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Improving the Performance of a Blood Transfusion Center through Modeling and Simulation: Case of the Casablanca Regional Blood Transfusion Center

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ABSTRACT
Over the years, the hospital sector in general and blood transfusion more particularly has not ceased to evolve and implicitly become more complex, it becomes all the more difficult to respond efficiently to the various organizational problems encountered without having recourse management and decision support methods; in particular, the modeling and simulation approach has proven its effectiveness. This study focuses on the component of blood transfusion in general and aims to contribute more particularly to a better understanding of the organizational functioning of a blood transfusion center in Morocco through the development of a simulation model. Discrete events under Arena. To respond to the problem of blood shortage, a scenario simulating a peak of activity linked to a massive arrival of donors following an awareness campaign is simulated in order to analyze the behavior of the center in the face of this sudden change.

General Terms
Modeling and simulation

Keywords
Modeling, Simulation, Performance, Blood transfusion, Blood shortage, Arena

1. INTRODUCTION
Health structures for several years have been confronted with various problems linked to highly organizational aspects which adversely affect medical performance if they are not correctly resolved. No health component can be excluded from this observation starting from the pre-hospital phase (SAMU) within the health structures themselves with all the diversity of specialties. In addition to the presence of several actors in hospital processes and their complexities, the tools and methods used must also take into account the random aspect and risk management. This is clearly in the presence of a complex system.

Discrete event simulation is one of the widely used techniques that are particularly well suited to complex systems, often used for the design and sizing of new structures (clinics, hospitals or departments) or simply, to allow end users to test the efficiency of the modeled system by exploring new avenues for improvement without the constraints of cost and probability of success. Very widely used in the industrial field to deal with problems such as storage, the use of resources, logistics. These tools were also used in a very complex system which is the hospital sector in the last few years. Where analytical methods become too complicated, unrealistic and difficult to implement, discrete event simulation can provide satisfactory answers.

In terms of the literature, it was found that simulation has been widely used for solving hospital organization problems for about thirty years, whether for the emergency department [1],[2], [3], [4], [5], [6], [7] or the operating theater [8], [9], [10], [11], [12], surgery [13], care units [14], home maternity care [15], imaging and radiotherapy [16], [17], hospital logistics [16], drug logistics [18], [19], [20], digestive medicine care unit [21], the admission process [20], information systems [22] and other units.

Blood transfusion in Morocco, an essential link is essential in the chain of care, also has its share of organizational issues such as the sizing of structures according to needs, optimization of human and material resources, stock management and finally but not least, concerns about the availability of blood products. Faced with these problems, the application of decision support methods [23], modeling and optimization [24] allow to have very promising results.

The transfusion system in most countries and in particular in Morocco based on voluntary blood donors, the key to the success of the transfusion process lies largely on the ability to ensure a sufficient number of voluntary donors and not paid to meet the need. The solutions adopted today consist in carrying out awareness-raising campaigns through the media, social networks and non-profit associations in order to encourage the population to donate blood and above all to retain them, these efforts must continue to be made in the long-term in order to achieve satisfactory results. Given this situation, it is common that during blood donation campaigns or during an exceptional event (Train overturning on October 16, 2018 at Bouknadel, Morroco), the blood centers experience a massive hunger for donors and the latter can easily be found overtaking. This study tries to provide an answer in this direction by modeling and simulating using the Arena © software [26] the operation of the regional transfusion center in Casablanca to study a scenario of a sudden increase in blood pressure. Activity due to a blood donation awareness campaign and then analyze the center’s behavior following this strong request.

