Simulation Of Oncology Unit: A Construction In Simio Software From Source Until Goodness Of Fit Test

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Abstract : *Simulation of discrete events is currently a trend, in addition to the already known production systems, it is analyzing services based on the observation of the agents that interact in the system, allowing to use an adequate approach with respect to reality at low cost and guaranteeing reliability in decision making based on the modification of variables and their consequences. Therefore, the construction of a model in the area of health is presented step by step, to provide essential knowledge of simulation and serve as a reference for more complex models.*

Keywords -Input Simulation, logical simulation construction, Management of operations in health, track results

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I. Introduction

In services there is generally a study interest due to the different implications it has on people's life quality. So, the health sector, where care must be timely in order to prevent and address the symptoms presented by the patient, results one of the most important to study.

Affirmations of other investigations, prove it:

"The hospital's leadership desired to improve the discharge time of day in order to alleviate the scarcity of available bed space for new patient intakes" [1]

"Experience a high volume of retentions in the emergency department. They believe that inadequate capacity in hospitalization units is causing these arrests" [2]

"In order to prevent negative consequences of high workload, methods must be created to manage and balance workload among healthcare providers" [3]

All these approaches in solving different problems to improve the work environment as well as patient care, are the reason of the paper is focused the subsector ofpatients receiving oncological administration, because it addresses one of the diseases with more medications, treatments and therefore has great uncertainty of the time of care.

The present paper offers an overview of the simulation from the experience proposed in an oncological unit, to give a guideline regarding the reduction of uncertainty in patient protocols. As well as, serving to reference those who are beginning in the knowledge of the simulation, then, it provides concrete descriptions of the tools used and their analysis during the approach of procedural reality in a software that determines different variables in a dynamic system with a wide range of application options.

II. Oncology Unit

1. Source of information

From a private non-profit entity that provides specialized health services based on the cancer's management of a comprehensive modein Colombia that is characterized by its excellent service implementing improvements through from different studies.

So, as part of this initiative is the theoretical and procedural support. Likewise, among the management activities carried out are the diagnosis using a VSM (Value Streem Mapping), the characterization of the process in the Oncology Unit, the study of times to the corresponding activities and the identification of the strategic control points raised respectively through the indicators.

All the above offers the reliability and traceability necessary for the respective organizational feedback. However, this information is private, so it will not be exposed in the article. Rather, based on all this, the comprehensive approach is directed to the simulation of the oncology unit.

