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Leveraging Artificial Intelligence to Transform Hospital Queue Management Systems: Challenges and Opportunities

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***Abstract*—Hospital patients' moods are affected by their experiences. The goal of the current study was to look into how a queue management system would affect patient satisfaction in emergency hospital waiting rooms. Process engineering or conventional queue management techniques like demand control, queue prioritization, or emergency department staffing are commonly used to address the problem of ED congestion. Standing in line every day is unavoidable and crucial. You could, however, do something fun with the time you spend standing in line. E-queue aims to revolutionize the line-waiting experience by offering a practical, all-inclusive, and entertaining alternative. Implementing a thorough queue management system that keeps track of people in line and provides real-time information on how long patients must wait to see their doctors or nurses is one way to solve this issue. Therefore, patients can make better use of the time they would otherwise squander waiting in line by implementing e-Queue. Numerous difficulties pertaining to queuing were considered when analyzing the current systems. To give patients vital queuing information, E-Queue employs a cloud-based database, a smartphone app, and online information exchange. Additionally, it allows hospitals to effectively control wait times. Hospital queue management systems must effectively connect with existing systems and overcome several challenges, including limited funding and limited resources, despite their aim to enhance patient flow. These challenges may lead to inefficiencies, unhappy patients, and a less-than-ideal patient experience.**

Keywords*— *Queue, Hospitals, Patients, Emergency, Management, Challenges.

I. INTRODUCTION

Around a century ago, queueing theory was created in Denmark as a result of Erlang research. Despite the length of time since the original mathematical assertion, queueing mathematics has not significantly changed [1]. Because "sometimes the psychology of queueing is more important than the statistics of the delay itself," queueing psychology has taken primacy [2]. On a daily level, queues can be bothersome owing to how one feels when waiting in them as well as how lengthy the wait is. For instance, research suggests that when we have a general idea of how long the wait would be, we are far more patient [3]. Furthermore, it is thought that time passes more quickly while something is being done rather than when waiting [2]. Long wait times in hospital emergency rooms have a number of negative effects, including crowding, patients leaving out of frustration without receiving care, patients' and their relatives' irrational behavior, stress on both staff and patients, and many others [17]. As a result, many people are growing increasingly concerned about them. Hospital management information systems, which consist of a number of integrated modules, frequently support both clinical and non-clinical operations in hospitals (HMIS). The service areas that make up the interfaces for transaction management in HMIS include patient registration counters, bill payment counters, laboratory test requisitions, sample or report collection counters, pharmacy counters, as well as patient waiting areas for out-patient visits and appointments. Effective approaches are needed in these settings to manage high patient loads, especially in tertiary care facilities. As a result of the increasing accessibility of mobile devices and ubiquitous technologies, a smart and effective queue management system (QMS) is increasingly crucial for enhancing patient experience and optimizing performance metrics for hospitals for effective healthcare service delivery [4]. Queuing has historically not changed, even though many parts of public service, particularly in a developing country like Nigeria, have seen technical and efficiency gains. In the past, one had

to advance one at a time while standing in line. The reality is that people must wait in line for as long as they need the services, regardless of whether the problem is a lack of staff or facilities or a hospital's capacity is insufficient for the population it serves, despite the fact that numerous solutions, including queue priority and numbered tickets, have been implemented in developed countries over the years. Particularly in an emergency room, long queues put an unnecessary and unpleasant pressure on both patients and medical staff. Patients receive care of inferior quality, have worse health outcomes, and are less satisfied when resources are limited relative to the demand for services. They are linked to a poor opinion of hospital stays. In Nigeria, where I was born, a system has been put in place to deal with and handle these concerns.

