Primary & Urgent Care Clinic Operation

1. Executive Summary

Healthcare is a fundamental aspect of society, and clinics serve as primary access points for medical care. The effectiveness of clinic operations directly influences patient well-being and satisfaction. We can make real-world improvements in healthcare delivery by addressing clinic operational issues. This project aims to analyze and improve the operational efficiency of a clinic system by employing discrete event simulation techniques. Our primary objective is to enhance the patient experience by reducing waiting times and optimizing the utilization of clinic staff. To achieve this, we collected data on patient arrivals and service times, implemented a simulation model using JaamSim, and assessed the system's performance over an 11-hour period.

We recognized that patient waiting times and clinic staff utilization were critical areas of concern within the clinic system. Long waiting times can lead to patient dissatisfaction and inefficiencies, while underutilized staff can increase operational costs. Using JaamSim, we created a discrete event simulation model based on observed probability distributions of patient interarrival times and service times. This model allowed us to mimic real-world clinic operations and identify bottlenecks and inefficiencies.

The simulation results provided valuable insights into the clinic's performance. We observed patients' waiting times were long, raising concerns about patient satisfaction and clinic efficiency. Moreover, the number of patients being seen was lower than the number of patients arriving. Staff utilization rates were unbalanced, with some staff members experiencing significantly lower workloads than others. We recommend several strategies to enhance the clinic's efficiency and reduce patient waiting times based on our findings. These include adding a nurse, optimizing staff level, and pre-informing patients about waiting time. Implementing these recommendations will lead to well-organized clinic operations, delivering efficient and effective services.

2. Problem Description

The clinic system currently faces significant challenges regarding patient waiting times and inefficient staff utilization, leading to patient dissatisfaction and operational inefficiencies. Addressing these issues is the cornerstone to enhance the overall quality of care and optimize resource allocation within the clinic.

3. Model implementation

3.1. Process flow

The first step in building a discrete event simulation model is creating a well-orchestrated process flow diagram, in which a sequential operational process of a system is sketched out using geometry symbols. Below is the featured process flow diagram of Primary Care Clinic, which involves 3 main service components: two receptionists, four medical assistants of different professional levels, and one doctor. The two receptionists are the initial point of contact, handling appointment scheduling, verifying insurance information, and guiding patients through registration, ensuring a seamless start to their medical journey. Once registered, patients move on to the core of the clinic's operation, where four qualified medical assistants will take over. These skilled professionals are pivotal in patient care, assisting with vital sign measurements, preliminary assessments, and medical history documentation. Given the differences in the experience level of each assistant (i.e. Trainees and New Medical Assistant are entry-level workers, while Senior 1 and Senior 2 workers with more significant expertise and specializations in certain areas), the time spent providing service for each patient will vary, which is demonstrated with different parameters in service time distribution. They are responsible for ensuring that patients receive thorough and comprehensive care before they meet with the doctor.

Upon completing preliminary assessments, patients are directed to the clinic's cornerstone, the doctor, who provides expert medical consultation and treatment. With a deep understanding of the patient's medical history and the initial assessments conducted by the medical assistants, the doctor offers personalized healthcare solutions. This team of professionals altogether works cohesively with the goal of ensuring a qualified healthcare service for customers.

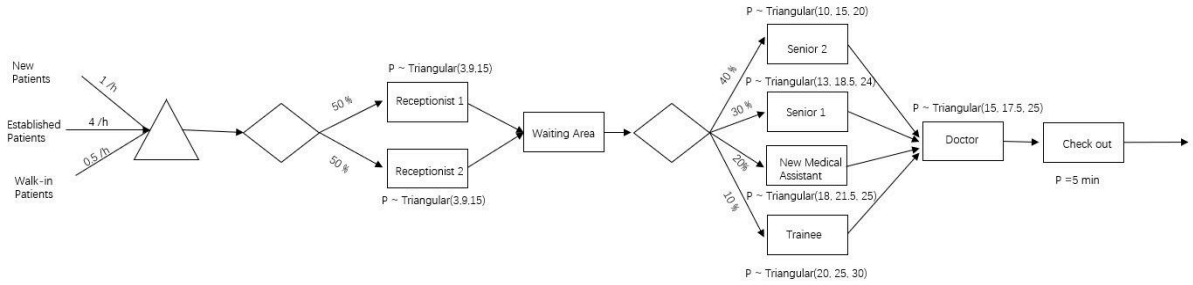

Figure 1. Process Flow

3.2. Data collection and statistical analysis

Data collection

For this project, we employed a primary data collection method to gather essential information about the clinic system's operations. We collected primary data by directly conducting surveys with clinic staff, including recording patient arrival times, check-in times, and departure times. This ensures data accuracy and gains insights into their work processes and any potential bottlenecks.