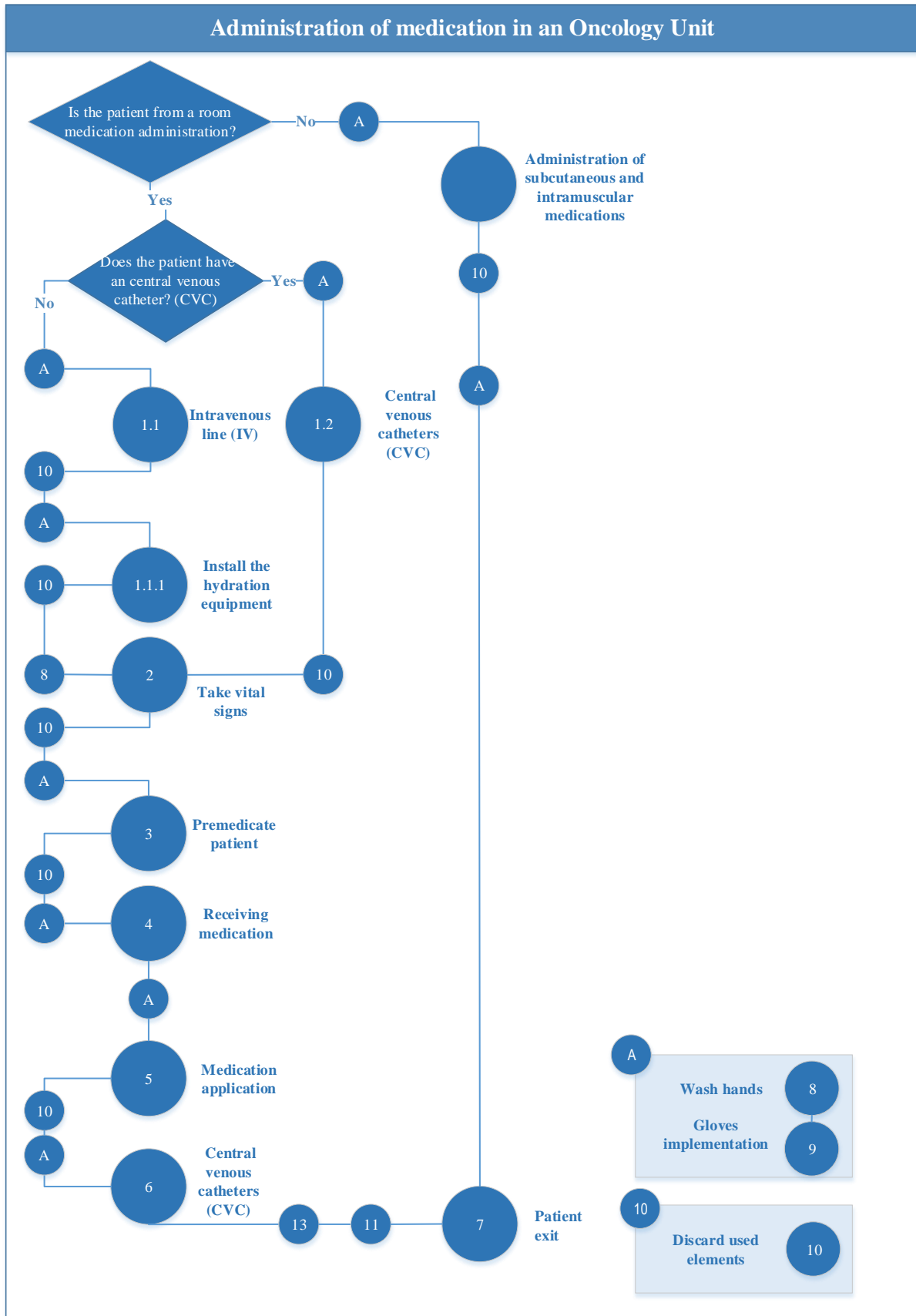### 2. Description of the process in the oncologyunit

Administration of medication in an Oncology Unit

Is the patient from a room medication administration?

No — A

Yes

Administration of subcutaneous and intramuscular medications

10

Does the patient have an central venous catheter? (CVC)

Yes — A

No

A

1.1 Intravenous line (IV)

1.2 Central venous catheters (CVC)

A

10

A

1.1.1 Install the hydration equipment

10

8 2 Take vital signs

10

10

A

3 Premedicate patient

10

4 Receiving medication

A

A

5 Medication application

10

A

6 Central venous catheters (CVC)

13 11 7 Patient exit

A

Wash hands 8

Gloves implementation 9

10

Discard used elements 10

Figure 1. Operation diagram's administration of medication in an oncological unit

According to figure 1, the patient arrives at the time (previously mentioned in the schedule), the receptionist attends to it (verifies the relevant information). Then, according to the order that the nurses have established, the patient is locatedat the appropriate cubicle. At this the moment, specialized care begins on the part of the oncology nurses and the nursing assistants, so the activities where only one of the two positions will be specified, otherwise, the activity will be carried out in accordance with the organization of teamwork

First, check if the patient has an implantable catheter, so that the oncologist can proceed to enable it, otherwise peripheral venous access is performed. Subsequently, the nursing assistant take vital signs, follow by premedication. Later, at the indicated time (specific hour) the pharmacy regent arrives with the indicated medications, it is administer to the patient and is configured with an adequate flow. Then, according to the protocol, premedication is reapplied or the treatment continuewith the application of the following medication to the patient by the oncologist nurse (in this way, until the protocol is finished according to the prescription of the attending doctor) and finally the venous access washes to conclude the administration of medications in the Oncology Unit.

III. Data Collection
1.1. Infusion time per protocol
The oncology unit is in compliance with the Clinical Practice Guidelines (CPG) of the Colombian Ministry of Health and Social Protection, and the NCCN National Comprehensive Cancer Network in all its medical procedures, including the administration of organizational medications, although this evidence also the subcutaneous and intramuscular applications, the paper specifically considers the intravenous applications in the outpatient service as it is the subject of relevant study.