II. MATERIAL AND METHODS

A queue management system for patients is proposed by Hedau et al. [5], in which notifications are given to the patient and an Android app interfaces with interfaces to schedule appointments with doctors. The OPD/doctor visiting area wait times are intended to be decreased by this technique. Their app also offers hospital navigation instructions. Android smartphones take the place of traditional token dispensers and token calling hardware at counters in Aizan et al "walk away “queue's management system [6]'s proposal for a service-based paradigm for token manufacturing and administration. Alerts are issued to users a predetermined period of time before the token is anticipated to be called because the user's cell phone is received at the time of token production. The advantages and use cases of a smart queue management system at a well known hospital in Delhi, India, are listed by Sahney [7]. Batbagon et al [8] Queue system uses a web-based QMS application augmented by Android apps, along with supplemental services like report production and data analytics for optimizing queue generation at service locations, to achieve comparable goals and functionality. A GSM-based queue management system that merges a PC-based system with a microcontroller has been presented by Arun et al. [9]. Internet of Things [10-11] and wireless technology-based strategies have also been put forth. The advantages of using a queue management system in improving hospital performance metrics such patient length of stay [12], waiting time for in-patient surgeries [13], triaging in emergency departments [14], [15], and decision support [16] have also been described in literature. This study describes an operational hospital management information system that can be simply equipped with a mobile-augmented smart queue management system (HMIS). It uses clever algorithms for token generation and allocation and offers a variety of interfaces for token generation and consumption on mobile devices integrated with hospital service counters. A single patient token can be used for efficient queue management across numerous hospital service areas, which enhances the patient experience and aids in tracking and optimizing important performance metrics for the hospital administration. We outline the system's architectural and functional design along with an example of how it was used to monitor the productivity of service counter employees during a pilot project [4]. The hospital is in conformity with Electronic Health Record (EHR) standards and has a functioning HMIS [18], [19] with several modules [20], [21], [22], [23]. In order to organize queuing systems, this research aims to create an automated queue management system that can assess the queue's status and decide which client to service first. This study focuses primarily on the bank's queuing system, various methods to queuing algorithms that banks employ to service customers, and the typical wait time. By utilizing two distinct queue control systems that have evolved, this queuing architecture model can transition between various scheduling algorithms based on the testing result, which is the average waiting time. The Intel Galileo Microcontroller, which is software compatible with the Arduino software development environment, regulates a number of processes. In order to assess the systems' performance, many testing scenarios have been used [24]. The current study's goal was to determine how using a queue management system in emergency care waiting areas affected patient satisfaction [25]. An comprehensive framework for managing queues dynamically from both the supply and demand perspectives is provided by this work. To be more precise, we present dynamic resource adjustment policies and intelligent dynamic patient prioritizing algorithms to control supply and demand. Using our paradigm, decision-makers can choose supply- and demand-side tactics to meet the demands of their ED. Through simulation, we can demonstrate that such a framework reduces patients' length of stay in the ED without limiting demand [26]. A centralized queue control system that can be applied to many hospital departments was developed in this study. The system makes use of Little's Law, the Haversine Model, the Poisson Distribution, and the Kendall Notation. It is a web-based system that was created to function on the Internet since it concentrates on outpatients and takes into account the fact that different departments in the majority of non-tertiary hospitals may be located in various structures or locations. The system was developed using Microsoft SQL and ASP.NET. Data gathered from non-tertiary hospitals in Benue State, Nigeria, was used to evaluate it. As a result, there were fewer patients in the hospital at any given moment, and there was some difference between some patients' actual arrival times and their estimated arrival times. The technique avoids crowds, improves hospital organization, and saves time for the patients. At the same time, there is also a major reduction in the burden on the hospital infrastructure. Both patients and medical staff benefit from enhanced service delivery and a safer atmosphere [27]. The purpose of this study is to create a queue assessment model to assess the flow of walk-in outpatients in a busy public hospital in a developing economy in the absence of appointment systems and to build a dynamic framework devoted to the practical application of the proposed model for continuous monitoring of the queue system [28]. The nurse caller device is used as a special communication device between the patients and the doctor or nurse within the hospital area as a means of speeding the doctor or nurse's time response in providing immediate care to the patients. The usage of the wireless nurse caller device facilitates and organizes communication between the parties. The microcontroller ATMega8 serves as both the sender and receiver when a Bluetooth module, the MH-10, is added. A microcontroller called an ATMega8 processes the data, producing characters on the LCD, turning on the LED, and sounding the buzzer to summon the doctor or nurse [29].