2. CASABLANCA REGIONAL BLOOD TRANSFUSION CENTER

2.1 Presentation
The regional blood transfusion center is responsible for ensuring the collection, processing and distribution of labile blood products. It is located within the economic city, the most important in terms of population and offers care, which

induces a very important demand for labile blood products PSL. Donors who come to the CRTS (Casablanca Regional Blood Transfusion Center) first go through the reception to register and then go to the medical interview, which determines if the donor is suitable to donate, if it is the case the next step is the collection room where the donation operation takes place. At the end, the donor enjoys a snack before leaving the center while the collected blood is transferred to be analyzed and separated into blood components **PSL** (Red cell concentrates, Plasma, Platelet concentrates) which will be stored while waiting to be delivered to the recipients. (Cf fig 1)

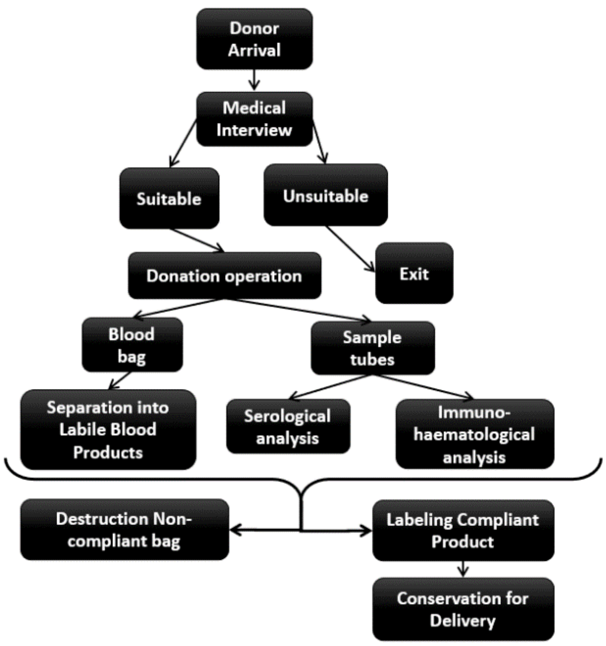

Fig 1: Donor treatment steps at CRTS Casablanca

In 2014, according to the figures provided by the management of the national blood transfusion center (CNTS), it can be seen that the Casablanca CRTS alone provided almost 29% of the demand for red blood cell concentrate -CGR- and 28% of the collection national. Apart from the recipient Immunohematology laboratory, it is fully computerized and automated. The increasingly expanding public and private healthcare offer and the presence of a hematology service implies an increasingly growing demand for PSL in the greater Casablanca area. Despite this position, the Casablanca CRTS suffered from a lack of raw material, and therefore blood from voluntary donors. In order to replenish these stocks, the CRTS received two types of donations, the first based on voluntary service and the second said by compensation where the families of patients are asked to donate their blood to compensate for the products delivered for lack of voluntary donations. This situation had to be overcome to reach 100% voluntary donors in order to meet all the needs.

Achieving self-sufficiency in PSL through voluntary donations is a major challenge, requiring considerable efforts to anchor the culture of blood donation over time within the population, a culture that will have difficulty in establishing itself as the citizen-public care system relationship will not improve. The efforts of communication, awareness, improvement of the service provided must be multiplied and repeated over time in order to hope to achieve the expected objectives. While waiting and in order to continue to meet the daily needs of patients, in addition to the annual planning of blood collection campaigns, calls for local or national blood donations are launched according to the needs observed in order to fill the stock of PSL of the various CRTS. These non-regular donation campaigns give rise to a pace of activity that varies depending on the situation, despite this still being the obligation for the CRTS to meet the needs with the same quality and time constraints.

This requires managers to make resource adjustments very often to be able to temporarily handle high workloads. The aim of this work is to provide a qualitative and quantitative answer to the question of resource sizing and the capacity limits of the current system. The solutions envisaged for the moment consist in carrying out awareness-raising and blood collection campaigns in order to recruit as many donors as possible according to an annual schedule, but in order to perpetuate the desired level of stock, the management of the center wishes to set up a new strategy. Aiming to sustainably increase the quantities of blood collected.

This strategy aims in a first phase which lasts 10 days to significantly increase the number of donors and blood bags collected to constitute a sufficient safety stock (equivalent to 7 days of consumption) through a regional awareness campaign blood donation. In a second step, the objective will be to stabilize at a lower level of collection but constant over time.

The question to be answered is: Do the current sizing of the center and the capacities of these resources allow this increase in load to be followed, especially during the first phase of 10 days and how will all the performance indicators react? Compared to such a change?