Therefore, together with the personal physician, composed of doctors and nurses specialized in oncology, documents that prove the information of the oncological protocols and the infusion times of oncological and non-oncological medication are documented. Due to, both documents have been prepared by competent professionals, with the respective adherence to the clinical guidelines and with compliance with current regulations regarding the subject. The document provides a trustworthy information source, sowith the union of both, the infusion time was obtained by protocol in minutes, which represents the time that elapses since the oncologist nurse applies the medicine until it enters the body normally (Table 1).

Table 1. Infusion time per protocol code

Protocol code	Infusion time (Min)
ME01	45
ME02	30
ME03	60
ME04	235
ME05	30
ME06	45
ME07	180
ME08	390
ME09	240
ME10	30
ME11	60
ME12	30
ME13	295
ME14	200
ME15	240
ME16	30
ME17	235
ME18	60
Protocol code	Infusion time (Min)
ME19	60
ME20	60
ME21	30
ME22	480
ME23	15
ME24	360
ME25	210
ME26	210
ME27	240
ME28	510
ME29	315
ME30	60

1.2. Service time

It is determined from the grouping objectively of the elements that constitute the same activity in the administration of medicines, based on the Westinghouse model, with the control limits of 95% of the level of confidence and + 5% of the level of error in the study of times made to the nursing staff of the oncology unit.

Table 2. Task sequence according administration of medication

Task Name	Data recollected	Distribution	Probability distribution in Simio Software
Check in the patient in the chemotheraphy unit	62	Weibull	Random.Weibull(2.6234,0.95049)
Admission of patients at the mentioned time	64	Log-Logistic	Random.LogLogistic(3.7642,1.0828)
Central venous catheters (CVC)	33	Log-Logistic	Random.Loglogistic(6.2336,10.55)
intravenous line (IV)	29	Pert	Random.Pert(0.28213,1.3888, 8.7976)
Install hydratation equipment	15	Pert	Random.Pert(0.72841,1.1777,1.3498)
Take vital signs	46	Triangular	Random.Triangular(0.28351 , 1.65 , 3.3696)
Premedicate patient	96	Johnson SB	Random.JohnsonSB(-0.3679,0.4724,0.12658,2.8041)
Receiving medication in the Chemotherapy Unit	93	Erlang	Random.Erlang(0.05014,7)
Medication application	42	Erlang	Random.Erlang(0.29099,5)
Cleaning of venous access	33	Gama	Random.Gamma(10.006,0.26841)

Table 3. Activities according figure 2

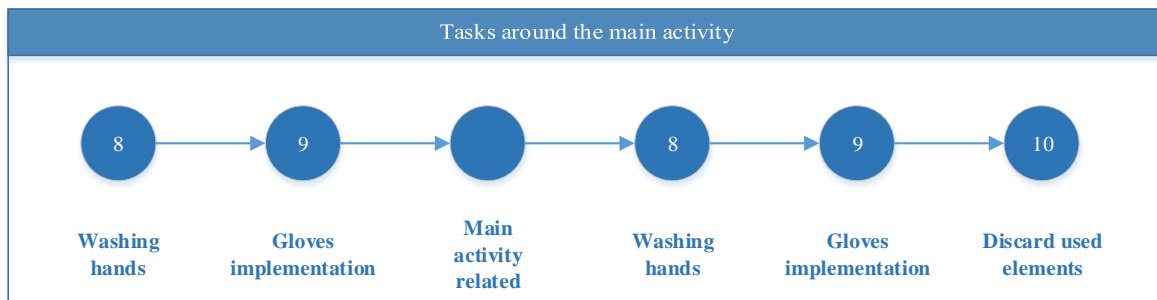| Task Name	Data recollected	Distribution	Probability distribution in Simio Software
Hands washing	111	Johnson SB	Random.JohnsonSU(-1.0541,1.7764,0.639,0.44716)
Gloves implementation	80	Triangular	Random.Triangular(0.12631,0.12632,0.93312)
Discard used elements	141	Gama	Random.Gamma(4.6347,0.02987)

Figure 2.Tasks around the main activity (according Table 2)

In Table 2. Sequence of tasks according to the administration of medications, the activities of the medication administration process in the Oncology Unit, mentioned earlier in the process description, are evidenced. Therefore, the service time or processing time was obtained, defined by the distribution associated with each activity according to the goodness adjustment made with the corresponding analysis and the EasyFit software implementation.