III. DEFICIENCIES OF THE QUEUE MANAGEMENT INFORMATION SYSTEM

1. High initial outlay

The initial outlay is comparatively more expensive. That's another major factor in why companies are so hesitant to choose a queue management system. The queue management system has a number of software and hardware components, which raises the project cost. Most of the time,

the hardware is more expensive. Customer announcement systems, numerous digital signage, interactive kiosks or ticket vending devices, counter plates or counter displays, networks, etc. These all-hardware components are slightly more expensive but durable, have a longer lifecycle,
and are covered by a warranty.

2. Routine maintenance

Regular maintenance is necessary because there are so many hardware parts involved. In Dubai and the rest of the UAE, it is customary for anyone purchasing a queue management system to also sign up for an annual maintenance contract. This affects the overall cost as well. To fix network-related issues, maintenance is typically needed on a regular basis. Less frequently, maintenance is needed on the interactive kiosk or ticket dispenser. Additionally, it has to have its
paper rolls regularly refilled in order to print tickets. Because of this, frequent maintenance is necessary.

3. Hosting locally versus using the cloud

Additionally, queue management software is included with the queue management system. This needs a server to host it. Businesses typically prefer to host the software in their own data centers, which is expensive and necessitates ongoing management and maintenance. The firm will have to sign up for the annual maintenance services in the event of online hosting or cloud-based solutions, which also raises the overall cost of a queuing solution. In either case, extra money and ongoing upkeep are needed.

4. Cost-prohibitive software system integration

The majority of the time, the cost of integrating queue management software with other business resources and enterprise solutions is minimal. However, in some circumstances where modification is necessary, the firms may be obliged to pay more to all parties. For instance, if the queue management system needs to integrate with the ERP or customer loyalty program for the
purpose of enabling a specific function, either a middleware must be constructed to synchronize
the two systems or changes must be made on both sides. In any case, the business will incur additional expenses related to the system integration.

5. Only Slight and Expensive Hardware Upgrades

Although software upgrades and customizations are significantly less expensive, hardware upgrades, customizations, or alterations are slightly more expensive. For the system to function practically, it can only have a certain amount of hardware parts. Consider the scenario where a customer or visitor needs to scan their Emirates ID card in order to sign up. However, you later realize that in addition to or instead of the Emirates ID card, you also need facial recognition. To create this functionality, the interactive kiosk must be modified or customized. Most of the time, after a kiosk design has been designed, it is very tough to change it. Businesses typically decide to buy a new kiosk model. In addition to raising the price, it also uses the outdated kiosks pointlessly. This makes hardware modification and updates difficult and costly.

IV. The Challenges of Hospital Queue Management Systems

i. Financial Constraints:

Hospitals often operate under tight budgets, making it difficult to invest in new technologies like queue management systems.

ii. **Limited Resources:**

Hospitals may have a shortage of staff or equipment, hindering the ability to implement and maintain these systems effectively.

iii. **Integration Challenges:**

Integrating queue management systems with existing electronic health records (EHRs) and other hospital systems can be complex and time-consuming.

iv. **Data Management:**

Collecting and analyzing accurate patient data to optimize queue management can be challenging.

v. **Patient Education:**

Ensuring patients understand and utilize the queue management system effectively can require significant effort.

vi. **Staff Training:**

Staff need to be trained on how to use and manage the system effectively.

vii. **Maintenance and Updates:**

Regular maintenance and updates are necessary for optimal performance, which can add to the overall cost.

viii. **Uncertainty in Patient Flow:**

Predicting patient arrival rates and service times can be difficult, making it challenging to optimize queue management.

ix. **Lack of Standardization:**

There is no universally accepted standard for queue management systems, leading to variations in implementation and functionality.

x. **Resistance to Change:**

Some staff and patients may be resistant to using new technologies.

xi. **Security and Privacy:**

Ensuring the security and privacy of patient data when using the system is crucial.

xii. **Emergency Department Challenges:**

In emergency departments, the need to prioritize patients with critical conditions adds complexity to queue management.

xiii. **Limited Data Input:**

Lack of accurate data and patient feedback can make it difficult to identify and implement improvements.

xiv. **Lack of Collaboration and Coordination:**

Communication and coordination between different departments can be challenging [30,42].

