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RESEARCH ARTICLE

Design and evaluation of QKlinik: A web-based queue management system for outpatient clinics

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Abstract - In outpatient clinics, where extended patient waiting times frequently result in discontent and inefficient workflow, effective queue management is still a recurring problem. The effectiveness of current digital queuing systems in cutting down on overall waiting time is sometimes limited by their lack of interaction with pharmacy services or mobile-based real-time updates. In order to improve patient flow and service transparency in outpatient settings, this study introduces QKlinik, a web-based queue management system. Through an integrated interface, the system enables patients to easily make pharmacy purchases, track real-time wait status, and reserve queue numbers online using QR codes. The system was developed iteratively via planning, design, development, testing, and evaluation phases using the Agile methodology. PHP, HTML, and phpMyAdmin were used to implement the prototype and maintain the backend data. Despite not having been verified in a real-world clinical setting yet, QKlinik was put through simulated user assessments and black box testing with patients, physicians, and clinic employees. According to the results, the system successfully lowers perceived waiting time, maintains precise queue sequencing, and offers a smooth and user-friendly experience, with an average usability rating of 4.78 out of 5. All things considered, QKlinik shows how web-based queue management may enhance clinical operations and raise patient happiness in outpatient environments.

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1. Introduction

There is growing demand for healthcare providers to maintain effective service delivery while improving patient happiness. Long patient waiting times in outpatient clinics are one of the most enduring problems, as they have an adverse effect on both patient satisfaction and operational effectiveness. Patients must be physically present to receive a number under existing queue systems, which frequently rely on manual or semi-digital procedures. This leads to crowded waiting rooms, scheduling conflicts, and wasteful use of staff resources [1].

Health is an essential aspect of an individual's life, enabling them to perform daily activities effectively. Therefore, it is important to maintain good health from a young age, including undergoing regular medical check-ups. In healthcare services, particularly in clinics and hospitals, long waiting times to consult with a doctor remain a major challenge. Patients often must wait for extended periods before receiving treatment, leading to discomfort and dissatisfaction. Manual numbering systems in clinics and hospitals present significant difficulties, especially for individuals with mobility issues, those living far away, elderly patients, or people with disabilities. Working individuals are also affected as they are forced to interrupt their tasks just to wait for their turn [2]. This problem becomes more severe during peak hours, when a small number of doctors must attend to a large volume of patients. Such conditions contribute to overcrowded waiting areas and increase the risk of disease transmission, particularly during pandemics or outbreaks. Therefore, there is an urgent need to introduce a system that enables patients to obtain queue numbers and manage waiting times online without the need to remain at the clinic [3].

Digital queue solutions are available, but their capacity to solve these problems is limited since many of them lack real-time tracking, medical service connection, or mobile accessibility. This research problem not only disrupts the smooth operation of clinics but also reduces patient satisfaction with their medical experience. In terms of integrating digital queue management with other clinical tasks like pharmacy transactions and appointment tracking, this study finds also as a significant research gap. Even with the development of digital queue management, few solutions have integrated medicine purchase, appointment booking, and queue tracking into a unified platform. Prior research has mostly concentrated on the effectiveness of patient scheduling rather than the complete patient experience, which includes data openness and medication collection. Additionally, there is an absence of empirical research on how these integrated solutions affect user satisfaction, workflow efficiency, and waiting times in outpatient settings. This disparity drives the creation and assessment of QKlinik, a comprehensive remedy that tackles these issues.

The introduction of an online queue number system integrated with patient data management can address this issue by providing a single platform to monitor queues, known as QKlinik. QKlinik is a web-based queue management system with integrated medication ordering, real-time queue tracking, and QR-based registration that optimizes outpatient operations. This study will explore how integrating technology into such a system can enhance clinic operational efficiency and simplify patient processes. This study investigates how a web-based queue management system can

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enhance outpatient clinics' operational effectiveness and patient experience to address these problems. The following concerns serve as a guide for the study:

i) How can a web-based queue management system be designed to solve workflow inefficiencies in outpatient clinics?
ii) How much can the system do to improve accessibility and cut down on waiting times to increase patient satisfaction?

To answer the research questions that have been raised, the following are the objectives of this research:

i) Develop and implement QKlinik, a web-based system for managing queues that combines pharmacy services, appointment scheduling, and queue tracking.
ii) Use user acceptance testing (UAT) and black box testing to assess the system's usability, performance, and functionality.
iii) Examine how well the system works to improve workflow efficiency and shorten patient wait times in simulated outpatient settings.