3. MODELING AND SIMULATION

To answer this question, the first step consists in modeling the operation of all the processes of the transfusion center and then using simulation, the second step consists in evaluating the impact of the new scenario on the operation of the blood transfusion center. The choice of the simulation tool fell on Arena Rockwell, which allows first to pose a logic model to model the system and then to move directly to the action model. A field study, as well as several interviews with managers, made it possible to establish and validate the different logic models for the following services. Reception and registration, Medical interview, Sampling room, Serology laboratory, Donor immunohematology laboratory (IHD), Production laboratory, Labeling (Cf figure 2), Delivery.

3.1 Input data: Law of arrival of visitors and requests for deliveries

The data relating to the number of entries in terms of visitors and delivery requests were retrieved and processed using the EasyFit © software. It allows you to test the suitability of a data series with respect to a statistical distribution and directly calculate the parameters relating to each distribution. The software allows correlation to be compared with over 55 distributions using three tests: Chi-square test, Kolmogorov-Smirnov test, and Anderson-Darling test. The correlation of the data collected with the distributions supported by Arena © has been tested. It was found that none of these laws can represent reality. The only law that comes close to reality is the negative binomial law with parameter n = 5 and p = 0.32542. Finally, the choice was made to configure the entries

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according to an arrival schedule, in fact Arena © allows through the "Schedule" module the programming of the frequency and number of arrivals.

Arrivals were scheduled in 30min increments for a period of 10.5 hours, which corresponds to one operating cycle of the CRTS. The center is open to the public from 8:30 a.m. to 6:00 p.m. from Monday to Saturday continuously, outside these hours the delivery continues for emergencies, from 6:00 p.m. to 7:00 p.m., the last requests for deliveries and donation operations continue.

