Optimizing Care Delivery: A Practical Approach to Hospital Load Distribution and Queue Management

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Abstract— Many hospitals today are dealing with too many patients at once while other hospitals nearby are not very busy. This creates long waiting times and wastes available resources. In this paper, we present a simple but effective system for managing hospital patient load and queue in real time. Our system keeps track of how many patients are in each hospital, how long the waiting time is, and shows this information to patients so they can choose a less crowded hospital. The goal is to spread patients more evenly across hospitals and reduce the pressure on overcrowded ones. Our tests show that this kind of system can make a real difference in how hospitals work and how patients are served.

Keywords—hospital load management, queue management, patient flow, real-time monitoring, healthcare efficiency, resource allocation, patient routing, hospital operations, congestion reduction, healthcare systems.

I. INTRODUCTION

A. Background

Hospitals all over the world are struggling with too many patients, not enough resources, and unequal patient distribution. In most cities and towns, patients go to hospitals without knowing how busy they are or how long they will have to wait. This results in some hospitals being too crowded while others are half empty. Old methods of managing queues — like paper registers, token numbers, and fixed appointment slots — work only within a single hospital and cannot give a bigger picture of patient flow across multiple hospitals. As patients expect faster and better care, there is a clear need for smarter systems that can handle hospital load in real time.

B. Problem Statement

Even though technology has improved a lot, most hospitals still do not have a way to show real-time patient load or share this data with patients. People usually pick a hospital based on how close it is or how well-known it is — not based on how busy it is right now. This leads to some hospitals getting flooded with patients while others are free. When a hospital is suddenly too busy, doctors and nurses get overworked and patients suffer. There is no shared system that can track and show patient load across all hospitals together.

C. Motivation

The main reason we worked on this topic is that patients and hospital staff both suffer when hospitals are overcrowded. Long waits are stressful for patients, and overworked staff may make more mistakes. If patients could be distributed more evenly, hospitals would work better and patients would get faster care. Today, more and more decisions in healthcare are being made using data. So, this felt like the right time to build something that helps patients find the right hospital and helps hospitals use their resources better.

D. Purpose of the Study

The main purpose of this study is to create and test a practical system for managing hospital load and patient queues. The system should show real-time patient data, help patients choose less crowded hospitals, and help hospital staff manage their resources better. We want to prove that even a simple, low-cost system can make hospital operations smoother and more balanced.

II. LITERATURE REVIEW

A. Traditional Hospital Management Systems and Their Limitations

For a long time, hospitals have been using paper records, simple appointment books, and token systems to manage patient queues. These methods work to some extent but need a lot of manual effort and cannot keep up with what is happening in real time. Each step — like registering a patient, updating a queue, or checking bed availability — has to be done by hand, which slows things down and increases the chance of errors. These systems also do not connect hospitals with each other, so patients and staff have no way of knowing which hospital is less crowded. As more patients come in each day, the weaknesses of these old systems are becoming harder to ignore.

B. The Rise of Digital Queue and Monitoring Systems

To fix the problems with manual methods, many hospitals started using digital tools for managing queues and tracking patients. These tools help reduce the workload on staff and make it easier to see how patients are moving through the hospital. Research shows that digital queue systems reduce waiting times and make service smoother [1], [3]. However, most of these systems still only work inside one hospital. They do not connect multiple hospitals together, so the problem of unequal patient distribution across the city or region still remains.

C. Real-Time Monitoring and Smarter Decision Systems

With better data tools available, hospitals have started using real-time dashboards to track how busy they are and predict when patient numbers will go up. Studies show that seeing real-time patient data helps staff respond faster and make better decisions [3], [4]. Smart systems that consider queue length, service speed, and department capacity can also help reduce bottlenecks. However, these advanced systems usually need a lot of money and good infrastructure, which makes them hard to set up in smaller or under-resourced hospitals.

D. Queue Optimization and Patient Routing

Researchers have looked at many ways to improve patient routing — for example, using priority-based scheduling, computer simulations, and load balancing methods. Studies confirm that smart patient routing can reduce delays and help hospitals use their staff and equipment more efficiently [5], [6]. Some systems combine real-time data with predictions to guide patients to the right place. But many of these solutions are very complex and are hard to use outside of a lab or research setting.

