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# Leveraging Simulation Models in Healthcare for Improving Patient Flow in King Abdulaziz Medical City in Riyadh, Saudi Arabia (KAMC-RD)

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## Abstract

Leveraging digital technology for effective decision making requires tools that can comprehend detailed complex process of healthcare organizations. Considering all dimensions, simulation is applicable in many ways throughout the healthcare system due to its ability to capture and mimic detail complexity in clinical operations decisions. Healthcare simulation not only helps ensure that providing services of the highest quality, but simulation ultimately increases the ability of following best practices, quality improvement, and risk management activities. Moreover, this representation of healthcare system has become a primary tool by which increased patient safety can be integrated and facilitated into clinical practices. This article presents a simulation model for healthcare outpatient clinics. This model aims to aid in setting up management guidelines

and propose procedure to improve the operation of the clinics and to optimize the performance of such dynamic healthcare clinic. Model optimization is used to find out the optimal staff as resources, which includes physician, nurses, and clinics minimize patient length of stay and smooth patient flow.

## Keywords

Simulation Model, AnyLogic, Healthcare, Modeling, Patient Flow

## 1. Introduction

In the era of digital transformation, the importance of integrating digital technology into all areas of a business processes is growing. In healthcare organizations, the need for efficient resource management, improved patient flow, and enhanced decision-making is urgent. Therefore, it has become necessary to adopt the various emerging technologies in the fields of health care, and among these technologies are simulation systems. This article explores the utilization of simulation models in the healthcare industry to improve patient flow and enhance operational efficiency in Outpatient settings. Simulation modeling has emerged as a powerful tool that enables healthcare professionals to analyze complex systems, simulate various scenarios, and make data-driven decisions. By providing a virtual environment to test hypotheses, identify bottlenecks, optimize resource allocation, and predict outcomes. Simulation models have the potential to revolutionize healthcare management [1]-[4].

This article is highlighting the significant contributions of simulation model to healthcare delivery and patient flow by presenting simulation model implemented and adopted in King Abdulaziz Medical City in Riyadh (KAMC-RD).

## 2. Use Case—Women's Health Specialist Hospital (WHH) Simulation Model

Women's Health Specialist Hospital (WHH) is one of the hospitals under King Abdulaziz Medical City in Riyadh. The Outpatient clinics operates under Women's Health Specialist Hospital (WHH) provide a wide range of medicine appointments including Obstetrics and Gynecology (OB/GYN), Maternal Fetal Medicine (MFM), Urogyn (URO) and Ultrasound (US). Developed model creating virtual replicas of healthcare systems in outpatient clinics in WHH, capturing their complexities, and simulating real-life scenarios. The outpatient clinics simulator models the resources and patients flow. The model demonstrates how the overcrowding affects: starting of registration to discharge treated patients, the waiting time in different areas, and estimate the resources according to simulated scenario. The simulation will allow organization management teams to practice and response to various conditions that affect patient flow and evaluate the impact of their decisions.

## 2.1. Simulation Modeling Development

This section delves into the development of simulation modeling, explaining the data requirements, analysis, design, methodology of implementation, and deployment process. The simulation model was developed using AnyLogic Software [5]. The key entities of the simulation model are patients, resources are physicians, and nurses, outpatient clinics, Point of Care (POC) and vital signs rooms. Patients are modeled as arrival entities through four kinds of services: OB/GYN, MFM, URO and US. The user able to fine-tune value to input parameters through a graphical user interface such as change the rate of patient arrival per hour and change quantity of resources. Arrived patients register, go through the several processes such as Point of Care (POC) and vital signs. After the stated process, patients are sent to the waiting area waiting for calls to the different clinics based on their appointment for an examination and treatment. After a patient is taken into the clinic, physician will assess and treat the patient, then the patient will move to the nursing station, where the necessary actions are done and the patient be discharged. Sequences of process that performs by the simulation system as a result of input from the users; help to express the workflow. The Overview of Ultrasound Process Flowchart is shown in Figure 1.