However, it is contemplated that the amount of medication depends on the different dose that each patient has, which varies with the consideration of the doctor who in turn depends on the patient's health status. Then, thisactivity presents a high variability, but it is mitigated by obtaining data per unit of medication delivered, then according to the probability distribution obtained random numbers are generated.

However, for the purpose of properly delimiting, the quantity of medications delivered per day and the time each was delivered was used, determining the associated distribution in the Simio software, such as: Random.LogLogistic (4.2575,0.34813) according with the goodness fit test, Chi-square. Then, a series of data is generated with the Easy Fit software, according to the associated probability distribution, as exemplified in fig 3.

	Date Time ▽
1	2019-10-01 10:00:36 AM
2	2019-10-01 10:01:28 AM
3	2019-10-01 10:02:31 AM
4	2019-10-01 10:02:56 AM
5	2019-10-01 10:03:08 AM
6	2019-10-01 10:04:17 AM
7	2019-10-02 10:00:28 AM
8	2019-10-02 10:01:12 AM
9	2019-10-02 10:01:53 AM

Figure 3. Sample of the Table in Simio Software (Medication Arrival Table)

1.3.   Arrival time

From the patient database, the programming dates for intravenous administration were extracted with the respective protocol assigned and finding the difference between them, it was determined the time between arrivals per protocol.

Subsequently, using the EasyFit software, the analysis of each of the corresponding samples was performed, in order to determine the distribution according to the goodness adjustment made by the program with the Chi-square test and in second consideration the Kolmogorov Smirnov test and Anderson Darling, as shown in the following table (Table 4).

Table 4. Arrival randoms according protocol code

Protocol code	Arrival random
ME01	Random.Loglogistic(1.6599,2280)
ME02	Random.Weibull(1.3296,5574.9)
ME03	Random.Exponential(0.00014815)
ME04	Random.Weibull(1.6169,8887.6)
ME05	Random.PearsonVI(284.79,0.99806,11.305)
ME06	Random.Erlang(8243.8,1)
ME07	Random.JohnsonSB(0.58971,1.0594,76.317,46959)
ME08	Random.Weibull(1.4425,12571)
ME09	Random.Weibull(1.2966,10769)
ME10	Random.Weibull(1.1036,7999.2)
ME11	Random.Weibull(1.2416,10511)
ME12	Random.Exponential(0.000079787)
ME13	Random.Gamma(4.6347,0.02987)
ME14	Random.JohnsonSB(1.9864,0.94726,0,89486)
ME15	Random.Gamma(1.1686,15249)
ME16	Random.Gamma(1.5086,4772.6)
ME17	Random.Weibull(1.2199,17330)
ME18	Random.Exponential(0.000046296)
ME19	Random.Gamma(0.52762,39119)
ME20	Random.Triangular(4320,5184,84960)
ME21	Random.Weibull(2.7228,50524)
ME22	Random.PearsonVI(132.36,1.5416,393.53)
ME23	Random.Exponential(0.000028262)
ME24	Random.JohnsonSB(2.4529,1.1816,11805,19294)
ME25	Random.JohnsonSB(1.3462,0.93688,64456,157706)
ME26	Random.Gamma(0.60585,72889.0)
ME27	Random.PearsonVI(745.23,4.616,222.64)
ME28	Random.JohnsonSB(0.36885,0.86095,0,95914)
ME29	Random.JohnsonSB(3.0005,1.5801,0,594310)
ME30	Random.Weibull(1.0651,14775)

In summary, the above tables (Table 1, Table 2, Table 3 and Table 4) gather the necessary information for the objects within the simulation and the activities associated with each of these according to operation diagram of oncology unit (Fig 1) and the detailed explanation of the process.

IV. Model Approach

Now, all above is related to the Simulation software used to build the model, Simio. It is a software that can be used by any industry obtaining the benefit of risk analysis, resource optimization, also, it's possible also

avoiding potential problem. For this, the use of sources, servers and sinks to construct a simple model must be known, however, in this paper the different relationships between them and the model are briefly explained.

1.4.   Sources
The Source provides the entities (Patients according to protocol) that will be the input of the system.In the simulation of the Oncology Unit, there are three possible ways of entering the data determined, each with characteristics and implications different from each other.

First, the input can be made by directly entering the data obtained historically in the oncology unit.Secondly, a source can be entered for each patient according to a protocol.

In this case, for prevent the running from being too slow and that the system can be failed as a result of a single server, it will implement a configuration of the Source associated with the frequency based on which patients have presented historically.

