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Solving an Emergency Department Crowding Problem by Establishing an Intermediate Care Unit

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Public hospitals in Jordan face congestion problems due to the increased number of patients, especially in the Emergency Department (ED). In particular, due to the shortage of beds in ICUs, some critical patients who require transfer to the ICU are boarded in ED. Boarding critical patients in ED not only increases ED occupancy rate but also exposes patients to higher risk of death. We used System Dynamics simulation (SD) to establish an intermediate care unit (IMCU) that can be considered as a buffer unit among the different hospital departments. We applied our study to the Jordan University Hospital (JUH), and simulated the current situation using system SD that could capture the causality relations among the different departments. JUH has eight different ICU types, with an occupancy rate that exceeds 100% as shown by the SD model and validated by the JUH employees. Due to these high occupancies, we suggested and compare two alternative solutions that could ease the ED and ICUs congestions: expansion of the ICUs, and the establishment of an IMCU. Both alternatives showed a very close behavior based on ED occupancy and number of patients per day during the five-year-simulation-model run, but establishing an IMCU was less costly.

Keywords: Emergency Department, Intensive Care Unit, Intermediate Care Unit, System Dynamics Simulation.

1. Introduction

Hospitals and other health services sectors are at risk of demand growth and limited resources (Hansen et al., 2009). They face the challenge of meeting the needs of various stakeholders, such as governments, healthcare professionals, healthcare products, services suppliers and insurance companies. The healthcare sector is essential to meeting the society needs, particularly during crises, such as the COVID-19 outbreak that has tested the resilience of health systems all over the world (Prado-Prado et al., 2009).

The National Hospital Ambulatory Medical Care Survey (NHAMCS) (Centers for Disease Control and Prevention, 2021) defines an Emergency Department as a hospital facility that is staffed 24 hours a day, 7 days a week, and provides unscheduled outpatient services to patients whose conditions requires immediate care. If an in-scope emergency department had an emergency service area that was open less than 24 hours a day, that area is included under the emergency department. If an emergency department is staffed less than 24 hours a day, that department considered as an outpatient clinic.

Emergency department (ED) overcrowding and excessive wait times for ED treatment are persistent problems for hospitals in many countries. Studies typically report the key indicator of ED overcrowding to be the number of admitted patients occupying beds in the ED while they wait for an inpatient bed to become available, otherwise known as inpatient “boarders” (Wong et al. 2010). There is consensus that the most significant contributing factor to ED congestion in a hospital is the lack of ICU beds availability. Thus, solutions to reduce volumes of boarders and time spent boarding are likely to have the greatest impact on the ED congestion crisis.

In the public hospital understudy, Jordan University Hospital (JUH), congestions are witnessed in all departments, namely, the emergency department (ED), eight intensive care units (ICUs), and the general wards (GW). Most ICUs have occupancy rates that is 100%; consequently, patients who require transfer to the ICU from the ED might be boarded in the ED until there is a vacant bed in the ICU. Boarding critical patients in the ED increases the ED occupancy rate and exposes patients to a higher risk of death. Moreover, the ED cannot offer services to new patients and need to transfer them to other hospitals, which endangers the lives of those unadmitted patients. Thus, in this paper, we compare two possible solutions, namely, increasing the number of beds in the ICUs and establishing an IMCU, to free the ED from patients who need ICU services but need to stay in the ED and to provide those patients with better service levels.

Patients arrive to the hospital either from the ER or from the outpatient clinics. They cannot go directly to any type of ICU or general ward until they are admitted through the ER admission system or the outpatient physician. Outpatient clinics cannot directly admit patients to the ICU until they are diagnosed in the ER1. Furthermore, these clinics have the authority to admit their patients directly into general ward beds. Patients are transferred from the ER to all departments based on their condition and the admission department occupancy rate. General ward patients whose conditions have deteriorated into severe conditions should to be admitted to any ICU type (based on their condition classification), taking into account the capacity of ICU beds and occupancy rate. ICU patients, who are in stable condition and do not need high levels of monitoring, can be transferred to the general ward if the flexibility of the system allows. Patients from all the above mentioned units can be directly discharged if the care provided in hospital is no longer needed. The following diagram shows patients’ flow through outpatient, ER, ICU and other general wards.

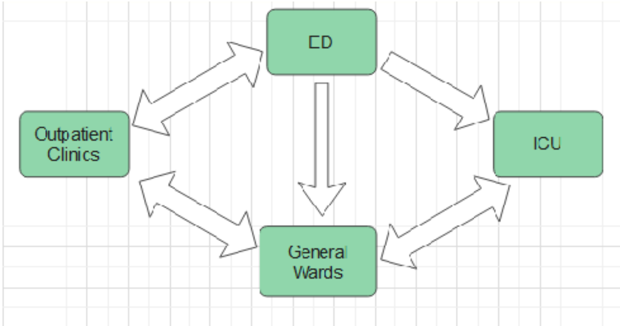

Fig. 1 Patient flow through outpatient clinics, ER, ICU, and General Wards

Average daily visits to the JUH's ER in 2019 increased by 200% in comparison with the average daily visits for the year 2015 (Accreditation and Quality Assurance Center, Jordan University Hospital, 2020).

Because of this huge increase in daily visits, JUH faced logistic challenges including the limited and insufficient number of beds in several departments such as ER, ICU, and General Ward. The insufficient number of beds in these departments has adversely affected the condition of patients and their flow through the hospital. Due to the shortage of beds in ICUs, in particular, some critical patients who require transfer to the ICU boarded in the ER. Boarding critical patients in the ER not only increases the ER occupancy rate, but also exposes patients to higher risk of death. The major causes of crowding in the ER and the shortage of beds in JUH are the following:

Intensive care, also known as critical care, is a multidisciplinary and inter-professional specialty dedicated to the comprehensive management of patients having, or at risk of developing acute, life-threatening organ dysfunction (Marshall et al., 2017). The primary goal of intensive care is to prevent further physiologic deterioration while the underlying disease is treated and resolves.

