube transport system present at various services of the Hospital. This process, as for all previous cases, requires validation of a Pharmacist and is prepared by the Technician or Assistant depending on the characteristics of the drug. If validated, it is sent by the vacuum system or, if the dimensions do not allow it, it is delivered by hand to the nurse of the service that made the request having to go to the Pharmaceutical Services in person. This request can happen at any time of the day, at the same time as other activities and sometimes, if necessary, stop regular activities to attend these urgent requests.

2.2. Problem Identification

Considering that the processes described, it is clear their complexity and the demand for human resources. It is in the interest of the Pharmaceutical Services to find the procedures that best suit the needs of the entire Hospital and that minimize errors and costs related to medication, as well as optimize the use of their human resources.

When analyzing medication distribution, inefficiencies are identified that are not in line with the objectives of the Pharmaceutical Services in this activity, which are:

- Increase safety in the drug circuit;
- Understand the pharmacotherapeutic profile of the patient;
- Decrease the risk of interactions;
- Better rationalize the medication;
- Allocate more correctly the costs;
- Reduce waste.

3. Literature review

Hospital Logistics regards the process of handling physical goods (e.g. drugs, surgical materials, medical equipment, clothing, meals, etc.) and the respective information flows, from the reception of goods from the outside of the hospital to the delivery to patients in the different hospital services (Moons, Waeyenbergh, and Pintelon, 2019). In the past, compared to other industries, hospital logistics and management internal flows have not been given the priority required. The reasons for the lack of attention are related to the complexity of the hospital supply chains and the importance that has been attributed to the hospital's main objective, which is the patient's wellbeing (Beier, 1995).

For healthcare staff and researchers, the potential for optimizing the hospital internal logistics is significant. The main advantage being that the decrease in costs does not directly affect the quality of service to the patient. Consequently, the hospital's main goal is to have a coordinated system that attends to its patients with great efficiency and quality, at a reasonable cost, making the hospital resources available when and where they are needed (Hall, 2012).

The medication distribution is one of the most important responsibilities of the Pharmaceutical Services being an essential part in the process of meeting patients' needs having a clear impact on the effectiveness of their treatment. This process is composed of several activities and involves a high number of human resources which increases the risk of medication errors and, consequently, adverse reactions (Noparatayaporn et al., 2017).

Regarding dispensing and distribution of medication, it is defined first the distribution with prior intervention of the pharmacist with the main objective of knowing the pharmacotherapeutic history of the patients. Pharmaceutical intervention starts before dispensing and administering the medication, actively collaborating in reducing medication errors, interactions, and adverse reactions. The unit dose distribution system is the one that best represents the described situation. The reason that drove the implementation of unit dose in the middle of the twentieth century was to improve the safety of the patient's therapy and the reduction of errors that arose with other methodologies (Barker, 1969). Other objectives of unit dose are: rationalize the distribution; ensure compliance with the medical prescription; ensure the correct administration of medication by the nursing team; enhance the role of the pharmacist in patient safety.

3.1. Discrete-Event Simulation

Several simulation methodologies could be chosen to solve the problem described. Simulation of discrete events is identified in the literature as a good tool for this type of problem (Gray et al., 2013; Wong et al., 2003). Law and Kelton (1991) explain that for the system to be simulated, it must be:

- Discrete, having state variables that vary at discrete moments;
- Representative of a dynamic system that varies over time;
- Stochastic, instead of deterministic, having random variables;
- Studies operational problems that can be analyzed quantitatively.

Some authors focus on the new technologies to be used in Hospital Pharmacy, in particular, the use of Automated Distribution Systems. Fitzpatrick et al. (2005) evaluate the effects of the implementation of these systems in Hospital Pharmacies emphasizing the reduction of distribution errors and increased satisfaction of the Pharmaceutical Services administrations. Granlund and Wiktorsson (2013) also address problems associated with the implementation of these systems the learning curve of the entities involved and the necessary starting investment. Gray et al. (2013) analyzed the problem of a hospital where 64% of the drug distribution was with Unit dose cars (similar to the reality of HBA) and 36% using SDA. The authors defined scenarios involving different combinations of Unit dose and SDA car use and, using simulation, came to the conclusion that the change intended by the Pharmaceutical Services (changing distribution only to SDA) was not profitable in terms of costs and human resources utilization.

