

Conceptual map based on system dynamics thinking for operating room theatre

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Abstract:

The economic crisis has a significant effect on healthcare resources. The management of limited and shared resources such as operating rooms and beds is challenged by the uncertainty of demand, which can lead to unbalanced utilization of the resources through the healthcare units and decrease the satisfaction of the patients in terms of waiting Time in the hospital and the quality of the service. Therefore, healthcare services need a conceptual tool to clarify the complexity of the interactions between resources and their effects on each other. A conceptual model based on system dynamics tools is developed to figure out the factors affect the behavior of operating room theatre in a healthcare system.

Keywords

Complexity, Conceptual, Causal Loop Diagram, Operation room theatre, System Dynamics.

1. Introduction

Long waiting list and delays for medical treatment results in human pain all over the world. Proper comprehending of the critical health care resources behavior and their effect on the overall performance of the system can result in decreasing such unnecessary human suffering by improving the performance of healthcare units and increasing their throughputs.

Tools used in improving the performance of any healthcare unite can be classified as analytical, simulation and statistical or empirical [1]. Simulation modeling approaches are considered suitable in cases where a complicated network of facilities needs to be modeled. Different simulation modeling techniques have been applied to various health care problems including patient flow modeling and operational performance analysis [4]. Preston and Ingalls [5] have classified them into continuous simulation represented by the system dynamics (SD) approach, Monte Carlo, discrete event (DES), hybrid, and agent-based simulations.

System dynamic approach used widely in healthcare improvement. SD was identified by Young et al. [2] as an appropriate method for improving health care management and was used in healthcare environments to explore policies for ongoing operations such as emergency departments [3]. The key performance indicators and objectives differ from one model to another according to the field that the approach applied in it. Many researchers used SD approach to improve the quality of a healthcare unit services.

The paper is organized as follows. In section 2, the methodology is defined. In Section 3 we formally define model conceptualization and causal loop diagram for a health care system and present the factors that affect the system. In the last section, the conclusion is concluded.

2. Methodology

As the level of complexity increases, the need for a conceptual tool to clarify the way of how the system components affect each other is increased. Causal Loop Diagram (CLD) tool based on System Dynamics (SD) is considered more appealing to model complicated network of facilities. CLD aims to give a better understanding of the system structure *and* the relationships between the system's factors. The components of the diagram are the

factors which are considered have a significant effect on the system performance [6]. The identified elements are connected by arrows. The “+” and “-” signs define the direction of the influence, but not its value.

3. Model Conceptualization and Casual Loops Diagram

To develop a general Model for operations rooms in a hospital, the system should be divided into its components. Any system consists of entities, attributes, resources, networks of processes, and variables (inputs and outputs) [7]. Generally, entities in a hospital model are patients, doctors, nurses, beds, and equipment can be thought as resources that cause entities to change state. The System may consist of several parallel sections that may be shared with multiple departments. Systems thinking considers the health care system and considers the key factors and relationships.

Patients are categorized into two groups elective and emergency. This model is focused on the first one. The flow of elective patients is as shown in Figure 1 patients must register first and wait for a bed if there are no available beds. When beds are available, the patients are admitted then prepared for the operation. The patients should wait for the operating room and doctors to be available. After the surgery, the patients remain in the post-acute care and not discharged before they have recovered.

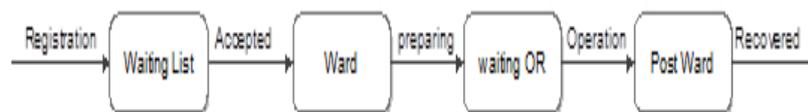


Figure 1 - Flow of Elective Patients

To figure out the affecting factors on hospital services quality, many researchers have been reviewed. The factors are determined by investigating different models and different simulations tools. Rashwan et al. [8] and Lane and Husemann [9] depend on many performance Indicators. Their factors were patients’ throughput represented in waiting and length of stay, and other factors were concerned with Emergency Department efficiency represented in staff (doctors and nurses) and capacity (beds), from this data we can figure out a Causal model as a start.

As shown in Figure 2, upon arrival, patients register for surgeries based on their types and wait for admission. Admission loop B1 reduces the number of patients on the waiting list by admitting them into the unit, when there are available beds.