An Intermediate Care Unit (IMCU) is logistically situated between the ICU and the General Ward. It can function as a physically independent unit or as a dedicated section, incorporated within the ICU. It can act as a "step-up" or "step-down" unit between the general ward and the ICU but can also be used to admit patients from the Emergency Department or recovery ward (Wood, 2007).

An important criticism of the utilization of IMCU is that they potentially admit patients who would otherwise be cared for on the regular ward, thereby wasting critical care resources (Jean-Louis and Rubenfeld, 2015). IMCU, also called step-down units or high-dependency units, attempt to provide appropriate resources to a subset of critically ill patients who do not require all the resources of a full ICU but need more care than that available in general wards (Neilson et al., 2005).

In order to improve the quality provided to patients in healthcare sector, challenges requiring the adoption of multidisciplinary approach and the consolidation of wide vision of knowledge should be taken into consideration. The goal of this study is to come up with new innovation using System Dynamics (SD) simulation. The Jordan University Hospital is taken as a case study.

Since this study requires a systemic approach to analyze the causes and effects existing in feedback structures, there are several methods that can be used such as Discrete-Event simulation and Agent-Based simulation. However, System dynamics simulation was chosen as the main methodology due to the robustness of using aggregate average data and providing long-term strategic insights.

2. Literature review

This section presents some of the studies related to the problem of the study. Therefore, the first subsection (2.1) goes over some studies that addressed the ED crowding problem. Section 2.2 reviews one of the most important solutions to it: establishing an Intermediate Care Unit. This solution can be foreshadowed by using a System Dynamics Simulation (section 2.3).

2.1 Emergency Department crowding problem

Pines and Griffey (2015) stated that the crowding problem in the ER is a problem threatening patients' safety and health around the world. Many countries including Ireland (Posfai et al., 2006), Australia and Canada (Guttmann et al., 2011) reported the increase of this problem globally. Many studies were conducted to identify the reason of the problem. Among the reasons studied are the system inputs (number of patients waiting to be examined in the ER), delay in determining treatment for patient present in the ER, and the work rate or obstacles preventing patients from leaving the ER after finishing their treatment (Moley et al., 2018). In addition, there are many other reasons that depend on the time and place of jam happening in the ER.

2.2 Intermediate Care Unit

As mentioned earlier, Intermediate Care Unit (IMCU) is located between the ICU and the floors. It can be an independent unit or a unit that assists the ICU [7]. It can act as step-up or step-down unit between the floor and the ICU (Jean-Louis and Rubenfeld, 2015). Notably, patients can enter the IMCU directly from the ER (Neilson et al., 2005).

Specifications, types and the amount of service provided through the IMCU depend on various factors including resources availability, institutional infrastructure and the general healthcare sector (Rubinson et al, 2008). Recently, after studying results of hospitals with an IMCU, it can be concluded that the mortality rate in hospitals with IMCU is less than the mortality rate in hospitals without this unit (Capuzzo et al., 2014). In addition, the time spent by patients in the ICU is less and the costs covered by the hospital are less as well. However, there is relatively little data published to support this claim (West et al., 2014). Earlier studies of IMCU have focused on the effect of IMCU on the ICU mortality (Plate et al., 2017); ICU readmission rates and in-hospital mortality (Vollam et al., 2018); cost-effectiveness of IMCUs (Kawatra and Maheshwari, 2013) and the level of staffing required at the IMCU. Such studies have specifically focused on IMCUs designed for minimal functions (Ronis et al., 1984), or have not discussed the utilization of IMCUs in details (Plate et al., 2017). By contrast, this study proposes that the introduction of IMCU in hospitals can help overcome many of the above-mentioned problems especially the ones related to overcrowding in the ER and mortality rates.

2.3 System Dynamics Simulation in healthcare service sector

Recently, there has been significant interest in developing System Dynamics (SD) simulation in order to analyze and study the problems of the healthcare sector as these problems are considered complicated. The limited progress when it comes to finding solutions for his sector result in delaying its development (Brailsford et al., 2009). In the healthcare system, the impact of various variables is clearly known, but the interaction of these variables as a whole with the system is difficult to study. Therein lies the importance of using SD simulation in developing the healthcare sector and understanding its problems (Fone et al., 2003). Under these circumstances, the simulation system assists in clarifying the unexpected behaviors of problems facing the healthcare sector (Sterman, 2001). Simulation modeling is a very good option due to the complexities of the healthcare sector that cannot be solved manually only. It is not easy to develop a simulation system for the healthcare sector due to the fact that there are no clear principles that can be relied upon in this area (Sterman, 2001). In fact, there are significant benefits for the application of the simulation system in the private sector that can help learn from complex problems and test interactions between the system problems.

3. Methodology

This study aims to find a solution to overcrowding and mortality rates in the ER. For this end, the researchers propose a simulation to evaluate three viable solutions in terms of cost, effectiveness and practicality; increase number of beds in the ER, increase capacity in the ICU, establish IMCU)

VENSIM-PLE Simulation Model

VENSIM is simulation software developed by Ventana Systems software corporate. It is one of several commercially available programs that facilitate the development of continuous simulation SD models. In particular, it adopts structures known as stocks and flows that changes the stocks level according to defined relationship between various system agents. The Personal Learning Edition (PLE) of VENSIM is going to be used through this study. VENSIM simulation software allows simulation of the system in general over a long period of time. VENSIM simulation model is capable of aggregating average data to provide long-term strategic insights. For instance, patients are considered to be a stock that increases by inflow to the hospital and decreases through death or discharge from hospital. Fig. 2 shows a simple representation of a stock and flow structure with inflow and outflow.