The models created are convenient and important for hospital management to visualize and make decisions based on inefficiencies detected in the system. It also allows the creation and study of new configurations for the system (Fialho, Oliveira e Sá, 2011). It is important to understand what are the gains that the discrete-event simulation provides to the study of healthcare systems. Davies and Davies (1994) and Karnon (2003) compare discrete-event simulation to other methodologies such as Markov's chain analysis, input-output analysis and queue analysis. The authors conclude that this methodology is adjusted to healthcare systems modeling due to its complexity. On the other hand, some optimization techniques, such as linear programming, are limited in what concerns the characterization of these complexities.

4. Methodology

A methodology that involves the decision makers and specialists in the process of modelling and simulation was used. Thus, and according to the literature review, the methodology entitled Modelling Approach that is Participatory Iterative for Understanding (Baldwin, Eldabi and Paul, 2004) will be applied as seen in figure 1. The main objective of this methodology is to use modeling as a discussion between the model and stakeholders, allowing:

- Detailed understanding of the model;
- Better perception of its components;
- More specialized contribution in its construction and possible changes.

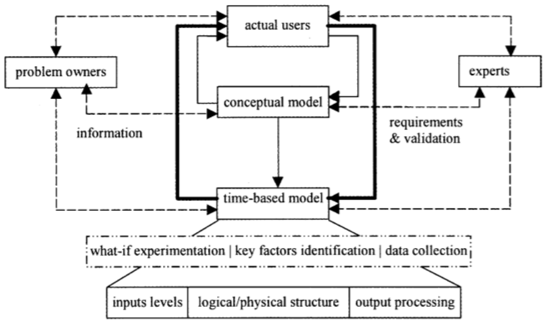

Figure 1 - MAPIU overall structure

This methodology also makes it possible to structure the problem and its actors in a clear way that considerably reduces its complexity and understanding. With this objective, the procedure suggested by Baldwin, Eldabi and Paul (2004) was followed, which is structured in the following steps:

- Initialization
- Processing
- Modeling

Given the iterative nature of this process and to implement this methodology the best way, regular meetings were held with the decision makers and specialists of the Hospital. Demonstrated by the regular interventions and feedback from the system entities, it is in the author's opinion that the meetings and presentations turned the modeling process into a joint problem. That was clear when making proposals that added value.

To create the model of the distribution system it is necessary to define the entities in it. These entities are the basic elements that directly influence efficiency of this system (Ferreira, 2012) and are categorized into: permanent that indicate that these resources are constantly present in the system during the simulation; temporary that enter and leave the system.

- Permanent
  - Pharmacist
  - Technician
  - Assistant
  - Carousel

- Temporary
  - Unit dose medication
  - Urgent medication

Data collection was one of the points discussed in the meetings with the Pharmaceutical Services. It was agreed with decision makers that the best way to approach this would be to jointly define the dates and services in which data would be collected, produce record sheets for data that are not computerized, and prepare a presentation to show to all staff of the Pharmaceutical Services what would be developed.

The data collection at HBA took place in the month of November 2019 as it was a representative month of the normal operation of the hospital according to service staff. The selection of services was made by the decision makers to generate a representative amount of the hospital without influencing its normal operation.

During the construction of the model (figure 2), there were attempts to create a single circuit in which the differentiation of services took place with labels. However, reaching the picking stage, the modeling became too complex, being impossible to discover and solve the errors that arose. Taking this into account, the model was designed with two circuits in parallel, which solved this issue.

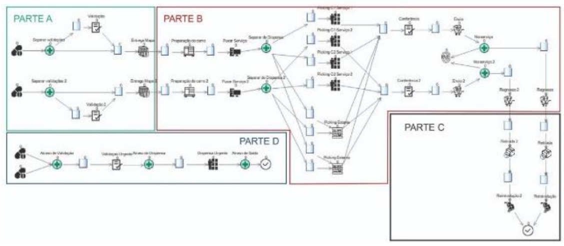

Figure 2 – Simulation model

This model was validated and verified in order to ensure that its operation was similar with what was expected and that it worked as a real representation of the system.