Statistical analysis

Descriptive Statistics: Frequency distributions were used to analyze the distribution of interarrival times for patients.

- Established Patients: scheduled every 15 minutes
- New Patients: scheduled every 30 minutes
- Walk-in Patients: scheduled every 1 hour

Probability Distributions: Probability distributions, such as the triangular distribution for service and waiting times, were fitted to our data. These distributions were used as input parameters in our discrete event simulation model.

	Service Time	Waiting Time
Receptionist	(3, 9, 15)	(3, 9, 15)
Trainee	(20, 25, 30)	(5, 17.5, 30)
New Medical Assistant	(18, 21.5, 25)	
Senior Medical Assistant 1	(13, 18.5, 24)	
Senior Medical Assistant 2	(10, 15, 20)	
Doctor	(15, 17.5 25)	(5, 12.5, 20)

Table 1. Distribution of Clinic Staff Service Times and Patient Waiting Times

3.3. Assumptions

For this simulation model, we assume that service times for different components within the clinic (receptionists, medical assistants, and doctors) follow triangular probability distributions. We analyzed historical service time data for each component and found that the service times exhibited a distribution that resembled a triangular shape. Secondly, we assume all patients behave similarly and follow the same path through the clinic (e.g., registration and examination). This assumption simplifies the modeling of patient interactions within the clinic and allows us to focus on system-level dynamics. Lastly, the number of receptionists, medical assistants, and doctors is assumed to remain constant during the simulation. It allows us to control and study the impact of other factors, such as patient arrival patterns and service time distributions, without the added complexity of varying staff levels.

3.4. Simulation Model

In our JaamSim simulation model for the clinic system, we have utilized various objects to represent processes. These objects work together to simulate the flow of patients and clinic operations.

a. Entities: These entities represent individuals seeking medical care at the clinic. We have three types of patients: established patients, new patients, and walk-in patients.

b. Event Schedule: These objects are used to schedule events in the simulation. It allows for the precise control of timing, including scheduling patient appointments.

c. EntityGenerator: These are used to generate patient entities at specified scheduled times, representing the arrival of patients at the clinic.

d. Queues

- Registration Queue: This is a queue where patients wait to complete the registration process with receptionists.
- Pre-examination Queue: Patients move to the examination queue after registration, waiting to be attended by medical assistants.
- Examination Queue: Patients move to this queue after completing the medical assistants' initial medical assessment and preparation.

e. Servers

- Receptionists: Receptionists are represented as server objects responsible for registering patients.
- Medical Assistants: These server objects represent the medical assistants who conduct initial assessments and prepare patients for examination.
- Doctors: Doctors are also represented as server objects responsible for diagnosing and treating patients.

f. Distributions: Triangular distributions for service time and waiting time (receptionists, medical assistants, doctors) are used to model the timing of events in the simulation.

g. EntitySink

- This object serves as the exit point for patients who meet the following criteria:
    - Patients leaving for the receptionist 1 wait time > 0.25 hours.
    - Patients leaving for the receptionist 2 wait time > 0.2 hours.
    - Patients leaving for the medical assistant wait time > 0.2 hours.
    - Patients leaving for the doctor wait time > 0.5 hours.
- This object represents the final destination for patient entities, where they exit the simulation after completing their clinic visit.