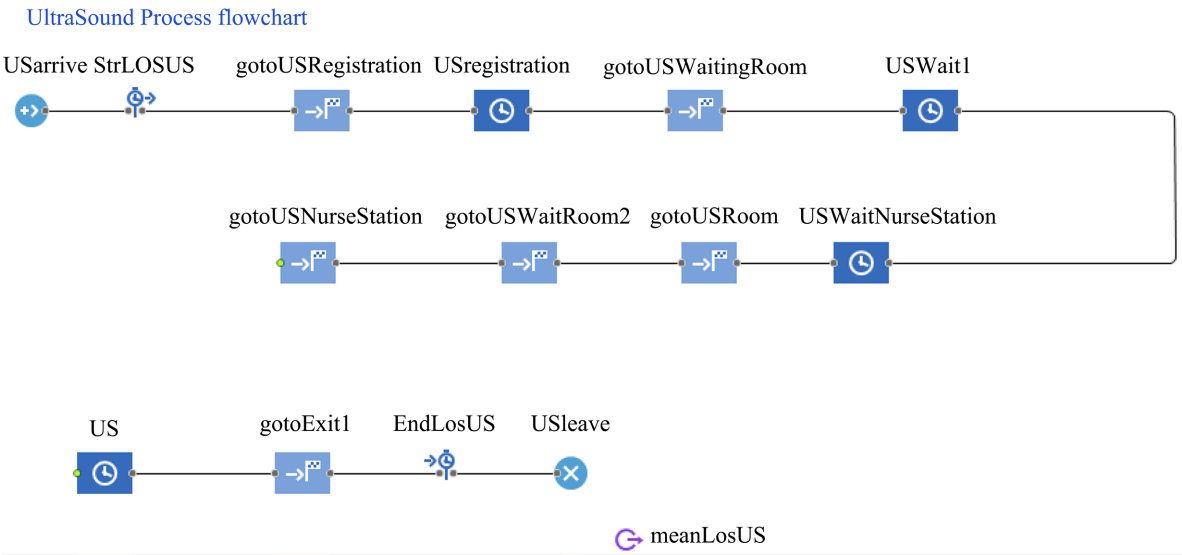


Figure 1. Overview of ultrasound process flowchart.

## 2.2. Simulation Modeling Results

It is important to manage the flow of patients throughout the hospital. Present patient flow at varying levels of parameters values through incorporating different resource pools with more or less staffing and patient arrival rates. This model used to explore the likely impact and the consequence of various parameters such as additional patient arrivals at the outpatient clinics. In order to construct this analysis, it is necessary to present a number of scenarios about how patients flow may affect due to the changes.

Figure 2 shows user interface of experiment screen were configuring parameters and then start simulation. Highlights how change in patients' distribution and flow change based on arrival rate and resources. And how the active clinic is organized to handle selected load. The arrival of patients, who will use more resources, will cause the backlog of other patients. By running the model, a number of times, we can test the robustness of the model and promote the best scenario to reduce blockage associated with patient flow. The list of model parameters, which are the inputs of the simulation model, were used to excuse the model and evaluate results:

- Rate of patient's arrivals/per hour
- Quantity, location and type of services/appointments
- Staff either physicians or nurses
- Time and resources for each appointment type
- Layout of the outpatient clinics
- Outpatient clinics capacities
- Processing times

Model outputs include the:

- Distribution of patients in each location over time
- Operation process of the outpatient clinics such as:
  - o System and patient flow
  - o Utilization resources
  - o Patient Length of Stay (LOS) for each appointment type.

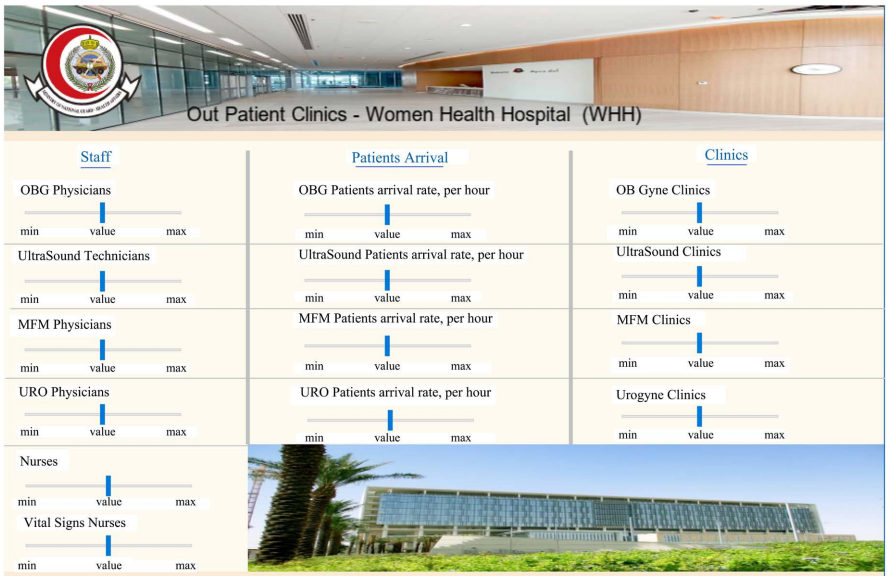


Figure 2. Outpatient simulation model overview.

Patient processing time is defined as Length of Stay (LOS), from patient arrival though the completion of treatment until discharge. LOS of four kind of services with selected value of parameters is shown in Figure 3 and resource utilization shown in Figure 4.