3.2 Law of arrival of mobile blood drives, blood bank collection and requests for hospital services

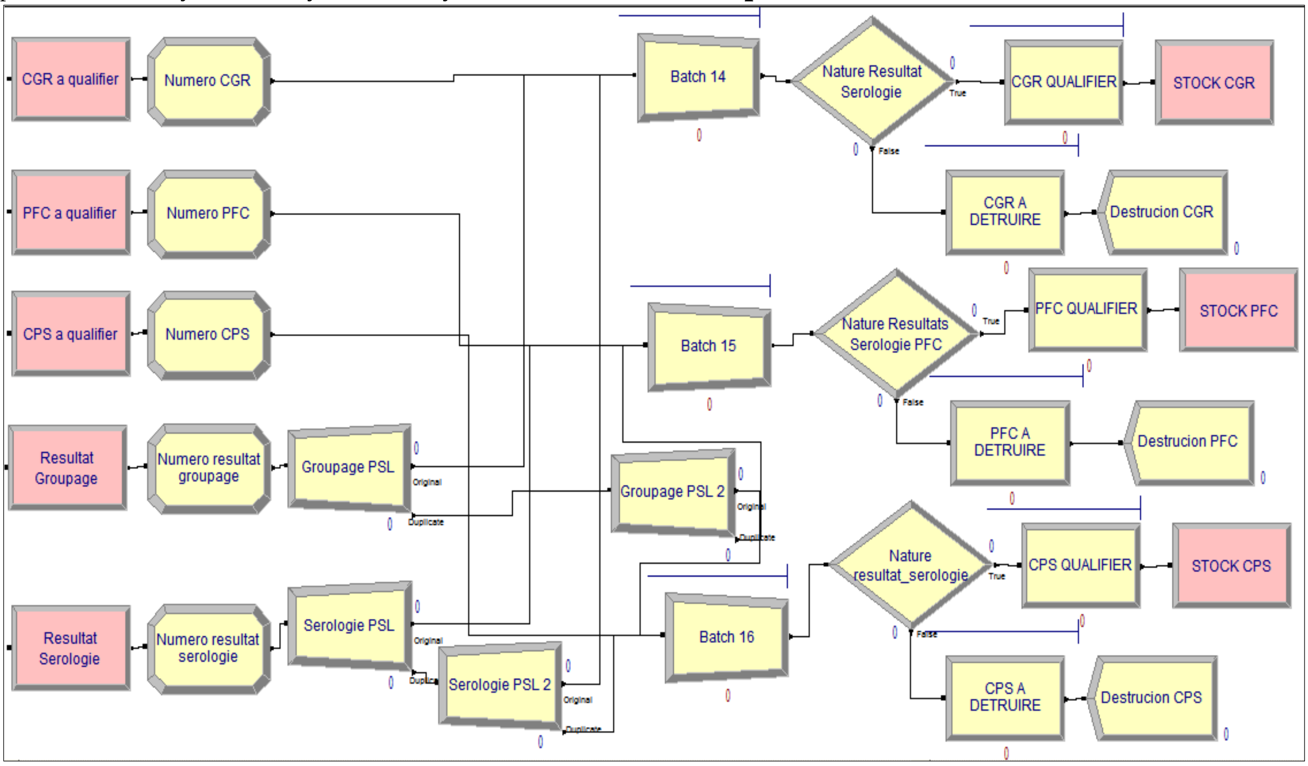

Fig 2: Logic model of the labeling phase of PSL within the CRTS

Other inputs to our system are mobile blood drives, BS blood bank collections, and requests from certain hospital departments, the latter arriving at a regular rate and in a well-determined quantity.

According to the statistics provided by the CRTS (Year 2014):

• The average number of CGR delivered per day (Sunday included) is: 171.28;

• The average number of fixed collections (CRTS) per day: 161.73 collections / Day;

• The average number of mobiles collect and BS per day: 53.88 Collections / Day

3.3 Model validation

In order to validate the model, the operation of the CRTS over a period of 30 days is simulated, the results are as follows:

Table 1. Comparison of reality data with simulation data

	Actual Data	**Simulation data**	**Difference**
The average number of CGR delivered	171,28 CGR/Day	171,73	0,26%
The average of the number of fixed collect (CRTS)	161,73 Collect/Day	163,29	0,95%
The average of the number of mobiles collects and BS	53,88 Collect/Day	54,30	0,79%

In view of the results obtained and the small difference between real and simulated data, the model can be considered valid and fairly representative of the reality of the transfusion center and the state of entries and exits.

4. RESULTS

4.1 Performance indicators: KPI's

In consultation with the management of the center, The KPI’s that will allow us to assess the performance of the center was determined. The simulation of the existing situation over a period of one month allows us to have indicators in relation to the average waiting time in the services in contact with donors, the average time for the preparation of the various PSL, the percentage of use of different human and material resources.

It should be noted that in table 2 that in the current state of things the services which are the most requested and know a certain expectation, are those in contact with the donor or the requests for deliveries as well as the production laboratory, they are services that are completely manual and cannot absorb a significant increase in the number of entries. The other services are automated with the exception of labeling, which explains the utilization rate which is around 50%.

4.2 Improvement scenario

In order to simulate the implementation of the action plan, the number of entries per day was increased by 56%. The results obtained and presented in Table 2, clearly showing that after the action which lasts 10 days, the level of stock reached is equal to 9.72 days of consumption which exceeds the initial objective. With this, as shown in Figure 3, the processing time required to obtain the blood products increased very slightly (30min longer on average).

This increase in the load in terms of the number of entries had a very low impact on the CRTS as a whole, this is explained by the fact that the increase in load suffered by the services in contact with donors only represents 17, 85% of the total increase.