1.5.   Servers
Servers are used to model a fixed location in the system. In the model are presented: UnitChemotheraphyEntrance, MedicationDelivery and Chair_1. They carry out the processes that their names indicate, they receive patients, they receive the medications, and they execute the activities of the administration of medications.
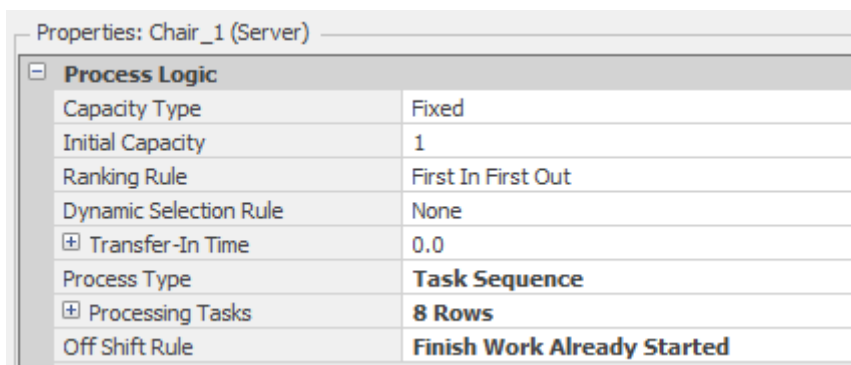
1.6.   Sink
In this model only one is considered, and this is where the processed entities leave the system. Also, it is feasible to say that a process or a state can be related as well. It all depends on how the object is configured in the system. In the current model, there is only one and is represented by an elevator.

VI. Translation To The System Model
Thirty types of patients were identified by the protocol assigned in the patient base, enter the associated tables, in a compact way in Simio Software, verifying that the type of "column" matches the types of data entered, in other words, if the data entering is of infusion time, the column table in Simio must be created as a real variable that runs in units of time (minutes). Next a source is created that generates several types of entities, then the patient is received at the door of the unit, directed to the medication administration chair in the application cubicle indicated. In other words, the entity (Patient) enters the Server (Chair) with the assistance of the necessary workers (Nursing staff).

Below is shown in Fig 5, Repetitive Properties Editor, the activities will be carried out, previously in Table 2. Sequence of tasks according to the administration of the medication. For this, first, by selecting the server and changing the type of process to the sequence of tasks and then entering information and resource declarations.

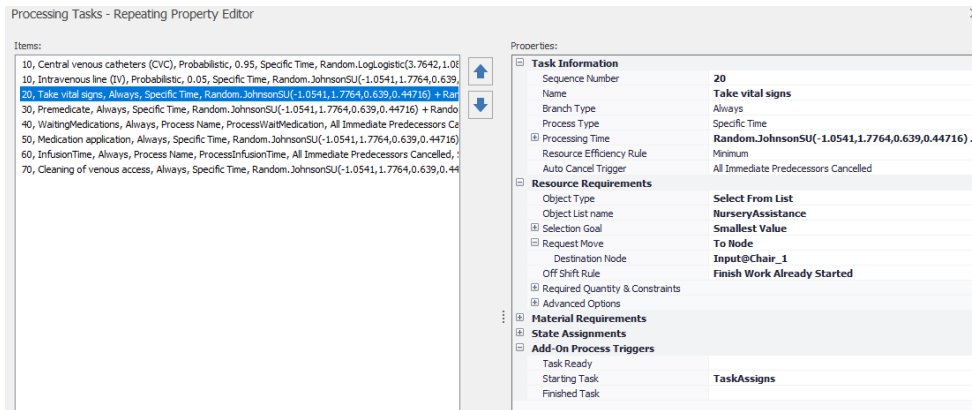
Figure 5. Chair_1 Properties

Figure 6. Repeating Property Editor

In other words, when the entity enters, all tasks are performed sequentially on the same server (Fig 6). However, it is necessary to observe that there are two tasks that are independent of human resources (Nurses), and there are subordinated to other factors.

These are: The arrival and reception of medicines in the oncologyunit at the time agreed on another server. Also, the infusion time, because it is dependent on the type of protocol the patient possesses.

Consequently, for each of these actions a process is proposed, which is associated in turn within the processing time of each task, as shown below.