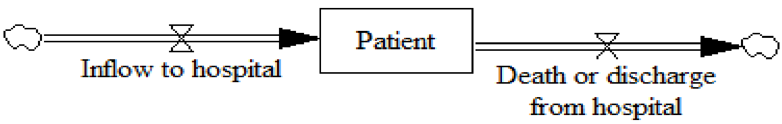

Fig. 2 Representation of a stock and flow structure in hospital

The value of stock at any time (t) can be calculated by adding the integral of its net flow (inflow minus outflow) over time to its initial value, presented as an equation:

$$Patient(t) = \int_{t0}^{t} \big(Inflow(s) - Discharge\ or\ death(s)\big)ds + Stock(t0) \quad (1)$$

Three SD simulation models that are going to be constructed through this study are the following:

1- An as-is situation high level model that includes ICU, ER and general wards.

2-An as-is situation low level model that includes all ICU types in JUH, ER and general wards.

3- Improvement case where an IMCU is added or an ICU is expanded to the system.

The study will use the notation illustrated in table 1 to describe the model (Data taken from JUH statistics):

Table 1 Notations to describe SD model

$\alpha 1$	ER arrival rate	8 patient/hour
$\alpha 2$	Arrival rate of outpatients to wards	2 patients/day
Q1	The percentage of patients in the ER who require ICU transfer	47%
Q2	The percentage of patients in the ER who require IMCU transfer	Not identified yet
Q3	The percentage of patients in the ER who require transfer to wards	36%
Q4	The percentage of patients in the ER who returned home	13%
1	The percentage of patients in the ICU who require IMCU transfer	Not identified yet
2	The percentage of patients in ICU who require transfer to wards	23%
3	The percentage of patients in ICU who died	13%
1	The percentage of patients in IMCU that require transfer to ICU	Not identified yet
2	The percentage of patients in IMCU who require transfer to wards	Not identified yet
3	The percentage of patients in IMCU who died	Not identified yet
$\sigma 1$	The percentage of patients in wards who are transferred to ICU	7%
$\sigma 2$	The percentage of patients in wards who released	88%
t1	The average time spent by a patient in the ER	4 hours
t2	The average time spent by a patient in the ICU	5 days
t3	The average time spent by a patient in the IMCU	Not identified yet
t4	The average time spent by a patient in wards	4 days

It is assumed that both ER and wards can accommodate more patients than their designed capacity. Usually, more beds can be brought to the ER or wards in case that more patients are accepted in these two departments. The instantaneous rate of change in ER number of patients is represented as the rate of patients who enter the hospital through ER, excluding the rate of patient who are transferred from ER to ICU, if the capacity of ICU allows, minus the rate of patients who transferred to IMCU, if the capacity of IMCU allows, minus the rate of patient who transferred from ER to the general wards, minus the rate of patients who are discharged from ER. Eq. (2) represents the ER patients rate of change which explains the dynamics of the model:

$$\frac{dER}{dt} = \alpha 1 - \frac{ER.\beta 1}{t1}.1\{ICU < ICU\ cpacity\} - \frac{ER.\beta 2}{t1}.1\{IMCU < IMCU\ capacity\} - \frac{ER.\beta 3}{t1} - \frac{ER.\beta 4}{t1} \quad (2)$$

If the capacity of ICU allows at any stage, the instantaneous rate of change in ICU number of patients is represented as the rate of patients who transferred from ER to ICU, plus the rate of patients who transferred from IMCU to ICU, plus the rate of patient who transferred from general wards to ICU, minus the rate of patients who transfer from ICU to general wards, minus the rate of patients who transfer from ICU to IMCU, minus the rate of patients who discharged from ICU. Eq. (3) represents the ICU patients rate of change.

$$\frac{dICU}{dt} = \frac{ER.\beta 1}{t1}.1\{ICU < ICU\ cpacity\} + \frac{IMCU.\delta 1}{t3}.1\{ICU < ICU\ cpacity\} + \frac{WARDS.\sigma 1}{t4}.1\{ICU < ICU\ cpacity\} - \frac{ICU.\gamma 3}{t2} - \frac{ICU.\gamma 1}{t2}.1\{IMCU < IMCU\ cpacity\} - \frac{ICU.\gamma 2}{t2} \quad (3)$$

The instantaneous rate of change in general wards number of patients is represented as the rate of patients who transferred from ER to general wards, plus the rate of patients who transferred from IMCU to general wards, plus the rate of patient who transferred from ICU to general wards, minus the rate of patients who transfer from general wards to ICU, if the capacity of ICU allows, minus the rate of patients who discharged from ICU. Eq. (4) represents the general ward patients rate of change.

$$\frac{dWard}{dt} = \alpha 2 + \frac{ER.\beta 3}{t1} + \frac{ICU.\gamma 2}{t2}.1\{ICU < ICU\ cpacity\} + \frac{IMCU.\delta 2}{t3}.1\{IMCU < IMCU\ cpacity\} - \frac{WARDS.\sigma 2}{t4} - \frac{ICU.\sigma 1}{t2}.1\{ICU < ICU\ cpacity\} - \frac{WARDS.\sigma 2}{t4} \quad (4)$$

The instantaneous rate of change in IMCU number of patients is represented as the rate of patients who transferred from ER to IMCU, if the capacity of IMCU allows, plus the rate of patients who transferred from ICU to IMCU, if the capacity of IMCU allows, minus the rate of patients who transfer from IMCU to ICU, if the capacity of ICU allows, minus the rate of patients who discharged from IMCU. Eq. (5) represents the IMCU patients rate of change.

$$\frac{dIMCU}{dt} = \frac{ER.\beta 2}{t1}.1\{IMCU < IMCU\ cpacity\} + \frac{ICU.\gamma 1}{t2}.1\{IMCU < IMCU\ cpacity\} - \frac{IMCU.\delta 3}{t3} + \frac{WARDS.\sigma 2}{t4}.1\{ICU < ICU\ cpacity\} - \frac{ICU.\delta 1}{t2}.1\{ICU < ICU\ cpacity\} - \frac{WARDS.\delta 2}{t4} \quad (5)$$

4. Results

This section proposes the results of applying the SD simulation. Section (4.1) will present the results of applying a High level VENSIM model. Section (4.2) shows the results of applying a Detailed System Dynamic Model, while section (4.3) gives the results of developing design alternatives.