Figure 2 - Admission loop

Figure 3 shows the effect of patients’ treatment loop on the admission policy. Loop R1 enforces patients’ treatment processes. The admitted patients are assigned to their beds in the ward. The ward patients are prepared for the surgery, then wait for the resources to be available. Once the resources become available, the patients proceed to their planned surgery. After the surgery, the patients are moved back to the ward for post-recovery before they are discharged from the hospital. Once they are released from the hospital, their beds become available to admit patients from the waiting list.

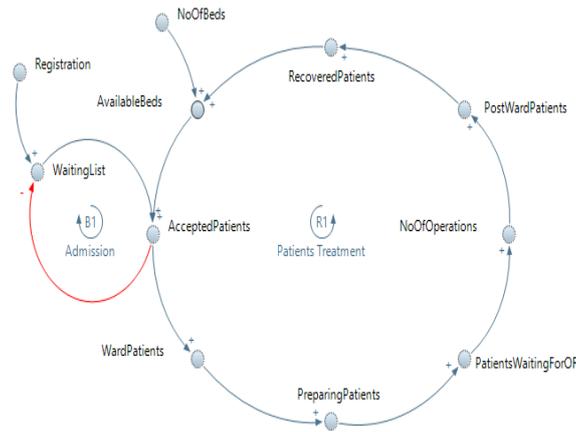


Figure 3 - Patients treatment loop

Figure 4 shows the exhausting effect loop B2 on the available time for operations which will affect the unit capacity. The nurses' unitization is measured to include the effect of over-exhausting, especially with highly utilized resources as nurses which reducing their productivity and reducing the available operation time.

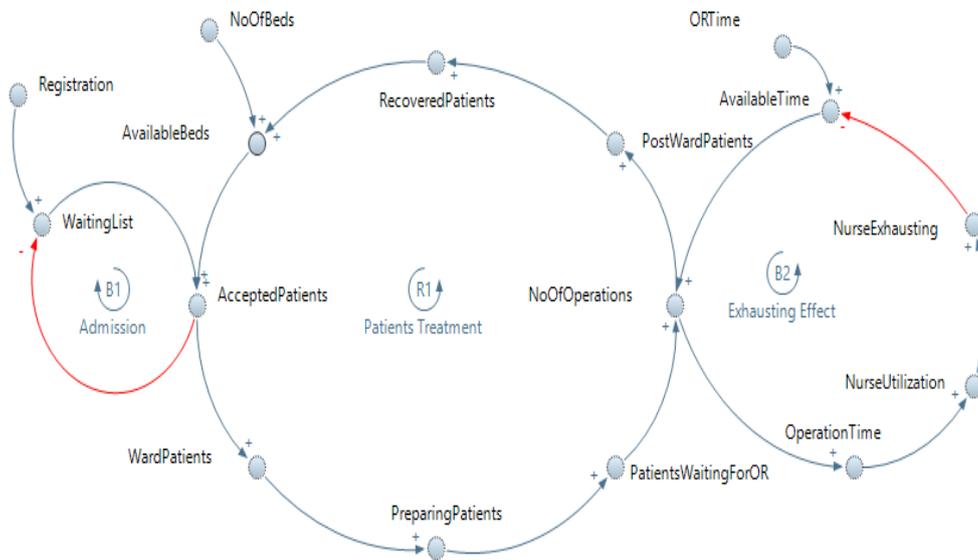


Figure 4 - Exhausting effect loop

On the hand, doctors' exhausting is ignored in this model because it is assumed that they work on flexible time scheme and are allowed to choose their working shifts. The model can be easily adapted to match the cases where doctors are required to work fixed long shifts by adding an exhausting loop to the doctors' availability with the same structure of the nurses' availability. Figure 5 shows a complete casual loop model for one department. The effect of the resources utilization on available time is added to the model. Nurse effect Loop B3 and doctor effect loop B4 show the effect on the available time for operation.

