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A SIMULATOR TO IMPROVE PATIENT'S SERVICE IN A NETWORK OF CLINIC LABORATORIES

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ABSTRACT

The general objective of this work is to present a generic simulator to be used in a network of clinic laboratories of the company ACHS-Arauco Health in Chile, which is to be used to standardize the service processes, the assignment of personnel and to guide investment decisions. The specific objective is to reduce the time in the system of the patients. The resulting simulator should represent all the laboratories of the company and use an electronic sheet as an interface for the parameters.

To build the model, the exams were grouped in different families and the process times and resources demanded were studied for each one of these families. The model was validated by experts and implemented with ARENA and EXCEL. Different configurations of resources were studied to detect bottlenecks, which allowed us to reallocate personnel to peak hours, to redesign facilities and to reduce the waiting time of the patients.

1 INTRODUCTION

This work presents a generic simulator of a clinical laboratory developed for the company ACHS-Arauco health, which has a network of laboratories in Chile. The simulator is to be used to standardize the service processes to clients, the assignment of personnel for each laboratory and to guide the investment decisions. One specific objective is to reduce the time in the system for the patients. The resulting simulator should be the sufficiently general to represent all the laboratories of the company and to be used by the chief nurse of the laboratory who will interact with the system through an electronic sheet. To build the simulator, families of exams were generated and the process times and resources demanded by each one determined. Information was provided by the chief nurse and the personnel of the lab, which was complemented with direct observations of the system and from computerized information records.

Different scenarios were studied to identify bottlenecks and to achieve a better reassignment of resources. It is necessary to point out that the main characteristic of the simulator is that all the resources involved in the operation of the lab are parameters that can be changed through an electronic sheet, in a highly user friendly environment, to study different operating conditions.

2 SYSTEM DESCRIPTION

The flowchart of a typical patient's process is presented in Figure 1. The process begins when a patient and his or her companions arrive at the laboratory, take out a ticket number and wait to be called by a receptionist, who consults the patient about the type of exams that he/she requests. Once assisted, the patient waits to be called by a technician to carry out the requested exams. The exams were classified in: blood, urine, gynecological, secretions, or a combination of them. Once the exams are carried out, the patient leaves the area of exams and meets with her companions to abandon the system.

Depending on the type of exam demanded by the patient, he is directed by the paramedic to a specific box to carry out the exam. For example, those of gynecology go toward the gynecological box, which is endowed with a special chair, a bathroom and of all the necessary elements for this family of exams.

From a schematic point of view, the generic clinic lab consists of an infirmary unit, 7 boxes for blood exams, 2 bathrooms, 1 box for gynecological exams and the corresponding annexed units.

3 DATA COLLECTION

The data were gathered for several days having peak demand, identifying these as Tuesdays, Thursdays and Saturdays. Inter-arrival times and services times were measured in different areas of the lab and represented by different

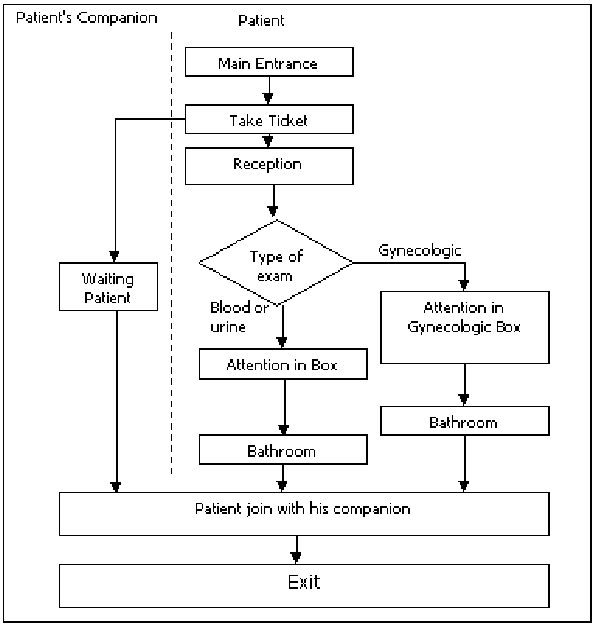


Figure 1: Schematic Patient Process

distributions. With the help of personnel from the laboratory, the exams were grouped in 7 different families. Some examples of the fitted distributions and the personnel working at different times of the day is shown in Table 1. For example, the inter-arrival times of patients from 8:00 to the 12:00 o'clock is Gamma distributed with parameters alpha of 163 and beta of 0.71, and both the number of lab technicians and receptionist in the same interval is 4 persons.