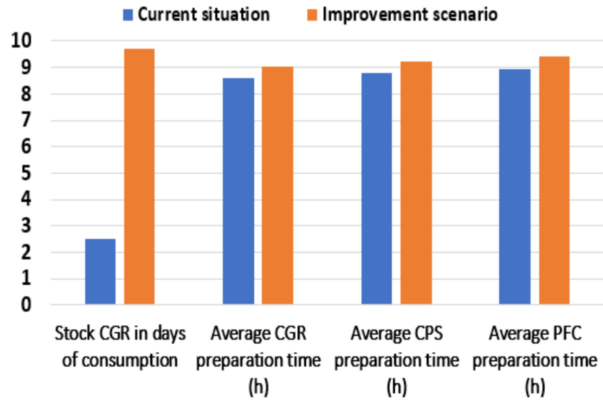

Fig 3: Evolutions of KPI's after simulation

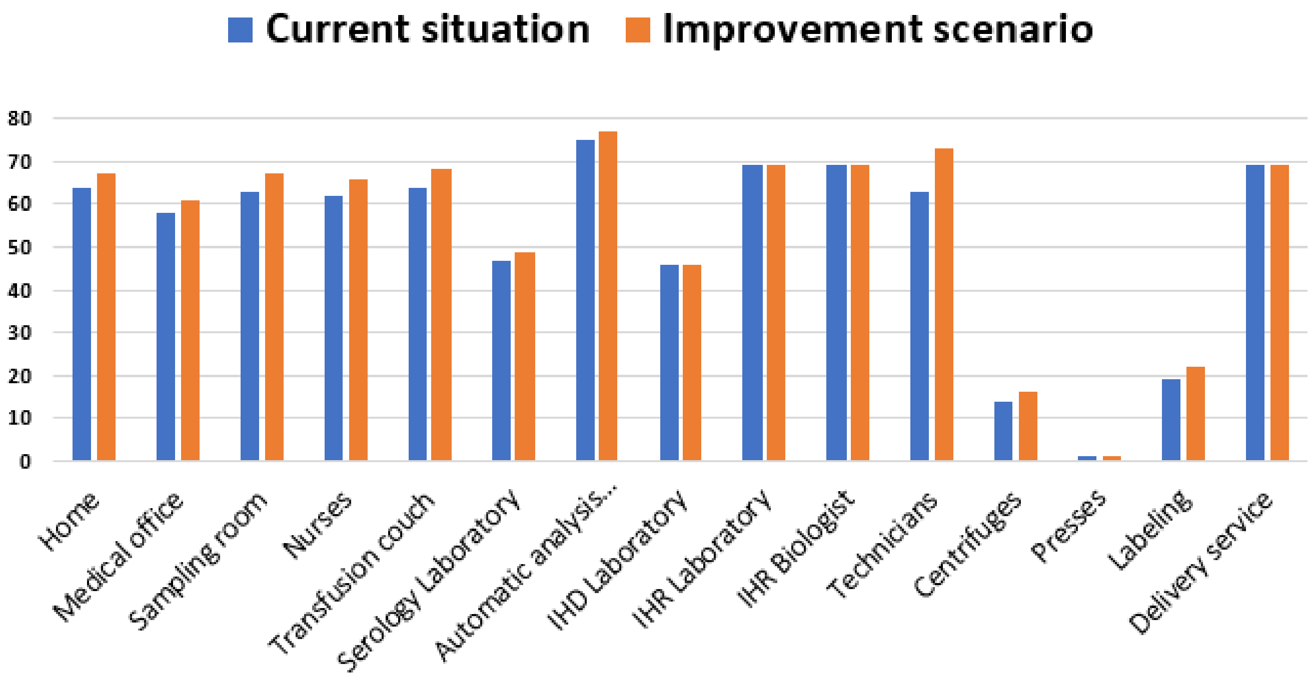

Fig 4: Resources use in%

Indeed, as detailed in section 3.2, the inputs consist of donors as well as bags of whole blood received from blood banks and collection trucks. The reception process, medical interview, collection room are the only ones affected by the increase in the number of donors, which in this case could very easily be managed without major overload.

On the other hand, the additional volume of whole blood bags generated during these 10 days and which comes from blood banks, collection trucks and donors within the CRTS had to be treated by the serology and immuno-hematology laboratories as well. That separation. Fortunately, the presence of an automatic analysis machine made it easy to deal with this additional load. The only resource for which an increase in use has been observed is the separation technicians (from 63% to 73%), this is explained by the manual nature of the task. Despite this, this increase remains quite manageable. (Cf fig 4)

5. DISCUSSION AND CONCLUSION

This study, carried out at the CRTS in Casablanca, provided a better understanding of the internal functioning of the center and these issues. Using the Arena tool, a simulation model was proposed and validated by actors in the field fairly close to reality, the simulation of the impact on the center of the sudden increase in activity over a period of 10 days, clearly shows that the current human and material resources can support this increased load without problem.