4.1 High level VENSI model

Fig. 4 shows the current high level situation of the ER, general wards and ICU layout at JUH.

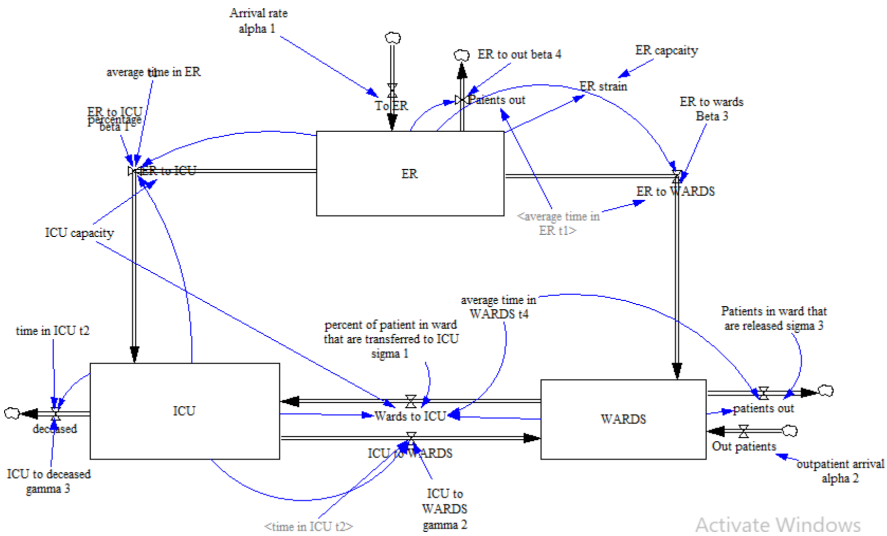

Fig. 4 High level simulation model for As/Is situation

As shown in Fig. (4), and as mentioned earlier, all patient to JUH are admitted through the ER department. Patients usually receive an initial treatment in the ER. If it does not work, then they are transferred either to the wards or to the ICU depending on their conditions. By the application of Eq. (2-5) to the as-is simulation model, we come to the following conclusions:

1. The average number of patients in the ER on any day of the year is between 71 and 79 patients, which matches the equation (ER =To ER -Patients out- ER to WARDS- ER to ICU) applied to the averages of the data collected from the JUH statistics department as shown in Fig. 5. below.

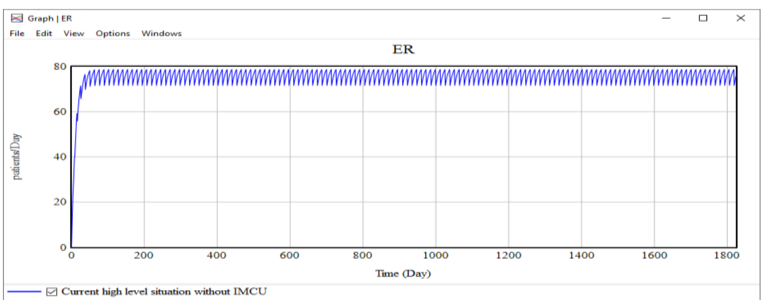

Fig. 5 ER output of simulation model for high level as-is situation

2. The average number of patients in the ward on any day of the year is between 38 and 43 patients, which matches the equation (WARDS= ER to WARDS+ICU to WARDS + Out patients-patients out-Wards to ICU) applied to the averages of the data collected from the JUH statistics department (approximately 39.6) as shown in Fig. 6. below:

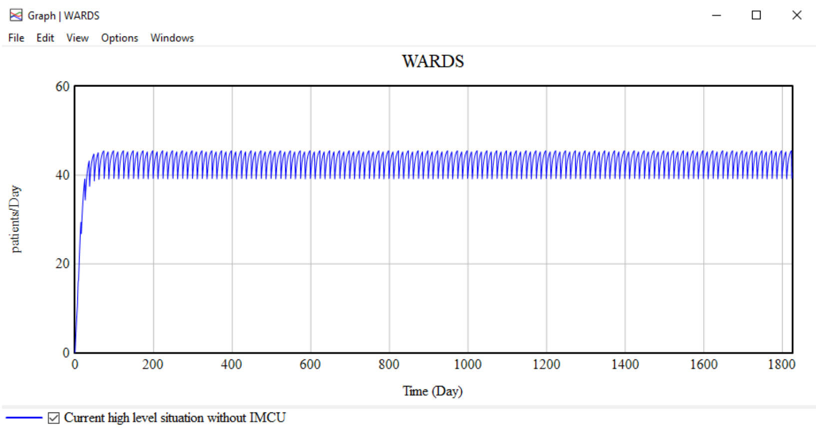

Fig. 6 Wards output of simulation model for high level as-is situation

3. The average number of ICU patients any day of the year is between 9 and 22 patients, which matches the equation (ICU= ER to ICU + Wards to ICU-died-ICU to WARDS) applied to the averages of the data collected from JUH statistics department (approximately 7.6) as shown in Fig. 7.

Fig. 7 ICU output of simulation model for high level as-is situation

These results validate the current high level VENSIM model that we design for the ER, ICU and the general wards. Based on the results shown in our model, the ICU occupancy rate is not that high due to the utilization of all ICU beds with extremely different occupancy rate. The results presented so far do not indicate that there is any problem with the ICU occupancy rate. Thus, the study constructed a more detailed dynamic model to clarify if such a problem exits.

4.2 Detailed System Dynamic Model

In the primary JUH scenario, which does not include either the expansion of ICU capacity or the introduction of an IMCU unit, we simulate the performance of JUH at equilibrium. The model produced ICU-type occupancy rates very close to the values observed in the literature.