This study focuses on the development and implementation of an online appointment and queue management system for clinics, aiming to reduce patient waiting times and improve operational efficiency in healthcare delivery. This area of research is closely related to healthcare digitalization, where Information Technology (IT) is applied to enhance patient flow and clinical services. The proposed system allows patients to obtain queue numbers via QR code scanning and track their queue position in real time, eliminating the need to remain physically in the waiting area for long periods. This is particularly important in addressing long-standing issues such as extended waiting times, overcrowding during peak periods, and reduced service satisfaction.

The contribution of this study is advancing the field of healthcare information systems by showing how Agile-based iterative development may be used to provide flexible, patient-focused healthcare solutions. Real-time queue monitoring and medicine purchase modules are integrated in a new way by QKlinik, backed by an intuitive web interface that can be used by users with different levels of digital literacy. The study offers empirical insights into how such systems might increase patient satisfaction, reduce perceived waiting times, and improve outpatient operational efficiency using a combination of design and evaluation research. The suggested framework provides a scalable approach for future developments in digital healthcare that seek to maximize service delivery and patient flow.

The subsequent sections outline the organizational structure of the remaining portions of this document: The initial section presents an overview of the paper on Developing Web-Based Queue Management in Outpatient Clinics. Section 2 presents a review of related works on Web-Based Queue Management. Section 3 summarizes the methodology employed in the study. Section 4 provides results and discussion of the newly developed Web-Based Queue Management. Section 5 concludes the paper and offers recommendations for future opportunities.

2. Related Work

With the goals of maximizing patient scheduling, minimizing traffic, and lessening the administrative load on medical staff, digital queue systems have emerged as a crucial innovation in the healthcare industry. According to recent research, outpatient clinics can greatly enhance time management and overall service quality by implementing digital queue and appointment management systems [4], [5]. Through real-time notifications and automated scheduling, web- and mobile-based queuing solutions have been shown to improve clinical workflow efficiency, decrease patient waiting times by roughly 20-30%, and raise patient satisfaction in several countries [4], [5]. Recent reviews further emphasize that queue optimization systems, when supported by hospital-wide digital transformation initiatives, can streamline patient flow and resource allocation, ultimately improving operational performance across departments. They may dynamically modify waiting lists and inform patients of their turn without needing them to stay in busy places; systems that combine location-based alerts and cloud-driven queue monitoring have shown an even bigger impact [6], [7]. Similarly, evaluations of web-based appointment management systems indicate measurable gains in scheduling accuracy and reduction in appointment no-show rates, validating the effectiveness of digital queue systems in clinical settings [8].

In terms of technology, most queue management systems in use today are built with relational databases like MySQL or SQLite for data storage and standard web technologies like PHP, JavaScript, or frameworks like Firebase for back-end communication. These are usually implemented on web and mobile platforms, providing patients and clinic employees with accessibility and flexibility. Despite these benefits, the literature identifies several enduring shortcomings that prevent the broad implementation and complete efficacy of current methods. First, there is still a significant problem with integration restrictions. Most digital queue solutions operate as stand-alone tools without connecting to other operational modules like pharmacy services or electronic health records (EHR) [1], [2]. Their capacity to support comprehensive patient care is hampered by this lack of interoperability. Second, even though a lot of systems facilitate online appointment scheduling and queue booking, they frequently fall short in offering real-time synchronization across several service locations, like pharmacies and consultation rooms [3]. Furthermore, the lack of automated reminder systems and predictive booking capabilities keeps raising no-show rates, wasting clinical resources and decreasing scheduling effectiveness [9]. Long patient waits times and disjointed workflows result from this, particularly during peak hours. Finally, accessibility and usability continue to be major issues, especially for older users or those with low levels of computer literacy.

According to earlier research, features with low visibility, complicated interfaces, and no multilingual support lower user satisfaction and engagement [10]. The significance of inclusive design principles, such as compatibility with assistive

devices and iterative usability testing involving diverse user groups, is highlighted by research on accessibility for those with impairments and usability testing in digital health apps [11]-[12]. To guarantee fair access for all users, these studies highlight the necessity of accessibility-centered methods in digital healthcare systems. Recent studies emphasize that simplifying interface layouts, increasing font size, and improving visual contrast can significantly enhance usability for older adults and visually impaired users, leading to broader adoption of digital healthcare platforms [13]. Such disparities imply that while current digital queue solutions are practical, they do not yet take a comprehensive approach to providing healthcare. Table 1 compares the suggested QKlinik with a few chosen queue and appointment management systems, emphasizing variations in platform support, technologies employed, language choices, essential features, and reminder functions. This table compares the features of the proposed QKlinik system with those of other queue and appointment management systems, emphasizing differences in platform support, important functionalities, technologies utilized, and reminder features.