This model constitutes a decision support tool that will improve the performance of the CRTS, and provides an organizational response to the problem of recruiting donors. The results obtained were of great help to the management of the center, as they made it possible to validate the proposed strategy and thus help in the decision to respond effectively to a blood transfusion requirement: the availability of labile blood products. The complexity of the CRTS process as well as the multitude of actors involved makes the task of modeling and simulation quite difficult, certain approximations had to be taken such as the fact of considering the Sunday activity equivalent to the other days of the week, this which constitutes a weakness of the proposed model.

Table 2. KPI's of the existing situation and the improvement scenario

KPI's	Current situation	Improvement scenario
Exact level of stock in CGR	440	1673
Stock CGR in days of consumption	2,5	9,72
Average CGR preparation time (h)	8,62	9,05
Average CPS preparation time (h)	8,78	9,22
Average PFC preparation time (h)	8,93	9,41
Average waiting time (Min)		
Home	8,49	8,70
IHR Laboratory	11,97	12,22
Medical interview	6,58	8,87
Sampling room	2,67	4,83
Resource use in%		
Home	64	67
Medical office	58	61
Sampling room	63	67
Nurses	62	66
Transfusion couch	64	68
Serology Laboratory	47	49
Serology Biologist	53	54
Automatic analysis machines Distribution	10	10
Automatic analysis machines Screening	75	77
IHD Laboratory	46	46
Blood grouping test biologist	43	43
Automatic Blood grouping test machines	71	71
IHR Laboratory	69	69
IHR Biologist	69	69
Production laboratory		
Technicians	63	73
Centrifuges	14	16
Presses	1	1
Labeling	19	22
Delivery service	69	69

IHR: Immuno-haemato recipient; **IHD**: Donor Immuno-Hemato, **PFC**: Fresh frozen plasma

CGR: Red blood cell concentrate **CPS**: Standard platelet concentrate,

Now that this simulation model is validated, there may be many perspectives, such as the study of the automation of the PSL separation service, the sizing of human and material resources according to the activity or the optimization of internal processes.

6. REFERENCES

[1] El Oualidi, M.A ., Saadi, J., El Hiki, L., Artiba, A., Bellabdaoui, A. (2010). Modélisation et simulation du flux des patients au service des urgences. Cas de l'hôpital Ibn Rochd à Casablanca (Maroc). GISEH 2010.

[2] Achour, S.B. , Hugli, O., Yersin, B., Wieser, P. (2010). Evaluation d'un modèle de simulation des urgences lors de la mise en place d'une voie rapide. GISEH. 2010

[3] Dehas, N., Aissani, J., Adjabi, S. et Abderrahmani, H. (2006). Evaluation des Performances d'un Système de Santé Cas de l'Hôpital Khellil Amrane (Béjaïa). Proceedings of the Francophone Conference in Management and Engineering of Hospital Systems GISEH, Luxembourg, Septembre 2006

[4] Aroua, A., (2018) département d'urgence ; un élément d'une chaîne de santé, Thesis presented at the University of Quebec in Trois-Rivières p. 85–103.2018

[5] Ireen Munira. I., Choong-Yeun, L., Sakhinah Abu, B., Noazura, A.,Najmuddin, A.F (2017). Minimizing patient waiting time in emergency department of public hospital using simulation optimization approach. AIP Conference Proceedings, Volume 1830, Issue 1, id.060005. April 2017

[6] Belaidi, A., Besombes, B., Guinet, A., Marcon, E. (2007). Réorganisation d'un service d'urgences et aide au pilotage des flux de patients : Apport de la modélisation d'entreprise et de la simulation de flux. Logistique & Management Vol. 15 – N°1, P.61-73

[7] Jlassi, J. (2011) Amélioration de la performance par la modélisation des flux logistiques des patients dans un service d'urgence hospitalier. Doctoral thesis. University of Paris 8 And University of Sfax.