1.7. Waiting time process
Since the task sequence is associated, changing the process type to Process Name
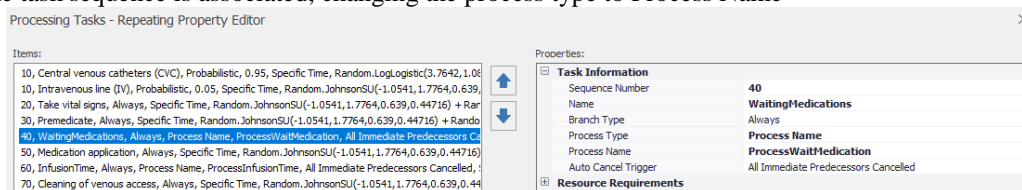
Figure 7. Process name associated

Later, in the process, decide if the medications server's processing time of is zero, becauseindicates that the server is off shift. The process forks and asks if the run time simulation is longer than the time the medications are received (It depends on the start time of the simulation and the workschedule of the medication), but, in this Occasion, the value is 2.16 hours. Finally, wait for an event to happen (EventAfterArrivingMedication) for trigger it when the server is off shift. So, this is another way to ask if the processing time is zero again, so, the first is established by a Condition Based while the second by an event. (Fig. 7 and Fig. 8).
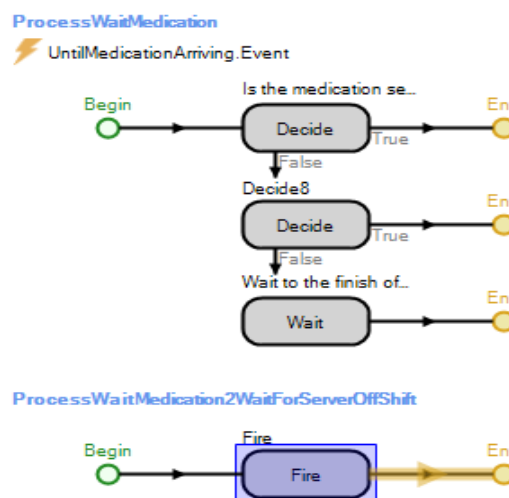

Fig 7. Process wait medication and process wait for server off shift

Basic Logic	
Decide Type	ConditionBased
Condition Or Probability	MedicationDelivery.ProcessingTime.HasValue==0
Basic Logic	
Decide Type	ConditionBased
Condition Or Probability	**Run.TimeNow >2.16**
Basic Logic	
Event Name	**EventAfterArrivingMedications**
Event Condition	
Events (More)	0 Rows
Properties: Fire (Fire Step Instance)	
Basic Logic	
Event Name	**EventAfterArrivingMedications**

Fig 8. Steps of process wait medication and process wait for server off shift

1.8.   Infusion time process
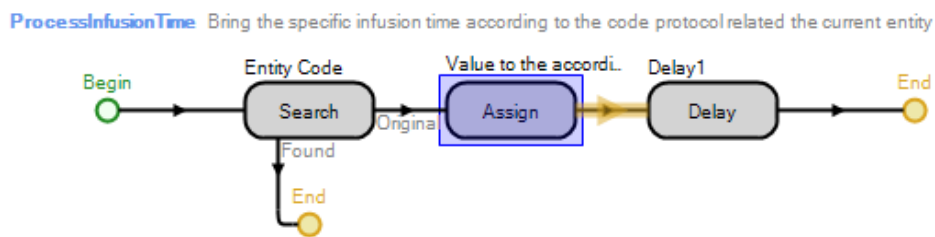
Fig 9. Infusion time process

This process, illustrated in Fig 9, is executed when the processing time of the task sequence begins in the infusion time activity, then, as in Fig 10, the search identifies the object, relating it to the compact table entered into Simio Software at the beginning of the model construction.

Later, according to the type of entity (Patient by protocol) assign a row in the table. And later with the state, it brings the related value for execute it with the delay. That is to say, after the application of the medication by the nursery chief, the patient must wait for the medication to enter through his body, in full, except for some adverse event or cause that allows the interruption of the administration.

