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***Hospital Outpatient Queue Management System (OPD) – Sri Lanka***

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Hospital Outpatient Queue Management System (OPD) – Sri Lanka

# **System Overview**

Public hospitals in Sri Lanka frequently experience long patient waiting times in Outpatient Departments (OPDs). Patients arrive randomly and proceed through multiple stages including registration, consultation, and pharmacy/payment. Delays at any stage create bottlenecks, reduce throughput, and negatively impact patient satisfaction.

The performance of the OPD system depends on:

* **Patient arrival rate** – varies by time of day and day of the week
* **Doctor availability** – number of doctors available for consultation
* **Service time per patient** – including registration, consultation, and payment

This system can be modeled as a queuing system (M/M/1 for single doctor or M/M/c for multiple doctors) to evaluate metrics such as:

* **Average patient waiting time**
* **Queue length**
* **Doctor utilization**

By modeling and analyzing the OPD workflow, we can identify bottlenecks, test interventions (like adding more doctors or registration counters), and optimize overall patient throughput.

# **Performance Objectives**

The primary performance objectives for evaluating the Outpatient Department (OPD) system focus on improving operational efficiency, patient satisfaction, and resource utilization. The evaluation is designed to measure how effectively the system manages patient flow, doctor workloads, and overall service delivery. The specific objectives are as follows:

* **Minimize patient waiting time**

The main goal is to reduce the total time a patient spends in the system from arrival and registration to consultation completion. Shorter waiting times indicate a more efficient process and directly enhance patient satisfaction. The system aims to identify factors contributing to delays, such as limited registration counters, consultation room queues, or uneven doctor allocation.

* **Optimize doctor utilization**

Ensuring that doctors’ time is used efficiently is crucial. Overburdened doctors can lead to fatigue and lower consultation quality, while underutilized doctors represent wasted resources. The system evaluates doctor utilization rates to maintain an optimal balance where each doctor handles a reasonable number of patients per hour without exceeding sustainable workload levels.

* **Identify peak load periods (bottlenecks)**

Patient arrivals often fluctuate throughout the day, leading to congestion during certain hours. The system analyzes arrival patterns to pinpoint peak load periods when queues and waiting times increase. Recognizing these bottlenecks helps in planning interventions such as dynamic staff scheduling, queue management, or appointment distribution.

* **Evaluate impact of adding resources**

The model examines how performance metrics change when additional resources such as extra doctors, nurses, or registration counters are introduced. This helps in performing “what-if” analyses to predict improvements in waiting time, service rate, and patient throughput, supporting data-driven decisions for resource allocation.

* **Improve overall throughput**

Throughput refers to the number of patients successfully processed within a specific time frame. The system aims to maximize throughput without compromising service quality or patient experience. This objective ensures that operational efficiency improvements translate into tangible increases in the number of patients served per hour.

# **Dataset**

* The dataset for this system represents **simulated hospital queue records** that capture how patients move through the system from arrival to service completion. Each record includes timestamps and performance-related variables such as waiting time and consultation duration.
* The following table shows an example record structure taken from the **dataset.csv** file used for system performance analysis.

|  |  |  |
| --- | --- | --- |
| Field | Description | Example Value |
| Patient ID | Unique identifier for each patient | P001 |
| Arrival Time | Time the patient arrives at the hospital | 2025-10-31 08:45 |
| Service Start Time | Time the doctor begins consultation | 2025-10-31 09:05 |
| Service Duration (min) | Length of the consultation | 15 |
| Waiting Time (min) | Time the patient waits before consultation | 20 |
| Doctor ID | Identifier for the doctor attending the patient | D03 |
| Available Doctors | Total number of doctors on duty | 5 |
| Queue Length | Number of patients waiting at arrival | 8 |

* This data is used to calculate the model's parameters like **average arrival rate** and **average service rate**.
* The model will then be used to calculate the performance **outputs**, such as **average waiting time, queue length,** and **doctor utilization**.
* This allows us to test our **objectives**, such as seeing how waiting times change when we increase the number of doctors.

***Note:***

Real waiting times and service durations are based on studies from Sri Lankan hospitals:

* **NHSL, Colombo:** median registration to consultation = 42 min, average total OPD time ~2 hours. [1]
* **District hospitals (Gampaha):** mean morning waiting time 43–47 min, afternoon 18–31 min. [1][2]

# **Expected Outcomes**

Through performance analysis of this system, the hospital can:

* Achieve **shorter average waiting times** (target <15 minutes).
* Balance doctor workloads by improving scheduling.
* Identify **peak hours** for better staff allocation.
* Increase **patient througput**, enhancing operational efficiency.

# **References**

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