5. Results and Discussion

After checking and validating the model and confirming it works as intended and it's a good representation of the real drug distribution system, it is now important to use this tool to test solutions that can improve its operation. These solutions were generated not only by frequent discussion with specialists and decision makers, but also by observing the system and its operation for more than 3 months on site. All the following solutions are possible to implement, without requiring large investments.

With the possible changes to the current system, it is intended to weigh both the quantitative gains that the simulator reproduces, and the qualitative gains that experts and decision-makers anticipate with these changes. The qualitative advantages are of great importance for the decision makers because they include issues such as the safety of the drug circuit, the guarantee of drug delivery, validation of all prescriptions and the impact of changes in the distribution organizational structure.

5.1. Experiment 1 – Service combination

Observing the results illustrated in figure 3, there are variations in resource utilization. It can be observed that the pairing of slightly different services (scenario 2) leads to a slight increase in the percentage utilization of all resources. On the other hand, the scenario with very different services (scenario 3) leads to a reduction in the utilization of all pharmacy resources compared to the two previous scenarios. This difference is more noticeable for the Pharmacist and the Technician who reduce 40 minutes and 15 minutes respectively, from scenario 1 to scenario 3. The behavior of the average time of urgent medication follows the same trend as the percentage of use.

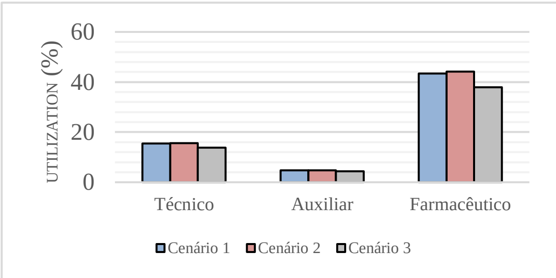

Figure 3 - Experiment 1 Resources utilization

Regarding the drugs average time in the system, there was no change as expected. Since the time between sending the map and sending the medication is defined, these changes could not influence the final average. However, it makes sense that these changes have an influence on the queues preceding the picking of medication. To evaluate this detail, the average waiting times prior to the use of the carousels were calculated. There is a reduction of approximately 6.5 minutes if the paired services are considerably different. This reduction in waiting becomes even more apparent considering that the pharmacy does this process for 8 pairs of services.

Against initial expectations, the pairing of quite different services can improve the performance of the distribution system. The decrease in resource usage associated with shorter queue time shows that this change leads to greater efficiency of the staff. In order to study this possibility, it is proposed to make an analysis of all hospital services and study the pairing of services with very different needs. The change of regular schedules of services may be one of the difficulties in implementing this change.

5.2. Experiment 2 – Urgent medication circuit delay reduction

This experience focused mainly on the urgent medication circuit parallel to the unit dose (figure 4). As mentioned before, it shows the influence of reducing or eliminating delays in the validation, dispensing and delivery of the urgent medication. The elimination of these delays has no influence on the average time the drugs are the main system. The usage of staff does not vary, which points to the small operational influence that the urgent medication circuit has on the unit dose circuit.

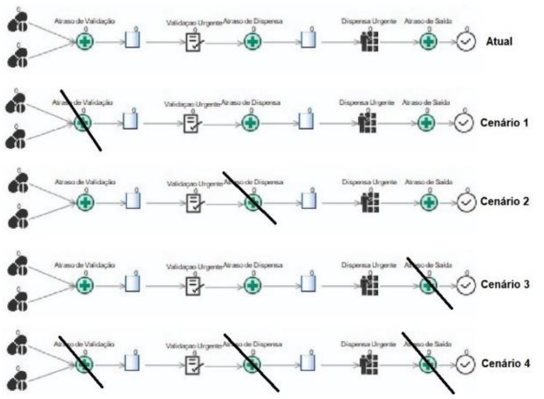

Figure 4 -Scenarios of Experiment 2

From the request for urgent medication (entry into the system) to being sent (exit of the system), the process lasts on average approximately 7 hours. This high value is due to the impossibility of dealing with these requests outside stafs' working hours. Nevertheless, the elimination of these delays has a considerable influence on the time the process takes, which is directly related to the service level of this circuit.