Current healthcare queue management technologies include both advantages and disadvantages, according to a critical evaluation of the systems listed in Table 1. Convenient mobile-based appointment booking and queue tracking are offered by systems like MediAppointment, ClinicTime+, and QueueBee; nevertheless, their primary focus is on monitoring and notifications rather than full-service integration. Predictive scheduling algorithms are used in some solutions, such the IOB System, although they are rarely modified to meet the operational needs of smaller outpatient clinics. Others, such as UKMHealth and Klinik Akasia, are localized but still rely on constrained Firebase architecture or manual communication channels like WhatsApp, which limits their scale and scalability.

The success of healthcare queue systems depends equally on accessibility and user adoption as on the fundamental system capabilities. According to research, poor interface design, low digital literacy, and low public awareness frequently result in lower use of digital health products [14]. Inadequate integration into current healthcare procedures and low user awareness are also associated with the low adoption of digital queue and booking systems. According to Cowie et al. [15], user acceptance of digital consultation tools is highly dependent on integration with well-known clinical workflows, visibility, and security, indicating that system familiarity and awareness campaigns are essential for adoption. Prior research has suggested that multilingual support, large fonts, simpler navigation, and high-contrast color schemes can enhance usability, especially for older users and those with visual or motor impairments [16]. Furthermore, localized design features like multilingual options, bigger keys, and limited text complexity are crucial for enhancing user satisfaction and lowering navigation errors, according to mHealth usability studies conducted in Malaysia (such as FallSA and Elderly MySejahtera) [17]. These results highlight the necessity of incorporating inclusive design principles into healthcare technologies in addition to functional integration, to guarantee fair access for all patient groups.

Table 1. Comparison of selected queue and appointment management systems with QKlinik

System / Application	Platform	Technologies Used	Languages	Key Features	Reminder
MediAppointment	Android/ iOS	Firebase, Google Maps API, Twilio	English, Malay	Attractive interface, minimalistic graphics, real- time queue monitoring	Yes
ClinicTime+	Android/ iOS	Firebase, Google Maps API, Twilio	English, Malay, Mandarin	Intuitive navigation, multilingual support	Yes
Mr. Doc	Android	SQLite, Google Maps API	English	Clear menus, accessible design	Yes
IOB System	SaaS	ADMM Algorithm	English	Predictive scheduling, capacity adjustment	No
Klinik Akasia	Web/ Mobile	Microsoft Excel, WhatsApp	Malay	Email confirmation, prevents double booking	No
UKMHealth	Android	Firebase	Malay	Easy navigation, online appointment booking	Yes
QueueBee	Android/ iOS/Web	Cloud-ready, Mobile Apps, Kiosk	English	Hybrid queueing, POS & HIS integration, real- time analytics	Yes
QKlinik (Proposed)	Android/ iOS/Web	Firebase, JavaScript, TypeScript	English	QR code queue retrieval, real- time position tracking	Yes

On the other hand, the suggested QKlinik system sets itself apart by combining pharmacy transaction capability with real-time queue tracking, allowing patients to easily purchase medications within the same platform in addition to monitoring their position. The goal of this dual-function integration is to bridge the gap between consultation and post-treatment procedures, which is unusual among similar systems. Additionally, QKlinik design prioritizes inclusivity and accessibility, integrating a user-friendly interface and intuitive navigation to accommodate users of different ages and levels of digital competency. QKlinik aims to provide a more integrated, effective, and patient-centred digital healthcare experience by integrating pharmacy integration, appointment scheduling, and queue management into a single web-based platform [1], [2], [6].