V. CONCLUSION

This study has thoroughly examined the hospital management information system as well as the queue management system. Both hospitals and the economy have benefited from their contributions. Their many forms and faults have also been investigated [29, 31-41].

The challenges are:

Long wait times, inadequate resource allocation, inefficient patient flow among others.

AI can help in addressing them by

1) Predictive Analytics
2) AI-powered real-time monitoring systems.
3) Automated scheduling using AI-powered system
4) AI-powered Resource Allocation
5) Integration: AI systems must be digitally integrated with the existing health records
6) Cybersecurity: like what happened during WannaCry
7) Data Quality: AI requires very high-quality data to make predictions accurately and make decisions with precision

References

1. U. N. Bhat, “An Introduction to Queueing Theory”, Birkhauser Boston, DOI:10.1007/978 0-8176-4725-4, ISBN: 978-0-8176-4724-7, [Online] Available at: https://link.springer.com/content/pdf/bfm%3A978-0-8176-4725-4%2F1, [Accessed 12 Mar. 2016], 2008.

2. A. Stone, “Why Waiting in Line Is Torture”, [online] Nytimes.com, Available at: http://www.nytimes.com/2012/08/19/opinion/sunday/why-waiting-in-line-is-torture.html. [Accessed 12 Mar. 2016], 2012.

3. D. Maister, "The Psychology of Waiting Lines", [online] Davidmaister.com, Available at: http://davidmaister.com/articles/the-psychology-of-waiting-lines/, [Accessed 12 Mar. 2016], 1985.

4. S. Soman, S. Rai, P. Ranjan, A. S. Cheema, P. K. Srivastava, "Mobile-Augmented Smart Queue Management System for Hospitals", 2020 IEEE 33rd International Symposium on Computer-Based Medical Systems (CBMS), pp. 421-426, 2020.

5. K. Hedau, N. Dhakare, S. Bhongle, S. Hedau, V. Gadigone, and N. Titarmare, "Patient queue management system," 2018.

6. A. L. Aizan, A. Z. Mukhtar, K. A. A. Bashah, N. L. Ahmad, and M. K. A. M. Ali, "'walk away 'queue management system using MySQL and secure mobile application," Journal of Electrical Power and Electronic Systems, vol. 1, no. 1, 2019.

7. R. Sahney, "Smart opd framework–new era in the digital healthcare initiative of sir ganga ram hospital," Current Medicine Research and Practice, vol. 6, no. 5, pp. 204–207, 2016.

8. C. C. Batbagon, O. B. Jayme Jr, and J. P. Pradilla, "I-queue: A centralized queue management system," 1 Semester of 2018, p. 24, 2018.

9. R. Arun and P. Priyesh, "Smart queue management system using GSM technology," Advanced in Electronic and Electric Engineering, vol. 3, no. 8, pp. 941–950, 2013.

10. M. Ngorsed and P. Suesaowaluk, "Hospital service queue management system with wireless approach," in Frontier Computing. Springer, 2016, pp. 627–637.

11. M. Ghazal, R. Hamouda, and S. Ali, "An IoT smart queue management system with real time queue tracking," in 2015 Fifth International Conference on e-Learning (econf). IEEE, 2015, pp. 257–262.

12. K. W. Tan, H. C. Lau, and F. C. Y. Lee, "Improving patient length-ofstay in emergency department through dynamic queue management," in 2013 Winter Simulations Conference (WSC). IEEE, 2013, pp. 2362– 2373.
13. K. E. Arnesen, J. Eriksen, and K. Stavem, "Gender and socioeconomic status as determinants of waiting time for inpatient surgery in a system with implicit queue management," Health policy, vol. 62, no. 3, pp. 329–341, 2002.