4 MODELING ASSUMPTIONS

In order to build a model, it was necessary to defines entities, attributes of the entities, variables, expressions, static values, resources, groups of resources, drawings and stations. The only entities considered in the model are the patient with their respective companions. Similarly, since the objective of the study is patient throughput, the laboratory technicians, receptionist, nurses and staff are modeled as generic resources differentiating them on their specific role.

Beginning at 7:30 in the morning, patients arrive with a probability distribution show in Table 1, and each arrival consists of batches of one patient with one, two or three companion. The service time of the receptionist is independent o the type of exam, but the service time at the exam box is different for each family of exam.

The human resources used by the model include: 1 nurse, 1 medical technologist, medical technicians and receptionist as shown in Table 1.

5 SAMPLE SCREEN

In Figure 2 it is presented a sample of the animation screen of the model which was implemented in Arena. Patients and his companions arrive to the system, take a ticket and wait for service. Then a medical technician will call the patient to take the corresponding exam(s). From the same figure it can be seen that dynamics statistics are reported about: the number of patient assisted, the percentage of occupation, cycle times of the receptionist and for the medical technicians, average waiting times and the number of persons waiting and served.

Table 1: Estimated Distributions

Time schedule (hrs.)		Distributions		
From	To	Inter Arrival Time (seconds)	N° Lab. Technicians.	N° receptionist
7:30	8:00	Expo(150)	1	1
8:00	12:00	Gam(163, 0.71)	4	4
12:00	14:00	Expo(400)	2	2
14:00	16:00	2 + weib(125, 0.839)	4	4
16:00	18:30	Expo(300)	3	3
18:30	21:00	Expo(2000)	1	1

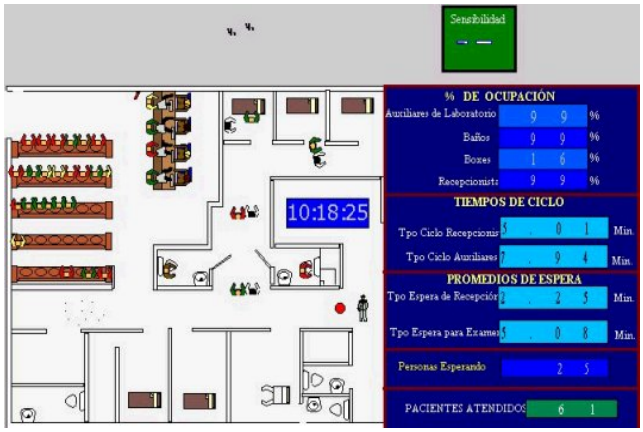


Figure 2: Animation Screen

6 MODEL VALIDATION

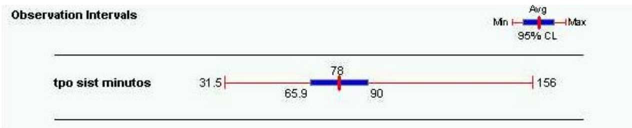
To validate the system aspects of the model, production runs were made and the results validated with physicians and nurses, and compared to actual data capture at the lab. Similarly, the animation was of help as a communications and verification device, since it allowed to track patients as they moved through the system. Since nothing unusual was detected, the model was accepted as valid.

7 SCENARIOS

Several improvement alternatives were analyzed in this study. However, just one of them is presented in this paper to illustrate the use of the simulator. This scenario offers the most significant impact in the system's performance. The description of the "as is" situation and the alternative scenario is presented next.

7.1 As is Scenario

The As Is Scenario (AIS1) considers the actual situation of the laboratory as shown in Figure 1. It was decided to use as performance measures the average time in the system and the average number of patients waiting to be served in the system. Figure 3 shows the 95% confidence interval for the average number of patients. These results were obtained running 30 replications. Figure 3 shows that the patient's average time in the system is equal to 78 minute. The average number of people waiting using this working scheme is presented in the next it figures.