As can be seen from the model (Fig. 8), JUH have 8 distinctive ICU types:

1- GICU: General ICU

2- 2- MICU: Medical ICU

3- Premature Unit

4- PICU: Pediatric ICU

5- CCU: Cardiac Care Unit

6- SCCU: Surgical Cardiac Care Unit

7- SICU: Surgical ICU

8- NICU: Nauru ICU

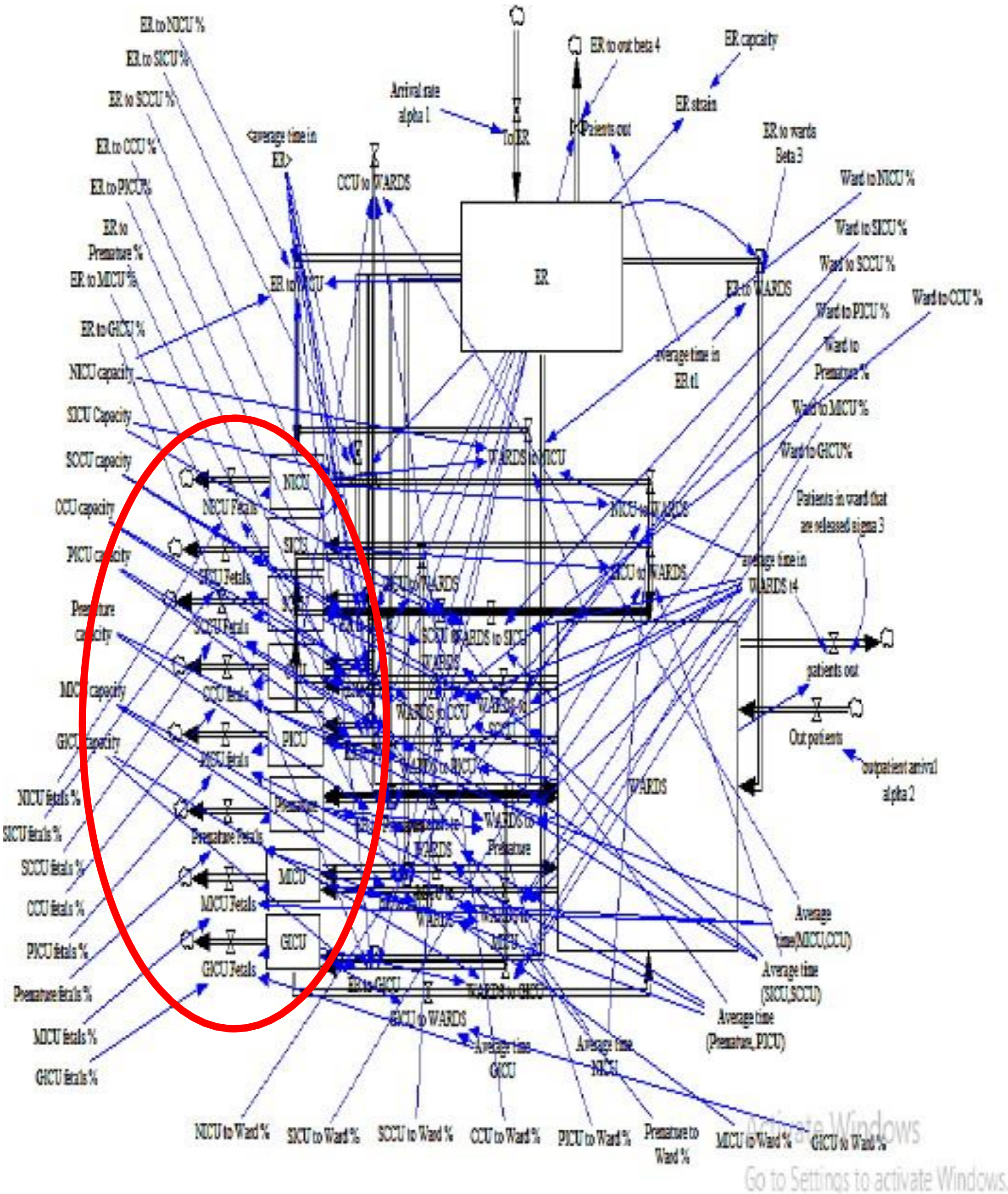

Fig. 8 Detailed as-is simulation model

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After inserting the parameters rates and equations into the model, we had the following results (as shown in Figures 9-16):