The elimination of the validation delay (scenario 1) reduces the time in the system by approximately 19 minutes per drug (see table 10). This time is justified by the location where most orders are received. They arrive at the pharmacy via a pneumatic transport system that is outside the circuit of all staff, causing them to often wait for validation even though there are pharmacists available. Knowing that changing the pneumatic system is not possible because it is incorporated in the hospital's infrastructures, it is proposed that sending the requests for urgent medication by the services should be altered. Making the requests electronically to the pharmaceutical services not only guarantees the reduction of the waiting time, but also makes the circuit safer.

Regarding the delay in dispensing (scenario 2), it appears that changes implemented to minimize this delay would have a considerable effect on the average time of urgent medication in the system. This scenario estimates a reduction of approximately one hour to the current situation, which is quite considerable in regard to the previous case. This delay is due to one of two reasons: the requests are waiting in the pharmacists' room until they are taken to the dispensing zone; the requests are waiting in the distribution zone next to the carousel. To reduce the impact of this waiting time, it is proposed that there is a Technician whom will be assigned to a request (or set of requests) to ensure the speed of the process, right after the validation. It may be necessary to assess whether the medicine is indeed urgent because, although it is in this circuit, it does not indicate that the medicine is needed as soon as possible.

Similarly, the elimination of the exit delay (scenario 3), reduces the average time in the system by approximately 19 minutes compared to the current process. This situation does not depend only on the pharmaceutical services because there are two ways of exit: pneumatic system and delivery by an employee of the service. One way to reduce or eliminate this wait would be to pass the delivery of the medicine in the service to the responsibility of the pharmaceutical services.

Finally, the study of the removal of all delays (scenario 4), making the system dependent only on the availability of resources, shows that there is a reduction of approximately one hour and forty minutes in the average time of the urgent drug in the system, compared to the current situation. This value is considerable considering that it represents 23% of the total time that the drug is in the system. All the changes proposed previously make this time attenuated or eliminated, also making the circuit safer.

5.3. Experiment 3 – Reduction of number of drug units delivered

The third experiment relates to the removal of some drugs from the unit dose circuit. This withdrawal leads to a decrease in the rate of drug arrival at the pharmaceutical services. This reduction will result in a decrease in the number of drugs consumed in the service as well as in the number of retrieved drugs. However, it is important to verify what is the change in the percentage of employee usage. This result allows to verify if the decrease in the flow justifies this change. As can be seen in figure 5, decreasing in usage is apparent for any of the resources. This decrease has a bigger impact of usage for the Pharmacists and Technicians.

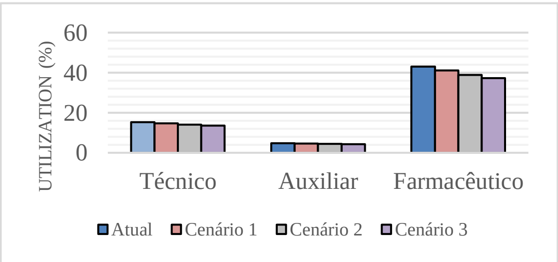

Figure 5 - Experiment 3 Resources utilization

It should be noted that this change may influence values implemented in this model such as the percentage of validated drugs and the percentage of drugs retrieved. The expected decrease in the percentage of retrieval that occurred in the 2018 stage, had direct effect on the usage of Assistants in the "Revertências" activity, as well as the decrease in the number of drugs that goes back and forth making their preparation not needed.

Finally, this change has the disadvantage of passing certain drugs to the warehouse that is in service, having a direct impact on the safety of the drug and the replenishment of stock levels.