E. Challenges and Need for Affordable Solutions

Even with so much progress, real challenges remain. A lot of existing systems are too expensive or too complicated for small hospitals. Problems like poor data sharing between hospitals, different software systems that do not talk to each other, and the cost of keeping everything running have been highlighted by researchers [2], [4]. This makes it clear that we need solutions that are not just effective but also easy to afford, easy to maintain, and adaptable to different hospital sizes and budgets.

F. Research Gap

Most research on patient flow and hospital load focuses on large hospitals with big budgets or stays at a theoretical level. There is not much work done on simple, practical, and affordable systems that smaller hospitals can actually use [6]. Most existing tools assume the hospital has fancy dashboards, large IT teams, and lots of data. Our research fills this gap by focusing on a simpler approach that still works well for managing patient load — one that any hospital can use, regardless of their budget or technical setup.

III. OBJECTIVES

The main goal of this study is to build a practical and efficient system for hospital load distribution and queue management. Below are the specific things we aimed to do:

- Look at what is wrong with current hospital management practices — especially the problems with manual work, isolated queue systems, and lack of real-time information.
- Build a system that can monitor patient load and queue conditions live, so both patients and hospital staff can make better decisions.
- Design a solution that is affordable, scalable, and can be used by hospitals with different types of infrastructure.
- Help spread patients more evenly across hospitals to reduce crowding and improve overall healthcare efficiency.

IV. SCOPE

This study focuses on designing and testing a model for hospital load distribution and queue management that works across multiple hospitals. The system tracks real-time patient numbers, waiting times, and service availability to help patients choose the right hospital and help administrators coordinate better.
The system is designed to be simple and scalable — meaning it can be used in small hospitals too, not just big ones with advanced technology.
This system does not handle clinical decisions, medical diagnoses, or internal department operations. It only focuses on distributing patients more evenly across hospitals and making hospital occupancy visible to patients and staff. We also looked at simple, low-cost tools to make sure the system is accessible to hospitals that don't have big IT budgets.

V. MATERIALS AND METHODS

A. System Components

1) Data Collection:
Each hospital in the system has a simple entry form where staff can update patient numbers, waiting times, and available services. Patients can then see this live data through a basic interface and use it to decide which hospital to visit.

2) Processing and Monitoring:
A central processing unit collects all the data from hospitals and combines it into one dashboard. It looks at things like queue length, available beds, estimated waiting time, and how fast patients are being served.
Hospital admins can see this data in real time to spot problem areas and plan accordingly.

3) Alerts and Recommendations:
If a hospital gets too crowded, the system automatically sends an alert to patients and staff. It also suggests nearby hospitals that are currently less busy, helping to balance the flow of patients across facilities.

4) System Design Overview:
The system connects hospital data inputs, a central processing unit, real-time dashboards, patient-facing screens, and alert systems. It is built to be flexible and work with different hospital setups.

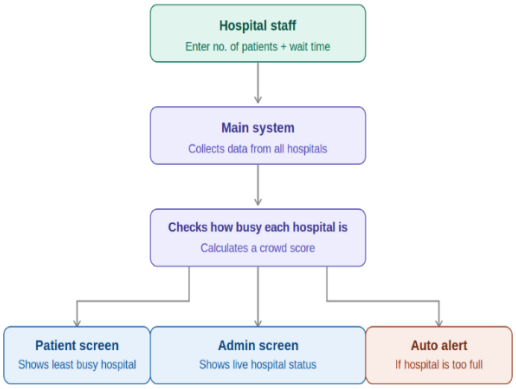

Fig. 1. System Architecture Overview

B. Software Components

The software side of the system includes a lightweight backend that handles data submitted by hospitals and calculates congestion levels. Patients can access current hospital information through a simple website or mobile app, where they can compare waiting times and see recommendations. Hospital admins have additional tools that can predict busy periods, helping them plan staff and resources in advance. All data is saved for future analysis and system improvements.

VI. METHODOLOGY

The system works in five clear steps:

1) Live Load Reporting:

Hospitals enter real-time information including patient count, waiting time, and how quickly they are serving patients. This data is saved and updated in the system automatically.

2) Load Analysis:
The system uses the submitted data to calculate a "load index" for each hospital. It considers how many people are waiting, how many staff are available, and the likelihood of the hospital becoming too crowded.

3) Helping Patients Decide:
The patient interface shows a list of nearby hospitals ranked from least to most crowded. Patients can pick the hospital where they are likely to wait the least.