1. NICU: 50% of the time NICU have occupancy rate more that its capacity (8 beds).

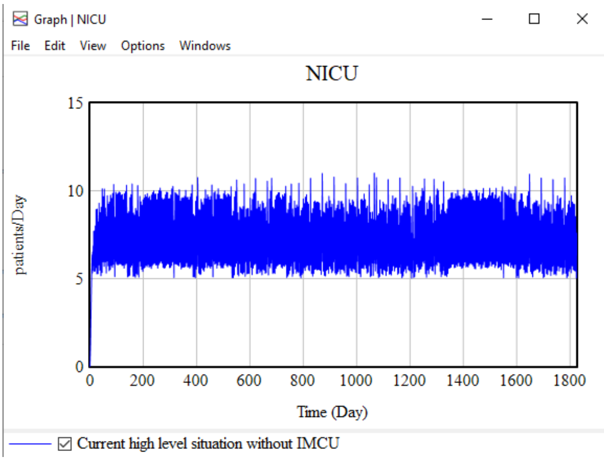

Fig. 9 NICU as-is simulation model

2. SICU: an occupancy rate of more than 140% all the time (6 beds)

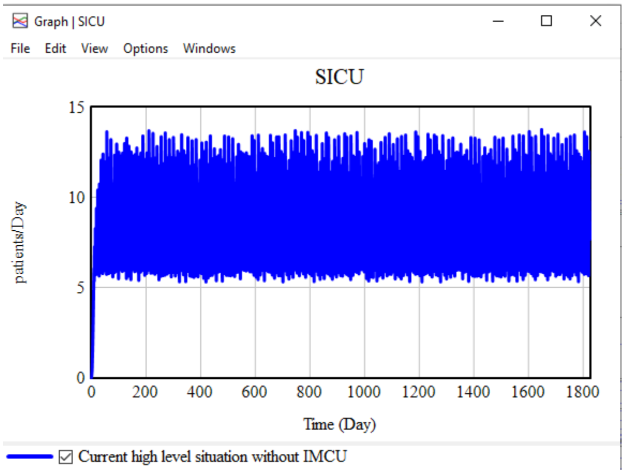

Fig. 10 SICU as-is simulation model

3. SCCU: an occupancy rate of more than 140% all the time (6 beds)

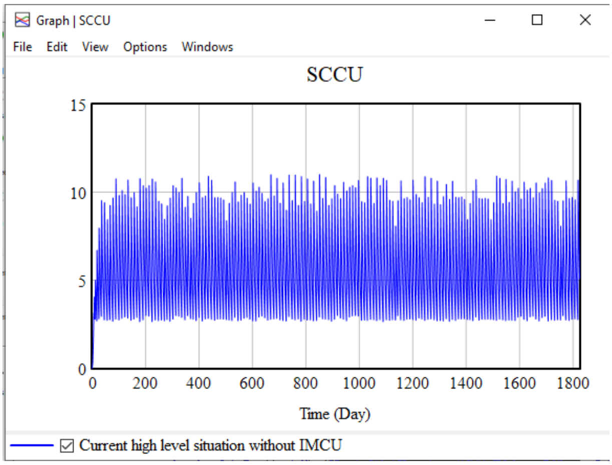

Fig. 11 SCCU as-is simulation model

4. Premature unit: 100% occupancy rate all the time.

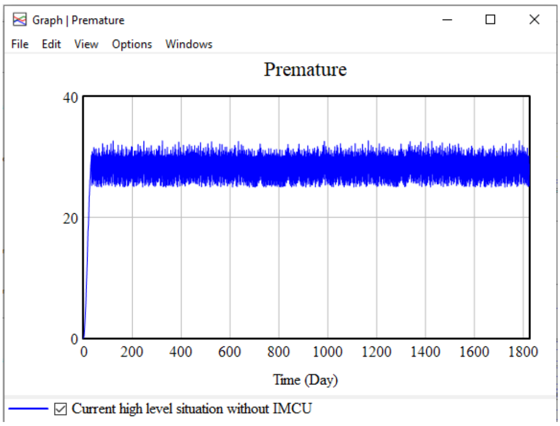

Fig. 12 Premature as-is simulation model

5. PICU: has an occupancy rate of 120% all the time.

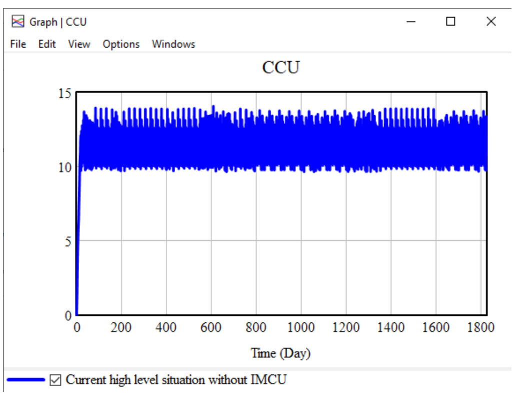

Fig. 13 CCU as-is simulation model

6. CCU: the situation is not very bad as the previous ICU types.

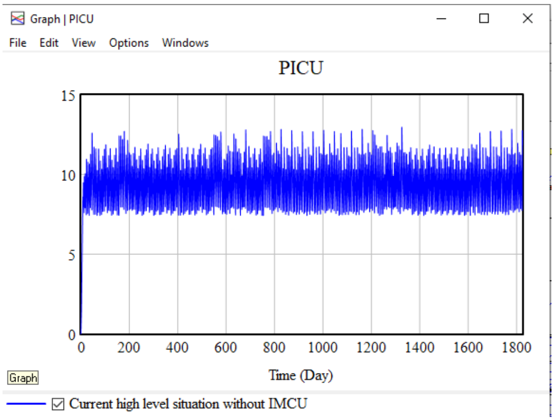

Fig. 14 PICU as-is simulation model

7. MICU: 100% occupancy rate all the time.

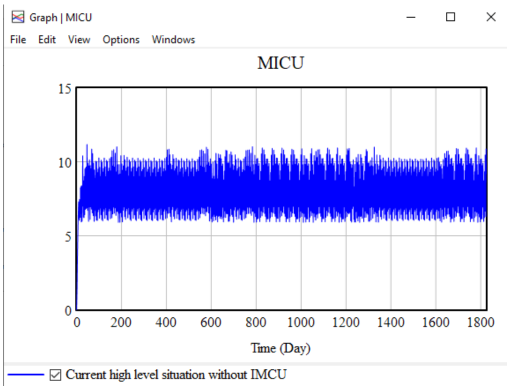

Fig. 15 MICU as-is simulation model

8. GICU: has 120% occupancy rate 70% of the time.

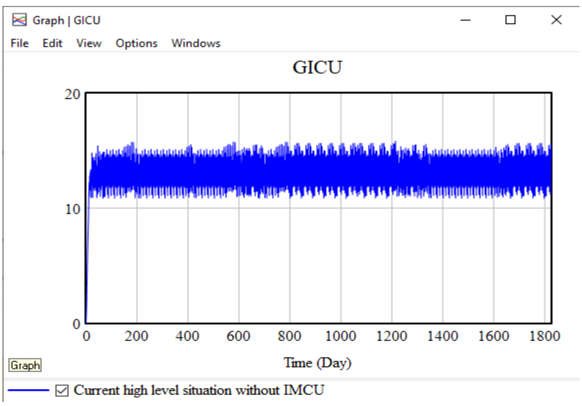

Fig. 16 GICU as-is simulation model

By reviewing these figures and results, the problem of high occupancy rates of ICU types was found to be the cause of bottlenecks. This ultimately results in the ER crowding problem.