5.4. Experiment 4 – Delivery number alteration per day

Finally, the biggest structural change tested that, if implemented, would make the pharmaceutical services work 24 hours a day. Since the resources are now constantly available in the simulation, the results of this experiment are not comparable to the previous ones. When analyzing figure 6, the Technicians and Assistants increase their use considerably as shipping moments are added, unlike the Pharmacists which remains unchanged. There is also a considerable difference in the average time the drugs spend in the system, both those taken and those retrieved.

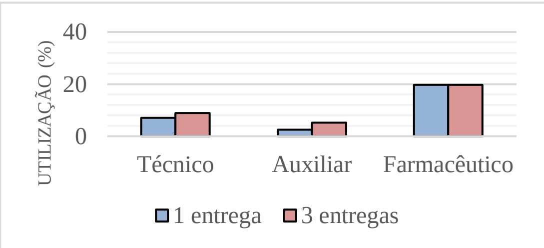

Figure 6 - Experiment 4 Resources usage

For the drugs that are consumed in the system, there is a decrease of approximately 70% of the average time they spend in the system from the current situation to 3 daily deliveries (scenario 1). It is also clear the time decrease for the retrieved drugs that decreases in approximately 60% of the current situation to 3 daily deliveries. This considerable decrease, which is directly related to the safety of the drug circuit, is associated with an increase of approximately 28 minutes of usage for the Technicians and approximately 38 minutes for the Assistants. It was also verified that the constant availability of resources leads to a much more efficient urgent medication circuit, taking, on average, 85 minutes send.

Regarding the 6 daily shipments (scenario 2), the differences are even more apparent. The Pharmacists usage remains unchanged, but those of the Assistants and Technicians increased considerably (see figure 7). The Technician has an increase of work of approximately 74 minutes and the Assistant of approximately 82 minutes compared to the current situation. This increase reduces the average time of the drug consumed in the system by approximately 75% and the average time of the drug retrieved by approximately 82%.

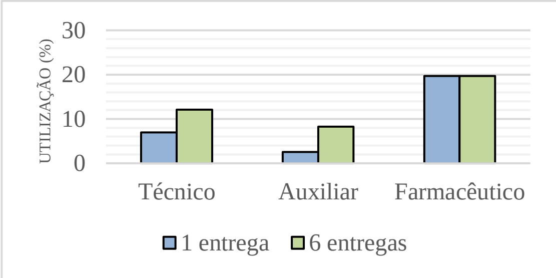

Figure 7 - Experiment 4 Resources utilization

The internship carried out in 2018 showed that, with the increase of deliveries to 3, the percentage of retrievals and the number of drugs sent decreased. It was identified that it was frequent to send drugs to patients who were no longer in service and therefore these would have to return to the pharmacy. The increase in the number of deliveries causes these situations to happen less regularly, which leads to less drugs being sent and a reduction in the percentage of retrievals. That said, an analysis was made to study the influence that these changes may have on the above-mentioned scenarios. However, the changes made have the same results as in previous experiences:

- Reducing the percentage of drugs sent reduces the usage of technicians without influencing the time they spend in the system;
- Decreasing the percentage of retrieval decreases the percentage of Assistants usage without influencing the time they spend in the system;
- The average time of urgent medication remains unchanged due to its reduced influence on the unit dose system.

These changes to the system created a safer drug circuit, and a better correspondence between the drugs sent and consumed, thus eliminating unnecessary work. However, the considerable weight this change has on the usage of resources must be considered.

5.5. Comparation between experiments

A Summary with performance indicators was made regarding the current HBA Pharmaceutical Services system.

Regarding the elimination of the delays in the urgent medication circuit, the main advantage is the reduction of the time that each drug spends in the system. This faster response is directly related to a better level of service.

Regarding the changes for three and six deliveries, the usage of resources is higher and considerably higher, respectively. However, this greater usage is directly related to the reduction of the average time that each drug spends in the system. This represents a smaller fraction of the time that the drug is outside the Pharmaceutical Services, thus ensuring greater control.

The indicators represent the results that the simulator allowed to measure. However, it is expected that the changes explained will influence certain parameters that were measured during data collection. In particular, the number of drugs sent in Unit dose and the number of retrievals. Other factors such as the safety of the circuit, the use of the urgent medication circuit and the complexity of implementing the change.