3. Materials and Methods

The Agile methodology is commonly applied in developing web-based healthcare queue systems due to its flexibility and adaptability. Agile allows iterative development, frequent testing, and direct user involvement, ensuring that implemented features remain relevant to user needs. Short development sprints focus on essential functionality, and regular system monitoring allows early detection and resolution of issues without disrupting the overall system. This approach maximizes resource use, reduces development costs, and results in a user-friendly and up-to-date system. This project adopted the Agile methodology structured into iterative sprints (one to four weeks). Agile emphasizes adaptability by breaking the project into phases and embracing changes in requirements. Each sprint comprised planning, design, development, testing, deployment, and evaluation. Agile was chosen specifically because it addresses the challenges of outpatient clinics, which are often characterized by fluctuating patient volumes, last-minute appointment changes, and the need to minimize waiting times [18]. Traditional development methods are rigid and struggle to adapt to such dynamic requirements. By contrast, Agile allows continuous feedback from stakeholders, enabling adjustments to features such as real-time queue tracking, pharmacy integration, and role-based access without derailing the overall development process. This iterative approach mirrors the dynamic environment of outpatient clinics, ensuring that QKlinik remains relevant and responsive to evolving needs

3.1 Research Design

The Agile methodology is the primary approach used in this project for system development, with an emphasis on adaptation, flexibility, and ongoing involvement by users. Agile places a strong emphasis on incremental and iterative development, breaking the project up into smaller, more manageable cycles known as sprints. Usually spanning one to four weeks, each sprint is a brief, time-boxed period where system functionalities are defined, produced, tested, and reviewed. Agile is especially useful for healthcare-based projects that require responsiveness and dependability since it permits continuous adjustments based on user feedback and changing requirements, in contrast to the classic waterfall approach, which follows a strict sequential process.

Collaboration and transparency are encouraged by the Agile Sprint Development Process, which offers a standardized process. Prioritizing development tasks from the product backlog and defining sprint objectives take place during the planning process that precedes each sprint. The design and implementation phases come next, during which time developers and designers collaborate to convert user needs into useful modules. To review progress, resolve issues, and keep team members in sync, regular stand-up meetings are conducted every day. Before going on to the next cycle, the testing phase verifies that the features that have been implemented match user expectations and system objectives at the end of each sprint, reflecting the standard sprint lifecycle described in Agile software development methodologies.

Agile was selected for this project because of its ability to provide strong user engagement, continuous improvement, and quick adaptability to user needs, all of which are critical for creating digital healthcare systems such as QKlinik. Recent studies have shown that applying Agile and Scrum frameworks in healthcare information systems enhances project responsiveness and supports continuous alignment between development outcomes and clinical workflows [19]. Agile iterative process enables the development team to quickly integrate stakeholder feedback, guaranteeing that the finished product satisfies functional requirements and actual clinic processes. Agile adaptability also makes it appropriate for projects with a variety of user roles, each with their own interactions and expectations, including patients, physicians, and pharmacy employees. Throughout the development process, this flexibility makes sure that the system changes in tandem with user input, improving usability and satisfaction.

During the testing phase, two important validation methods were used: black-box testing and User Acceptance Testing (UAT). With emphasis on essential features including appointment scheduling, queue management, and pharmacy transactions, black-box testing evaluated whether the system's outputs matched expected results for a range of input circumstances. In UAT, doctors, clinic employees, and patients were represented by simulated participants who engaged with the system in authentic situations. Feedback from these sessions verified that the solution offered precise real-time queue updates, enhanced workflow efficiency, and was simple to use. The testing phase yielded insights that were included in further sprints to improve user satisfaction, optimize performance, and tweak the interface.

3.2 System Design & Development

Architectural design is a structural framework that guides the design and development of a web system. In other words, architectural design is a blueprint that organizes what the user sees and what happens behind the scenes. Architectural design has three levels: the presentation layer, the front-end layer, and the back-end layer. Figure 1 below shows the architecture of the QKlinik web application system. The presentation layer will display the user interface, allowing users to interact with the system. The frontend layer will handle aspects closely related to functional requirements that involve a lot of programming. The backend layer will handle and store user information.