Properties: Entity Code (Search Step Instance)

Basic Logic	
Collection Type	**TableRows**
Table Name	**PatientArrivalTable**
Search Related Rows Only	True
Search Type	Forward
Match Condition	**ModelEntity.Priority == PatientArrivalTable.EntityCode**
Limit	1

Properties: Value to the according state (Assign Step Instance)

Basic Logic	
State Variable Name	**StInfusionTime**
New Value	**PatientArrivalTable.InfusionTime**
Assignments (More)	0 Rows

Properties: Delay 1 (Delay Step Instance)

Basic Logic	
Delay Time	**StInfusionTime**

Fig 10. Steps of infusion time process

VII. Tracking Results Of Simulation

Currently Simio software have a Results tab that contains all the intelligent objects (Sources, servers, sinks, paths, connectors, among others). So, if the variable to analyze is there, it can be filtered with the tabs above, as is done with any filter. However, if the object to be tracked is not defined by default, the program

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infrastructure allows to measure whatever the object is, it is only necessary to know the different functionalities of Simio Software.

Now, this time, the current model determines the number of entities per day generated by the system, that is, the number of patients that are treated in the oncology unit daily.

For this, a process is created (Fig 11) and executed by a timer (Fig 12), which defines a time interval every day, then the writing step is configured, with StateAssignments, as Run.TimeNow (Return the value of run) and the states in which entity information is stored.

For example, if in the simulation is need to know: How many entities go through to chair? It relate a state, which can be called "StExitChair" and assigned to it in the Assignment statethat every time an entity leaves the server (Chair), perform this calculation "StExitChair + 1", executing a counter in the Simio logic.
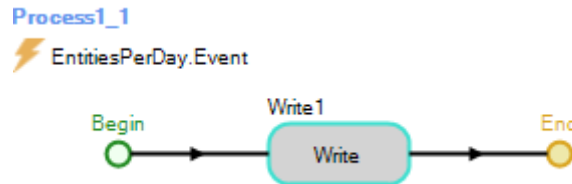
Figure 11. Write output process

Figure 12. Steps of write output process

Finally, after running the simulation, a goodness fit test must be carried out that determines the model corresponds to reality. But only the following variable is displayed within the model, consider that the nomenclature ending in "R" is the real data and the ending in "S" is the product of the simulation.

Using the SPSS software,the analysis of means tested by the result of the t-test for independent variables, is shown below:

Table 5. Meansanalysis

Group Statistics

	Clasification	N	Mean	Std. Deviation	Std. Error Mean
DataNumber	**7_R**	93	.3774	.13757	.01427
	7_S	1718	.3787	.19049	.00460

Thus, data were obtained to certainty a little difference between the averages, and the graph corroborates it, since the standard deviation of "7_R" encompasses all of "7_S" in Fig 13.
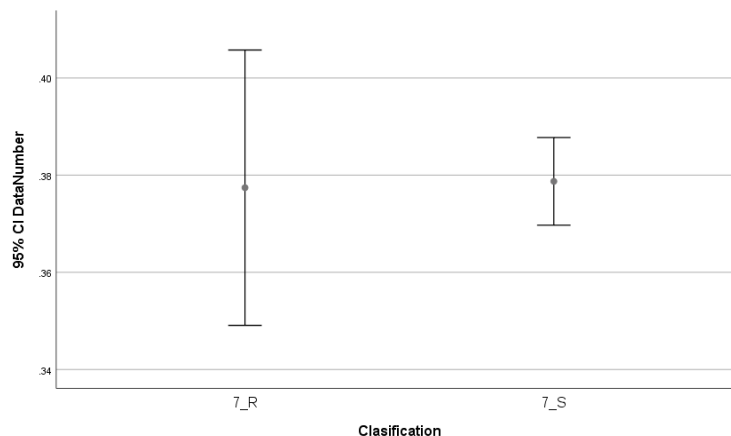
Figure 13. Means compared

However, the other measure of dispersion, the variance, identified with "Sig" gives the assurance that the null hypothesis is true, so the value 0.2 is below of 0.5 error limit in the 95% entered confidence level.

Table 6. Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F	Sig.	t	df
DataNumbe Equal variances assumed	1.641	.200	-.065	1809
r　　　Equal variances not assumed			-.087	112.023

VIII. Conclusion

The construction of a model in oncology unit in a practical simulation software, easy to use, with efficient and effective support. In addition, it providesunderstand traceability in a context outside the health specialists and closer to the engineering analysis seen from the process perspective. For all the above, this paper includes help tools that can be used for more complex, creative and productive analyzes by the simulation analyst that contribute to the organization and informed decision, making at low cost and high accessibility with respective constrained settings.

Acknowledgement

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