[8] Marcon, E., Kharraja, S., Smolski, N., Luquet, B. et Viale, J. (2003). 'Determining the Number of Beds in the Postanesthesia Care Unit: A Computer Simulation Flow Approach', Anesthesia & Analgesia 96, 1415-1423.

[9] Millard, P. H., Mackay, M., Vasilakis, C. and Christodoulou, G. (2000). Measuring and modelling surgical bed usage. Annals of the Royal College of Surgeons of England, 82:75–82.

[10] Dussauchoy, A., Combes, C., Gouin F., et Botti, G. (2003) : Simulation de l'activité d'un bloc opératoire en utilisant des données recueillies au niveau d'un département d'anesthésie. GISEH. 2003

[11] Ramis, F. J., Palma, J. L. et Baesler, F. F. (2001). The use of simulation for process improvement at an ambulatory surgery center. Winter Simulation Conference.

[12] Tyler, D.C., Pasquariello, C.A. and Chen C.-H. (2003). Determining optimum operating room utilization. Anesth Analg, 96:1114–1121.

[13] Vasilakis, C., Kuramoto L. (2005). Comparing two methods of scheduling outpatient clinic appointments using simulation experiments. Clinical & Investigative Medicine, 28:368–370.

[14] Gascon, V., Bélanger, M., Hébert, K. (2010). Analyse du processus de prélèvement dans un centre hospitalier. GISEH Clérmont-Ferrand.2010

[15] Nidhal Rezg, NG. Monteiro, T., Emmanuel, E. (2010). Dimensionnement par simulation d'une structure de prise en charge de la maternité à domicile. MOSIM'10 - Hammamet – Tunisie.

[16] Mebrek, F. (2008). Outils d'aide à la décision basés sur la simulation pour la logistique hospitalière, application à un nouvel hôpital. PhD thesis Blaise Pascal University - Clermont-Ferrand II

[17] Moussa, M., Belkadi. K. (2009). Simulation de flux dans un service d'imagerie de l'HMRUO, 2nd International Conference SIIE, Hammamet, Tunisie.

[18] Ouzayd, F., Saadi, J., Benhra, J. (2012). Proposed a simulation models in medicine drugs circuit with UML and Colored Petri Net: case Moroccan hospital system, I.R.E.M.O.S., Vol. 5. n. 1, pp. 489-496.

[19] Huet, JC., Chopineau, J., Pinon, V., Grémeau, I.,Gourgand, M., Paris, JL. Kouiss, K. (2010). Proposition d'un outil d'aide à la décision pour l'organisation du circuit du médicament. GISEH.

[20] Tavakoli, M. Ghanavatinejad, M., Jalalifar, F., Yavari, E. (2019). Discrete- Event Simulation of Patients' Admission Process and Presentation of Improvement Scenarios with The Aim of Reducing Patient Waiting Time. jhosp 2019, 17(4): 67-80.

[21] Aleksy, B., Barrier, A., Chabrol, M., Gourgand, M., Rodier, S. (2010). Modélisation des systèmes hospitaliers : du générique au spécifique. Application à une unité de soins de médecine digestive. GISEH.

[22] Hamana, S. (2017). Modélisation et simulation des flux d'informations ville-hôpital et évaluation de leur impact sur le parcours de soins. Doctoral thesis from the University of Lyon carried out within the Ecole des Mines de Saint-Etienne. Pages 47-151.

[23] Bennis, I., Saadi, J., Benajiba, M. (2013). Amélioration et optimisation du processus transfusionnel au Maroc : proposition d'une nouvelle organisation. Clinical and Biological Transfusion, Vol 20 N°1 p : 21-29.

[24] Bellabdaoui, A., Bennis, I., Saadi, J. (2014) Optimisation des niveaux de stock dans les centres de transfusion sanguine au Maroc. Clinical and Biological Transfusion. Volume 21, Issue 1, Pages 15–22.

[25] Law, A. M. et Kelton, W. D. (2004). Simulation Modeling and Analysis. McGraw-Hill.