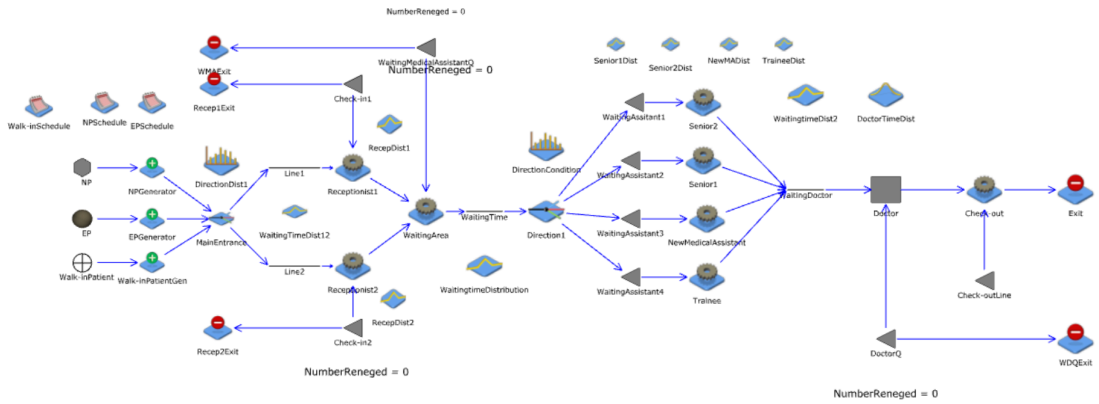

Figure 2. Clinic Operation Model

3.5. Simulation Run

For this simulation, we have set the number of replications to 100. Each replication provides insights into system behavior under different random variations. Besides, the replication length is set to 11.1 hours, representing the duration of a single replication run. Furthermore, we have used "hour" as the standard time measurement. This choice is based on its compatibility with the observed data and the modeling requirements of the clinic system.

4. Simulations Results

Measure	Average	Minimal CI	Maximal CI
Time of Patients Waiting Doctor	1.147	1.136	1.158
Number of Patients Being Seen	33.870	33.797	33.943
Receptionist 1 Utilization	0.264	0.255	0.273
Receptionist 2 Utilization	0.266	0.257	0.275
Trainee Utilization	0.142	0.129	0.155
Medical Assistant Utilization	0.254	0.239	0.270
Senior 1 Utilization	0.345	0.329	0.360
Senior 2 Utilization	0.336	0.322	0.350
Doctor Utilization	0.898	0.896	0.900

Table 2. Simulation Results of Current Clinic Model

Based on the simulation results in Table 2, several key findings have emerged regarding the clinic system. The average utilization of receptionists is notably low, indicating that the current staffing levels may exceed the clinic's requirements. This suggests that there may be a surplus of receptionists, potentially resulting in the underutilization of their skills and time. Additionally, the utilization rates of the four medical assistants are both low and imbalanced, raising the possibility of overstaffing within this category of staff members. The combination of low utilization and an uneven distribution of tasks among medical assistants highlights an inefficiency in resource allocation. Furthermore, the high utilization of the doctor primarily stems from the clinic having only one doctor available. This results in prolonged patient wait times, and the doctor may become overwhelmed due to the heavy workload.

5. Conclusion and Recommendation

In conclusion, the clinic faces several operational issues. The waiting queue time for the medical provider is excessively long, resulting in patient dissatisfaction. The utilization of the doctor was excessively high, indicating a heavy workload. In contrast, the utilization of receptionists and medical staff was unevenly distributed, with some staff members experiencing relatively low utilization.

We recommend that the clinic enhance the medical team's capacity by adding one more registered nurse to reduce the long waiting time for medical providers and ensure high-quality patient care. The clinic should also optimize its staffing levels by organizing a rotating schedule for staff members throughout the week. This approach ensures that the clinic maintains an appropriate staffing balance to avoid excess and shortages of medical staff while ensuring an equitable workload distribution among all staff members. Since the capacity of medical providers has increased and the staff workload is well-organized, the clinic should consider accommodating more patients. To achieve this, we recommend reorganizing the scheduling calendar and allocating specific time slots for different categories of patients. In addition, to ensure that staff members can complete their work within the clinic's regular hours and avoid extended working hours, the last appointment should be scheduled before the closing time.

Furthermore, to prevent patient dissatisfaction due to long wait times, we should inform patients in advance that their doctor's visit may take between 20 minutes to 1 hour. This notification will allow them to prepare for their visit accordingly.

Well-organized clinic operations, along with the delivery of effective and efficient services to patients, play a significant role in the clinic's success, impacting its clinical performance and financial improvement.

6. References

[1] Williams KA, Chambers CG, Dada M, Hough D, Aron R, Ulatowski JA. Using process analysis to assess the impact of medical education on the delivery of pain services: a natural experiment. Anesthesiology. 2012 Apr;116(4):931-9.

[2] Clymer JR: Simulation-based Engineering of Complex Systems. Hoboken, NJ: Wiley & Sons, 2009.

[3] Zonderland ME, Boer F, Boucherie RJ, de Roode A, van Kleef JW: Redesign of a university hospital preanesthesia evaluation clinic using a queuing theory approach. Anesth Analg 2009; 109:1612–21