4.3 Developing design alternatives

Two design alternatives were considered to solve the ER crowding problem:

1- Introducing an IMCU with 10 beds.

2- Adding 10 ICU beds, one for each of PICU, Prematurity, MICU, GICU, CCU and NICU, and two for each of SICU and SCCU considering the high occupancy rate of these 2 types.

Introducing an IMCU with 10 beds.

We start with the first alternative. To study the impact of IMCU presence in JUH on patients' flow, we considered adding an IMCU to the system. Based on previous studies, IMCU can be defined as a step down, high dependency and/or step up unit [9]. This means that patients can be transferred from any ICU type (except Prematurity and PICU) to IMCU if they are partially recovered and do not need full ICU monitoring equipment and staff. IMCU can also be a high dependency unit, which means that moderately sever patients can be admitted directly from the ER to the IMCU. The step up unit means that IMCU patients with complications can be transferred to any ICU type (except for Premature and PICU). Moderate complication that may occur in wards, i.e. patients who do not require more attention than that provided in the IMCU, can be managed in wards without the need to transfer them to the IMCU. Bülbül et. al. (2023) calculated that the percentage of patients transferred from the ICU to the IMCU must be 13.6%. On the other hand, Mahmoudian-Dehkordi and Sadat (2020) found that 23% is more logical. Zimmerman et.al. Zimmerman (1995) gave a much higher percentage. For them, 35% of patients must be transferred from ICU to IMCU. We considered the 3 percentages proposed in these three studies and took the average (i.e. 24%) to use in our system dynamic model,

The percentage of patients transferred from the IMCU to any type of ICU (except Prematurity and PICU) was 31% based on (Heidegger et al., 2005).

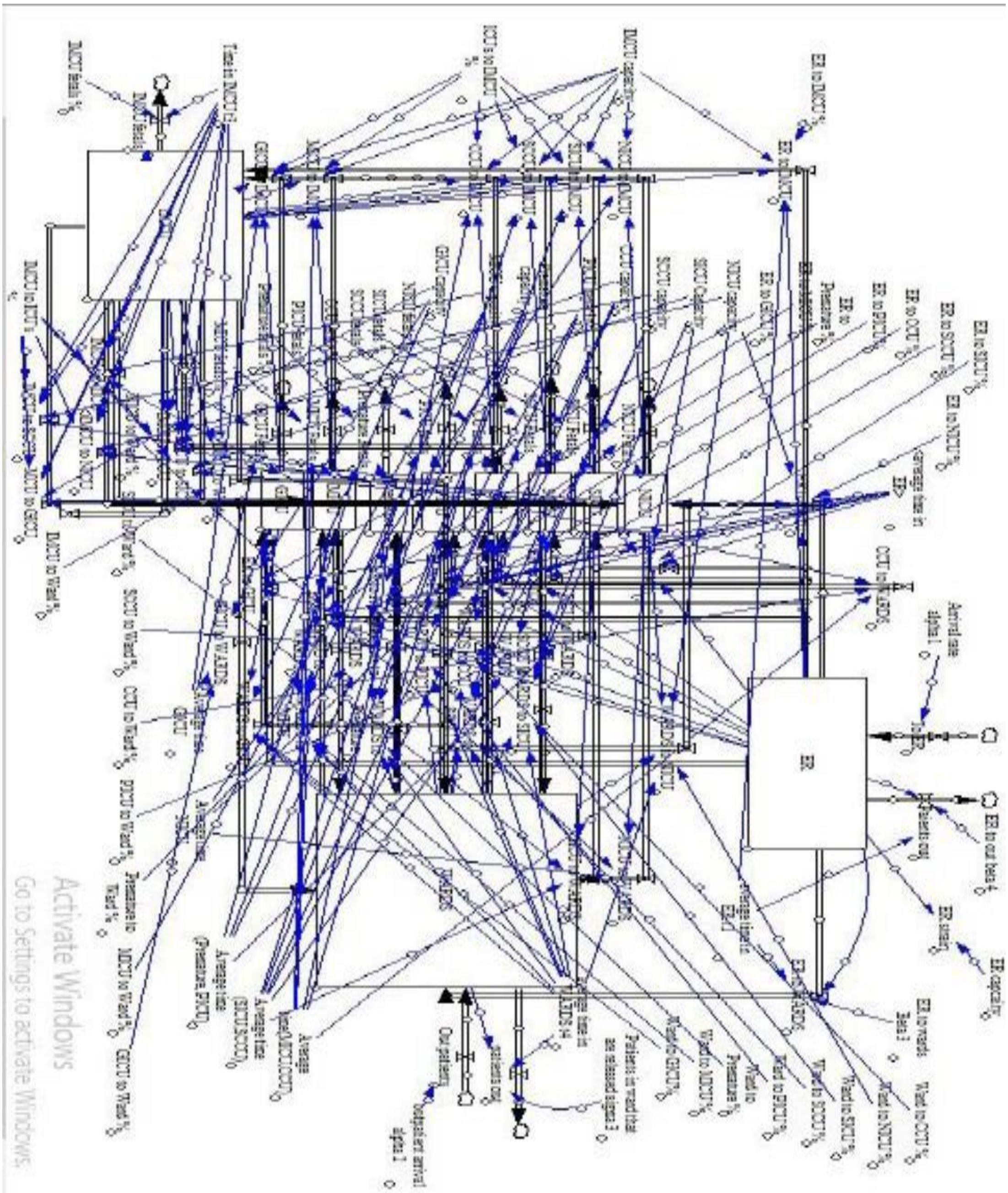

Fig. 17 VENSIM simulation model after IMCU addition

The average number of patients in the ER any day during the simulation period (5 years) decreased significantly with the presence of an IMCU in the hospital as shown in Fig. 18.