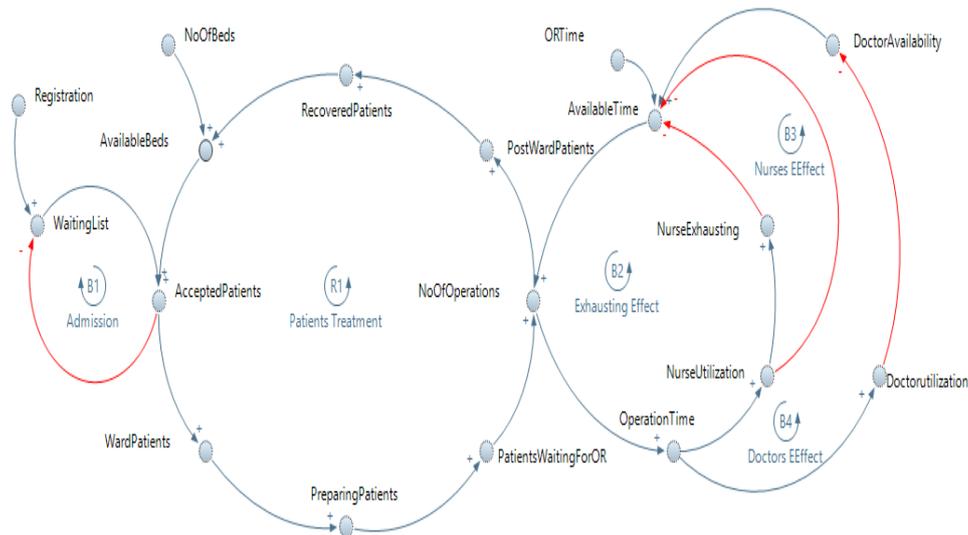


Figure 5 - Casual loop model for one department

Patients are classified into many categories according to their department. To be able making the classification, the patient's dimension is added. Also, Resources will be assigned to each category should be defined as an array. All involved factors will depend on matrices, so the model can evaluate the data for each type.

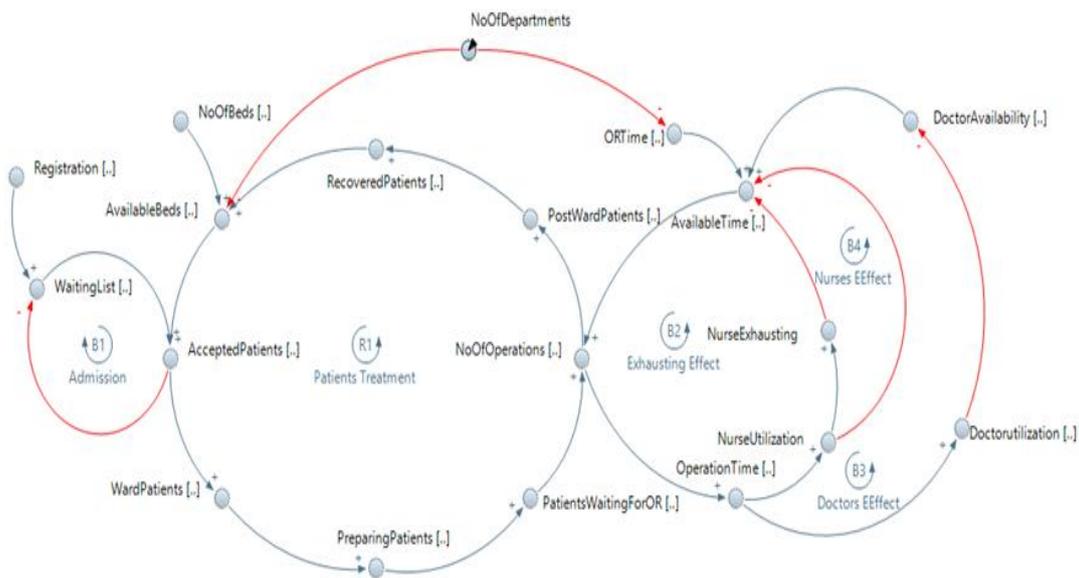


Figure 6 - General model for multiple departments

Figure 6 shows a general model for multiple departments and resources sharing. As shown in the modelFigure 6, all the factors become matrix; the model has three dimensions: dimension for patients, dimension for doctors, and dimension for operating rooms. The model includes four resources with different sharing strategies:

- Nurses, who are fully and flexibly shared among departments.
- Beds, which are split into department dedicated sections and a fully shared section.
- Operating rooms, which are shared based on a pre-determined fixed time schedule.
- Doctors who are assigned only to their specialty and are not shared among departments.

This model can be adapted to fit any system to improve the experience for both of patients and staffs and clarify the ambiguity of the relation between different factors in the system.

4. Conclusions

The developed Causal Loop Diagram based on system dynamics thinking helped to figure out new insights of understanding the complexity of the operating room theatre. This model also illustrates some of the effects on patients' experience and on the quality of service that they receive. This framework is discussed with experts, and they approved the model. The model can be adapted to fit new assumptions, and it is considered as a start for using simulation to test different scenarios that will help decision makers to take the decision that has the most significant impact on the system performance.

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Biographies

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