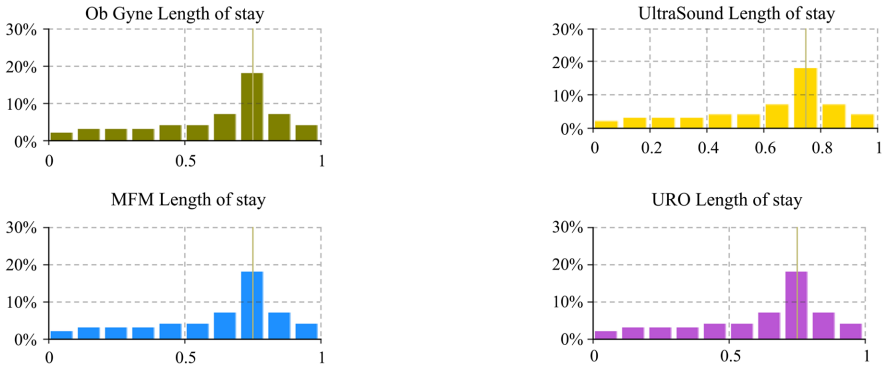


**Figure 3.** Patient length of stay at specific levels of patient arrival and resources.

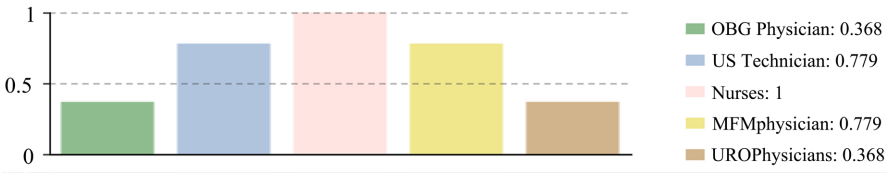


**Figure 4.** Recourses utilization at specific levels of patient arrival and resources.

The results of the simulation model will help assess the of current staffing utilization levels to ensure timely and appropriate patient care. Also, the results obtained by using an alternative patient flow scheme are promising and a better understanding of the problem is achieved.

## 3. Discussion

The advantages of utilizing simulation models in KAMC are still in the early stages, as the model is subject to continuous change and improvement. However, there are some important advantages achieved from adopting the model. The most important is how the simulation models enable healthcare professionals to evaluate the impact of process changes, optimize resource allocation, reduce patient wait times, enhance patient safety, and analyzing the impact of policy changes. In Outpatient area, the simulation model reduce patient wait times, improving appointments scheduling, and enhancing capacity planning. In addition to the cost-effectiveness of simulation modeling by minimizing trial-and-error approaches, optimizing department workflows, and enhancing capacity planning [2] [6] [7].

The role of simulation modelling in healthcare has been recognized and is now one of the commonly used approaches to studying clinical problems. Simulation may have considerable power as it can readily provide experience with anatomic or clinical practice, and basic skills before beginning to work on real patients. In this way, simulation is applicable to support lifelong learning. With emphasis, simulation will not replace the primacy effect of training for medical practitioners or students on real patients with some degree of supervised work on real patients [8]-[11].

The values and the benefits of simulation can be as good as the input data, yet

availability and completeness of data is the main challenge in healthcare [9]. Simulation results influenced by the logic of the model and input values into the model and thus does not take it into consideration the external factors that could affect [12]. Also, profound verification and validation is a must to make predictions then decisions based on the model outcomes, otherwise decision it would be risky, if not disastrous. Simulation tool is still a highly technical and sophisticated, requires tremendous effort and time especially for detailed simulation, which triggers user resistance [9]. As well, simulation requites criterion levels of competency for key aspects of knowledge and skill [10]. This exists in concert with the fact that system, process and workflow complexity of the healthcare system is huge and extensive, at the same time, model in rich in representation should be still an easy means of understanding and communication among stakeholders [4] [9] [13]. Finally, the revolution empowered by simulation can only be achieved if the related applications are fully integrated and be a part of the routine process of healthcare delivery [10].

The future potential of simulation modeling in healthcare is emerging machine learning algorithms into simulation models, the use of real-time data for dynamic modeling, and the potential for personalized medicine through simulation-based optimization.

## 4. Conclusion

This article aimed to develop simulation model can be used to demonstrate clinical and operations practice of outpatient clinic. Moreover, rapid changes to care processes and patient flow needed may be facilitated by a simulation, developing and testing new scenarios and then embedding new systems and changes. The healthcare field is now more prepared and ready to embrace simulation modeling with all its ability and potential. Such initiative could inspire healthcare professionals, administrators, and researchers to leverage this powerful tool to transform healthcare delivery and optimize patient outcomes.

## Conflicts of Interest

The authors declare that they have no conflict of interest.

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