4) Admin Monitoring:

Hospital administrators can see dashboards showing live load patterns, possible overcrowding, and predicted busy times. This helps them adjust staffing and prepare for surges before they happen.

5) Alerts and Alternative Suggestions:
When a hospital reaches its limit, automatic alerts go out and the system recommends other hospitals with more capacity. This keeps patients moving and prevents any single hospital from getting overwhelmed.

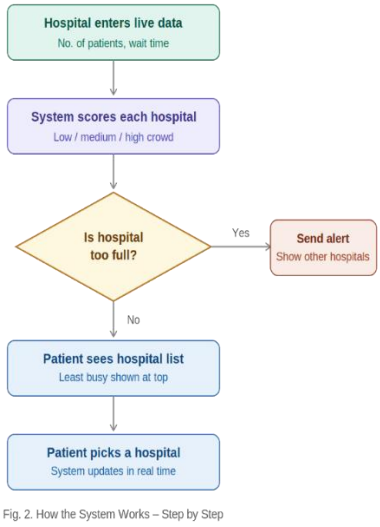

Fig. 2. System Operational Flow

VII. EXPERIMENTS

We ran four tests to check how well the system performs:

1) Data Accuracy Test:
We checked whether patient load numbers entered by hospitals were showing up correctly and without any delay. We compared the system data with actual manual counts to verify accuracy.

2) Real-Time Update Test:
We monitored how quickly changes in load data appeared on the patient-facing screen. Updates were expected to appear within 1–3 seconds.

3) Recommendation Accuracy Test:
We simulated different load conditions across hospitals and checked whether the system consistently recommended the least crowded option.

4) Alert Trigger Test:
We tested overload scenarios to see if the system correctly sent alerts when hospitals were too full, and also verified that no false alerts appeared when things were normal.

VIII. RESULTS AND DISCUSSION

The tests showed that the system works well overall. Here is what we found:

- Data Accuracy: All patient counts and queue times were recorded correctly, with no missing or wrong data.
- Real-Time Updates: Load information showed up on the patient screen quickly, helping them make timely decisions.
- Routing Suggestions: The system reliably pointed patients toward the least crowded hospitals during all test scenarios.
- Congestion Alerts: Alerts were triggered correctly during overload tests, and there were no false alarms when hospitals were operating normally.
- System Stability: The system ran smoothly throughout testing with very few interruptions or delays.

Overall, the results confirm that this system can genuinely help patients get to the right hospital faster and help hospitals manage their load better.
Importantly, it does all of this without needing complex infrastructure — which means it is practical for hospitals of all sizes.

IX. CONCLUSION

In this paper, we built and tested a real-time system to help manage hospital patient load and queues more effectively. We found that traditional systems — which depend on manual processes and operate only within individual hospitals — are simply not enough for today's healthcare environment [1], [3], [4].
Our proposed system brings together live patient load monitoring, smart queue analysis, and simple patient guidance to create a more balanced hospital network.
Testing showed that it records data accurately, gives reliable hospital recommendations, and sends timely congestion alerts. These results confirm that the system addresses the gap we identified — the lack of practical, affordable tools for managing patient flow across multiple hospitals [2], [4], [6].

In short, this research offers a working, scalable solution that helps patients make better choices and helps hospitals run more smoothly, especially in settings where expensive technology is not available.

X. FUTURE WORK

Our current system works well as a prototype, but there is a lot of room to grow. Here are some directions for future development:

• Add predictive analytics to forecast patient surges using past data, seasonal patterns, and machine learning — so hospitals can plan staffing in advance [4], [6].

• Use IoT devices like automatic patient counters or smart check-in kiosks to reduce manual data entry and improve real-time accuracy.

• Expand the system to support ambulance routing, emergency triage load tracking, and bed occupancy prediction.

• Develop communication between hospitals so they can automatically coordinate and redirect patients when one gets too busy.

• Run real-world pilot tests in actual hospitals to check usability and reliability over time, and also look into data privacy, security, and system compatibility.

ACKNOWLEDGMENT

We would like to sincerely thank Prof. Ramakrishnan Iyer, Department of MCA, Aditya Institute of Management Studies and Research, for his continuous guidance, helpful feedback, and encouragement during this research. We also thank our institute and the University of Mumbai for providing the resources and environment needed to carry out this work.

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