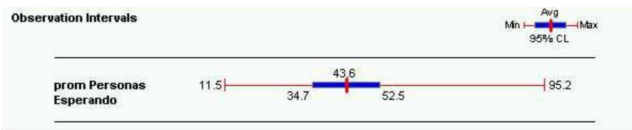
Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS
tpo sist minutos	78	32.3	12	31.5	156	30

Figure 3: Patient's Time in system (AIS1)

Figure 4 shows that the average number of clients waiting in queue to be served by the receptionist and the medical technicians is around 43.6 persons.

The next step in the study was to generate an alternative that could offer better performance results in terms of number of patients and time in the system. One of the alternatives studied is presented in the next section.



Classical C.I. Intervals Summary

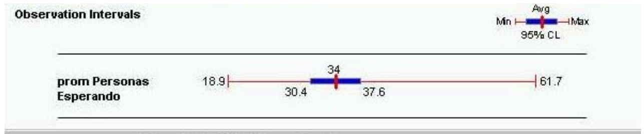
IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS
prom Personas Esperando	43.6	23.8	8.89	11.5	95.2	30

Figure 4: Average Number of Patients Waiting (AIS1)

7.2 Alternative Scenario

The Alternative Scenario (AS2) was to assign 6 technicians to the 8:00 hrs to 12:00 shift, where the peak demand was observed, and only 2 assistants to the 14:00 to 18:30 hrs. interval. In this way, more personnel is assigned to serving the clients.

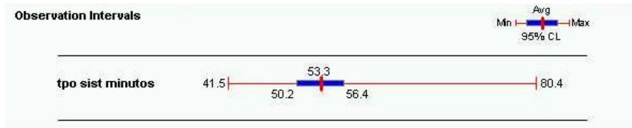
In Figure 5 and 6 it is shown the improvement with the new assignments. The average number of persons waiting is decreased to 34 clients and the average time is



Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS
prom Personas Esperando	34	9.62	3.59	18.9	61.7	30

Figure 5: Average Number of Patients Waiting (AS2)



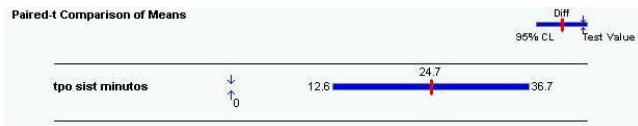
Classical C.I. Intervals Summary

IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS
tpo sist minutos	53.3	8.28	3.09	41.5	80.4	30

Figure 6: Patient's Time in system (AS2)

the system is decreased to 53.3 minutes. The confidence interval showing these results is presented next.

In order to confirm these results from a statistical point of view, a *pair-t test for comparison of means* was conducted. The results obtained from the test show that there is significant difference between the two scenarios in terms of average time in the system. This test shows that the hypothesis that patient's average time in the system *in both scenarios is not different*, was rejected with a 95% confidence. The difference observed was 24.7 minutes. Figure 7 presents the plot showing the hypothesis rejection.



Paired-T Means Comparison :

IDENTIFIER	ESTD. MEAN DIFFERENCE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS
tpo sist minutos	24.7	32.3	12.1	31.5	156	30
				41.5	80.4	30

REJECT H0 => MEANS ARE NOT EQUAL AT 0.05 LEVEL

Figure 7: Pair-t test for Comparison of Mean for Patient Time in System

8 CONCLUSION

The management of the laboratory wanted to improve the service conditions for their clients. They wanted to know which were the bottlenecks and what had to be done to eliminate long waiting times for service in all their facilities. With this in mind a generic simulator was built, which allowed us to study different scenarios. The resulting model is user-friendly because all the possible resources used in the lab are parameters that can be changed from an electronic sheet. Thus, the user of the model has a management tool to study and improve the performance of the system when facing different operating conditions. As an example, the management wanted that, as a service conditions, no patient had to wait more than 5 minutes in queue. It was determined that this was not possible with the existing number of boxes.

The equipment used to process the exams was not included in the model because they were not a restriction at the moment. But a more general model it should include equipment capacities.

For the example that was presented to illustrate the use of the simulator, it is concluded that with no investment, only reassigning the personnel to different shifts, a significant improvement for the clients is achieved. The lowest time in system is achieved assigning 6 medical technicians to the morning shift, from 8:00 through 12:00.

The simulator can be run for any time of the day, not only for the peak hours, and for any configuration of resources of a clinic labs were there are two serial servers with their respective queues. Certainly, it is useful for the network of labs the company has in Chile, which range from one receptionist and one medical technologist to more than 40 employees. Because of the user-friendly built-in interface, any person can run the model with a basic training in statistics.

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