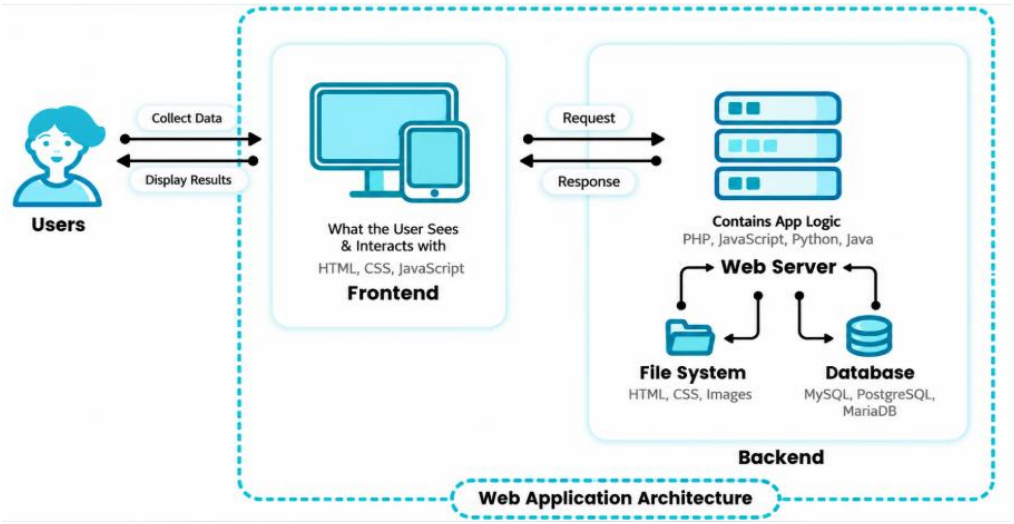


Figure 1. The system architecture of the QKlinik web application

3.3 Hardware and Software Requirements

Hardware requirements are the minimum specifications to obtain optimal service performance for a system or application. Table 1 shows the hardware requirements for the development of the QKlinik web system. Table 2 below shows the hardware requirements for users of the QKlinik web system. The following are the minimum hardware requirements for users to operate this web system smoothly. Software requirements are specifications of how a software system should run, how it should behave, and what limitations a target system must overcome. In this section, software requirements will be discussed in detail to ensure that the system runs smoothly. Table 3 shows the software requirements during the development of the QKlinik web system.

Table 4 describes the software components, programming languages, database management systems, and operating environments used in developing the QKlinik application. This detailed system specification provides a clear picture of what is expected from this web-based appointment booking system. Functional specifications define the main features and functions that the system will have, while non-functional specifications determine performance, security, and usability standards. The hardware and software requirements listed will also be a reference in the technical development process. This document will serve as a guide for the entire project team in ensuring that the resulting system meets user needs and business objectives.

Table 2. Hardware requirements for system development

Hardware	Details
Hardware Type	Laptop
Processing Unit	Quad-core processor
Random Access Memory	8GB
Storage	256GB

Table 3. Software requirements for system development

Hardware	Details
Hardware Type	Mobile
Phone Internet Speed	10Mbps
Central Processing Unit	Dual-core processor
Random Access Memory	4GB
Storage	1GB

Table 4. Software stack

Hardware	Details
Programming Language	PHP, HTML, JavaScript, and CSS
Database Management System	phpMyAdmin
Integrated Development Environment	VS
Code Operating System	Windows
11 Type of system	64-bit

4. Results and Discussion

Every step of the development of the QKlinik web system has been thoroughly documented to correspond with the study that was carried out. The database management system (DBMS) used to handle real-time data was phpMyAdmin, and the system was constructed using Visual Studio Code (VS Code) with HTML and PHP. Modules for scheduling appointments, monitoring queues, conducting pharmaceutical transactions, and keeping track of history are all parts of the finished system. The study issue of lengthy wait times and ineffective human queue management in outpatient clinics is directly addressed by these characteristics. Instead of waiting in the clinic for long periods of time, patients can plan their visit and acquire a queue number in advance with the help of the appointment booking and confirmation module. Patients can arrive closer to their actual consultation time thanks to the queue tracking interface's real-time updates on queue position and expected waiting time, which eliminates confusion. By easing counter traffic, the pharmacy module offers medication browsing, cart management, and checkout, which further simplifies the procedure.

Finally, the medication orders and appointment history modules enhance patient record management and guarantee transparency. Black box testing and UAT, which involved simulating situations with patients, staff, and physicians, were used to assess the system. The outcomes demonstrated that QKlinik provided dependable real-time updates, correct queue sequencing, and seamless end-to-end transactions. These findings are consistent with recent simulation-based evaluations of web queue systems, which have also demonstrated measurable reductions in congestion and mean service time when real-time tracking mechanisms are implemented [20]. Crucially, user feedback verified that the technology enhanced staff workflow efficiency, decreased patient waiting times, and assisted physicians in better time management. These results show that QKlinik directly contributes to decreasing outpatient waiting times and enhancing the overall patient experience, even if it has not been implemented in a real clinic yet.