14. W.-y. YE, F. LIU, and C.-z. LIANG, "The application of electronic queue management system in the triage of the emergency department [j]," Clinical Medical Engineering, vol. 10, 2009.

15. K. W. Tan, C. Wang, and H. C. Lau, "Improving patient flow in emergency department through dynamic priority queue," in 2012 IEEE International Conference on Automation Science and Engineering (CASE). IEEE, 2012, pp. 125–130.

16. A. M. H. Pardede, "Framework for patient service queue system for decision support system on smart health care," 2018.

17. A. O. Itegboje, Y. N. Asafe, "A Systematic Review of Queue Management System: A Case of Prolonged Wait Times in Hospital Emergency Rooms", South Asian Research Journal of Engineering and Technology, vol. 1, no.1, pp. 11-16, Journal Homepage: www.sarpublication.com/sarjet, 2019.

18. P. Ranjan, S. Soman, A. K. Ateria, and P. K. Srivastava, "Streamlining payment workflows using a patient wallet for hospital information systems," in 2018 IEEE 31st International Symposium on Computer Based Medical Systems (CBMS). IEEE, 2018, pp. 339–344.

19. S. Soman, P. Srivastava, and B. Murthy, "Unique health identifier for india: An algorithm and feasibility analysis on patient data," in Ehealth Networking, Application & Services (HealthCom), 2015 17th International Conference on. IEEE, 2015, pp. 250–255.

20. S. Srivastava, S. Soman, A. Rai, A. Cheema, and P. K. Srivastava, "Continuity of care document for hospital management systems: an implementation perspective," in Proceedings of the 10th International Conference on Theory and Practice of Electronic Governance. ACM, 2017, pp. 339–345.

21. P. K. Srivastava, S. Soman, and P. Sharma, "Perspectives on SNOMED CT implementation in indian HMIS," in Proceedings of the SNOMED CT Expo 2017. SNOMED International, 2017.

22. S. Srivastava, R. Gupta, A. Rai, and A. Cheema, "Electronic health records and cloud based generic medical equipment interface," arXiv preprint arXiv:1411.1387, 2014.

23. Md. N. Uddin, Mm. Rashid, Mg. Mostafa, H. Belayet, Sm. Salam, Na. Nithe, S. Z. Ahmed, "Automated Queue Management System", Global Journal of Management and Business Research, vol 16, no. 1, pp. 51-58, 2016.

24. A. Bidari, S. Jafarnejad, N. A. Faradonbeh, "Effect of Queue Management System on Patient Satisfaction in Emergency Department; a Randomized Controlled Trial", Archives of Academic Emergency Medicine, vol. 9, no. 1, pp. 1-6, 2021.

25. K. W. Tan, H. C. Lau, F. C. Y. Lee, "Improving Patient Length-of-Stay in Emergency Department through Dynamic Queue Management", pp. 1-12, Proceedings of the 2013 Winter Simulation Conference.

26. C. O. Egbunu, O. Onyekwere, M. A. Rufai, T. S. Yange, S. P. Atsanan, "Queue Management in Non-Tertiary Hospitals for Improved Healthcare Service Delivery to Outpatients", International Journal of Applied Information Systems (IJAIS), vol 12, no. 31, pp. 36-48, www.ijais.org, July 2020.

27. K. A. Safdar, A. Emrouznejad, P. K. Dey, "An optimized queue management system to improve patient flow in the absence of appointment system", International Journal of Health Care Quality Assurance, vol. 33, no. 8, pp. 477-494, DOI 10.1108/IJHCQA-03 2020-0052, 2020.

28. A. H. Muhammad, A. Y. Abdullahi, A. Abba, A. Isah, A. A. Yako, M. A. Baballe, " The Benefits of Adopting a Wireless Nurse Call System", Global Journal of Research in Medical Sciences, vol. 02, no 03, Journal homepage: https://gjrpublication.com/gjrms/, May-June | 2022.