First, the combination of services has no changes in any of the parameters indicated. However, it was concluded that pairing very different services has a positive operational influence, by reducing the waiting time between carousels. This change may cause the interval between sending the map and sending the drugs to the service to be reduced. For this implementation it is only required to know the needs each service, easy to acquire by the Pharmaceutical Services.

In relation to the reduction of urgent medication delays, this change may increase the safety of the medication circuit within the Hospital. Turning the requests computer based, instead of being on written paper as it is at this moment, reduces the risk of misinterpretation and the reduction of waste. However, these changes are complex because their execution requires resources external to the Pharmaceutical Services.

Then, the main negative point of the reduction of drugs requested per day is the loss of safety of the drug in the system. This reduction of orders happens if part of the drugs that are in the unit dose circuit are present in the warehouses of each service, making it unnecessary to send them through this process. However, the inability of the Pharmaceutical Services to control them is considered a disadvantage. On the contrary, this implementation is expected to reduce the number of drugs sent in unit dose, which reduces the work of the Technicians, and the reduction of retrievals, which reduces the work of the Assistants. The reduction of retrievals is also an indicator that the drugs sent to the service are in better accordance with the actual consumption of the patients present in the hospital. Because of the internship developed in 2018, this change to service 2.1 showed good results that this experience confirms.

Finally, the change in the number of daily deliveries presents itself as the most complex implementation, but the expected results seem to be quite advantageous. Firstly, the increase in the drug circuit safety, directly linked to the time they spend outside the Pharmaceutical Services. Secondly, a reduction in the number of drugs sent is expected as these will be more in line with the reality of the service. The risk of sending medication to patients who will no longer be in service is considerably reduced. This effect also makes the percentage of retrieval decrease and thus reduces the replacement work of the Pharmaceutical Services. Finally, it is expected that the use of the urgent medication process that serves only to fill failures in the main unit dose circuit are reduced.

6. Conclusions

The results of the solutions tested showed results that are important to consider, should the Pharmaceutical Services decide to change the distribution structure of medication in the hospital. It was found that pairing services with different drug needs can improve system performance. This change is easy to implement and it is only necessary to know the service's needs. It was analysed and discussed possible changes in the urgent medication system that considerably influence the time they spend in the Pharmaceutical Services. If all delays are solved, an average of one hour and forty minutes of this time can be reduced. It was also assessed that a reduction in the number of orders per day has an influence on the use of pharmacy resources. Although this result is intuitive, it was important to quantify this change, so that a possible loss of control over the drug by moving to advanced warehouses is justified. Finally, it was analysed structural changes in the dispensing of drugs from one delivery per day, to three and six. These changes showed that the use of resources would increase considerably, although the drug circuit would become safer, verified by the lower percentage of retrieval expected from this change.

As main difficulties of this work, the data collection in Pharmaceutical Services was the first. This collection was done on paper, which made the registration of data in computer very slow. However, the constant availability of all Pharmaceutical Services staff who have always been useful and interested in the work to be developed should be highlighted. Another difficulty that influenced the duration of the development of this work was the little support that exists for *Simul8* software. Many barriers were overcome using techniques that may not be the most efficient, but which were built with the available information.

This work intends to be, at the same time, the continuation of the internship in the summer of 2018 and the beginning of a work of constant development and improvement of the HBA drug distribution system. It is the intention of the entities involved in this project to continue the development of this work, in order to create a model of all the activities of HBA medication distribution. It is proposed that the simulation model developed in this work be revised to reduce the simplifications made. Once the limitations of this model have been overcome, the extension to all HBA services is a step that must be taken in order to test the influence between pairs of services, a detail that has not been taken into account in this work. It is also suggested that a model should be created, that takes into account the three types of distribution of Pharmaceutical Services (replenishment of stock levels, distribution of unit dose and distribution of urgent medication) and that is linked to inventory management. A model with all these components could be very advantageous for inventory planning and operations of the Pharmaceutical Services, not only for HBA, but also for other Hospitals in the country.

7. References

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