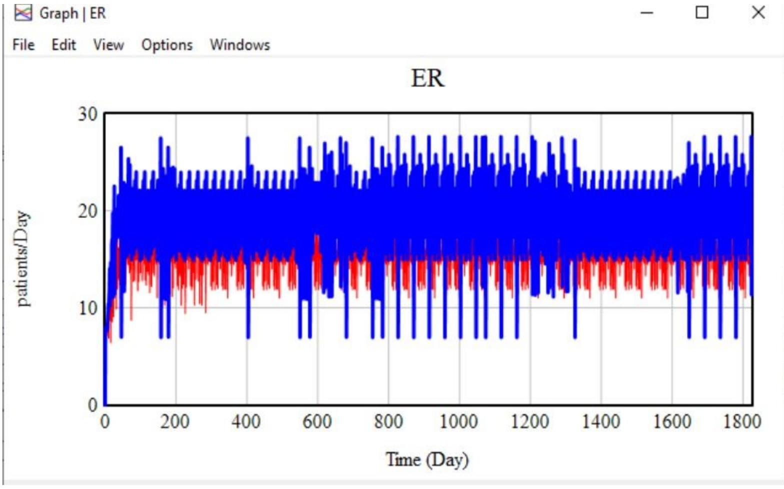

Fig. 18 ER output of simulation model for low level after IMCU addition

The Figure above shows that patients admitted to ER fluctuate between 7-28. Recall that without IMCU, it was 71-79 as shown in Fig. 5 above. Thus, the introduction of IMCU has dropped the number of patients admitted to ER almost to a quarter.

Adding 10 ICU beds

Results related to the ER, after the addition of IMCU, show a significant decrease in patients' presence in the ER on a daily basis. These results were based on the system simulation for 5 years after. However, adding 10 beds to the ICU may sound like another viable option. Running the simulation model, the result will look like Fig. 19. below:

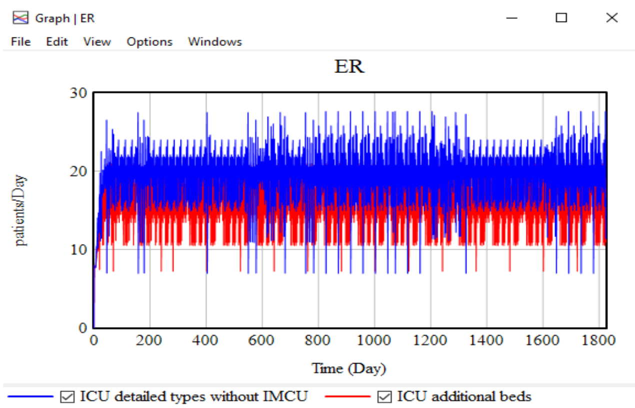

Fig. 19 ER results after the addition of 10 ICU beds

Fig. 19 above shows that adding 10 beds in the ER may reduce the occupancy rate to 8-28 per day. This means that this solution is viable. Recall that high occupancy rate in the ICU's and consequently the lack of beds available in these systems decrease the admission of new patients in these departments, which result in increasing occupancy rate in the ER and the waiting time of patients who need intensive care, hence a longer waiting time for the ICU admission (Bing-Hua, 2014) as shown in Fig. 20 below.

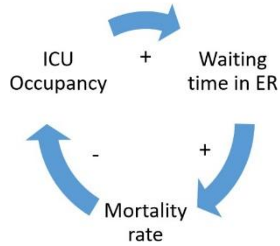

Fig. 20 Balanced feedback structure

4.3 Evaluating and selecting the best alternative

Based on the output, the alternatives to improve the process were:

1- Increasing beds in the ER.

2- Increasing beds in the ICU. 3- Establishing an IMCU.

Bed capacity in the ER will not be increased due to space considerations; however, its availability will be increased by reducing the occupancy rate through adding ICU beds or establishing IMCU. Here, we will consider the previous studies to find out the best of the two options (adding ICU beds or establishing IMCU). Previous studies show that the total hospitalization cost (inpatient cost) is equal to the sum of the expenses of ICU, IMCU, and wards (Armaignac, et al., 2018). We used Russell's equation, and the ICU and wards costs detailed by (Halpern and Pastores, 2015) to calculate the total cost of patients' hospitalization under each alternative. Based on Russell's equation:

a. The annual cost of an ICU= ICU inpatient days* ICU cost per inpatient day.

b. ICU inpatient days = ICU beds* 365 days *average ICU occupancy rate.

These equations can be used easily to find out the ICU costs. Based on these equations and on (Halpern and Pastores, 2015) and (Armaignac, et al., 2018), the annual cost of IMCU will be between 74% and 33% of the annual ICU cost. i.e. the operation cost of an ICU is estimated to be 1.35 to 3 times of operation cost of an IMCU (Armaignac, et al., 2018). Accordingly, we conclude that establishing an IMCU with 10 beds is cost effective and a good solution to our crowding ER problem.

5. Conclusion

The reason behind conducting this study is the shortage of ICU beds and their high occupancy rates which result in the delayed admission of patients and the delay of transferring severely ill patients from the ER to the ICU. The ER staff are required to deal with these cases until the capacity of ICU beds allows the admission process to be completed. The occupancy of ER beds with these patients aggravates the crowding issue in general. For our case study, we chose JUH because it one of the three tertiary care centers in Jordan, it is a trauma center, and it receives all government and some private sectors insured patients. To solve the problem we applied an SD simulation. Previous studies did not use this methodology in the healthcare sector. Two long-term investment policies were investigated to come up with reasonable solution for the problem of the study: Expanding ICU capacity to 10 beds, and establishing an IMCU with 10 beds. It was found that we establishing an IMCU with 10 beds is cost effective and perhaps the best solution to the crowding ER problem.

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