29. M. A. Baballe, A. S. Muhammad, J. Y. Abdullahi, M. H. Abubakar, A. Ya'u, I. I. Giwa, U. S. Farouk, Z. Abdulkadir, "The Impact of Hospital Queue Management Systems", Global Journal of Research in Medical Sciences, Volume 02, Issue 05, Sept.-Oct. | 2022, https://gjrpublication.com/gjrms/.

30. https://www.google.com/search?q=The+challenges+of+Hospital+Queue+Management+Systems&oq=The+challenges+of+Hospital+Queue+Management+Systems&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIHCAEQIRigATIHCAIQIRigAdIBCjE5ODE3ajBqMTWoAgiwAgHxBTEkemVk-Qh6&sourceid=chrome&ie=UTF-8.

31. M. A. Baballe, et al., "Issues with our Hospitals' Queue Management Information Systems", TMP UNIVERSAL JOURNAL OF RESEARCH AND REVIEW ARCHIVES VOLUME 1 | ISSUE 2 | YEAR 2022 | OCT - DEC 2022.

32. M.A. Baballe, S. H. Ayagi, & U. F. Musa. "Using artificial intelligence (AI) technology in the health sector has several goals", Global Journal of Research in Engineering & Computer Sciences, 3(5), 31-35. 2023, https://doi.org/10.5281/zenodo.10048487.

33. Garba, M. B. Ahmad, & M. I. Bello, "Applying AI in the Healthcare Sector: Difficulties", Computer and Information Science, 16(4), 2023.

34. Namoun, I. A. Ibrahim, E. Mustafa et al. "Generative artificial intelligence in education: an umbrella review of applications and challenges", available at Research Square https://doi.org/10.21203/rs.3.rs-4892155/v2.

35. I. A. Ibrahim, M. A. Baballe, "Essential Elements Required for a Successful AI Application in the Healthcare Industry", In Global Journal of Research in Engineering & Computer Sciences, Vol. 4, Number 5, pp. 46–51, 2024, https://doi.org/10.5281/zenodo.13755067

36. A. Ibrahim, Abdurrahman I. A., & Muhammad A. B. "Artificial intelligence-Enhanced Wireless Medical Alert Systems: Overcoming Challenges, Mitigating Effects, and Addressing Limitations", In Global Journal of Research in Engineering & Computer Sciences, Vol. 5, Number 3, pp. 53–58), 2025, https://doi.org/10.5281/zenodo.15521486

37. A. Ibrahim, M. A. Baballe, "Developing a User-Friendly Smart Blind Stick for Visually Impaired Individuals in the Digital Era", JETIR, Volume 11, Issue 9. 2024.

38. A. Ibrahim, Abdurrahman I. A., & Muhammad A. B. "Artificial intelligence-Enhanced Wireless Medical Alert Systems: Overcoming Challenges, Mitigating Effects, and Addressing Limitations", In Global Journal of Research in Engineering & Computer Sciences (Vol. 5, Number 3, pp. 53–58). 2025, https://doi.org/10.5281/zenodo.15521486

39. A. Ibrahim, M. A. Baballe, "Heartbeat Sensors: Revolutionizing Cardiovascular Monitoring in the 4IR Era", JETIR, Volume 11, Issue 10, 2024.

40. I. A. Ibrahim, M. A. Baballe, "Step-by-Step Guide to Building Wearable Health Devices", In Global Journal of Research in Engineering & Computer Sciences, Vol. 4, Number 5, pp. 52–59, 2024, 2024, https://doi.org/10.5281/zenodo.13759291.

41. I. A. Ibrahim, Abdurrahman I. A., & Muhammad A. B. "Navigating the Challenges of Artificial Intelligence in Healthcare: Overcoming Barriers in the 4th Industrial Revolution and Beyond", In Global Journal of Research in Engineering & Computer Sciences (Vol. 5, Number 3, pp. 81–87). 2025.

42. L.I. Abba, Muhammad A. B. "Challenges and Deficiencies in Adopting and Sustaining Hospital Queue Management Systems", In Global Journal of Research in Engineering & Computer Sciences, Vol. 5, Number 3, pp. 102–107, 2025, https://doi.org/10.5281/zenodo.15635192.