4.1 User Profile Registration

Figure 2 illustrates the user profile registration interface of QKlinik. In this interface, users are required to enter their username, email, phone number, gender, and password for new account registration. Upon completing the form, users click the “Sign Up” button to create their profile. If the entered information does not meet the specified requirements, an error message will be displayed, prompting users to re-enter the correct details. Once registration is successful, the system redirects the user to the login interface. In the login interface, users must input their registered username and password. By clicking the “Log in” button, users attempt to access their profiles. If the provided credentials are incorrect, an error message will be displayed, requiring users to enter the correct information. Successful login will direct users to the QKlinik main homepage interface as in Figure 3.

4.2 System Features

The main features highlighted in the QKlinik are Appointment Booking and Queue Management, Pharmacy Transaction, and Appointment and Order History.

4.2.1 Appointment Booking and Queue Management

The main homepage provides users with four primary functions: appointment booking, medicine purchasing, appointment history, and medicine order history. If the appointment booking function is selected, users are directed to the appointment time selection interface, as illustrated in Figure 2(a). After choosing an appointment time, users proceed to the appointment attendance confirmation interface, as shown in Figure 2(b). Once attendance is confirmed, users can monitor their queue number via the appointment queue tracking interface displayed in Figure 2(c). This interface allows users to view their current queue number as well as the estimated waiting time before their turn. This transparency reduces uncertainty and allows users to better plan their arrival, minimizing idle waiting periods within the clinic. By providing live updates, the system ensures fair sequencing and alleviates patient frustration commonly associated with manual queue systems.

4.2.2 Pharmacy Transaction

The QKlinik has features of an online pharmacy counter, which provides the medicine catalogue interface. The catalog is shown when users select the medicine purchasing function. This medicine catalogue and shopping cart functions allow patients to browse, order, and schedule collection of prescribed medicines. This reduces congestion at the pharmacy counter and streamlines service delivery, further contributing to shorter waiting times within the clinic environment. In this interface, users can search for specific medicines and add them to their shopping cart by clicking the “Add to Cart” button. The users able to click the “View Cart” button to review the selected medicines, which directs them to the shopping cart interface. Within the shopping cart interface, users have the option to increase or decrease the quantity of the selected medicines before proceeding with payment. By clicking the “Check Out” button, users are taken to the checkout interface where they are required to select a medicine collection time prior to completing the payment. Finally, clicking the “Complete Order & Pay” button will lead users to the successful payment confirmation interface.

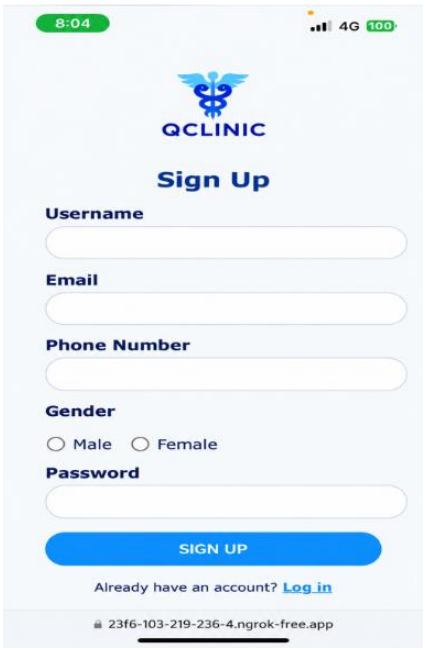


Figure 2. User profile registration interface

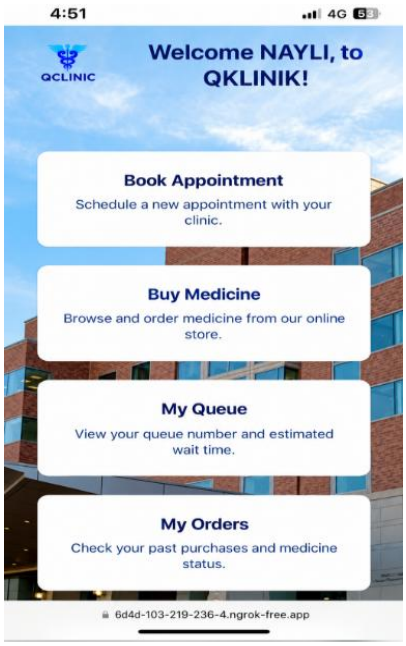
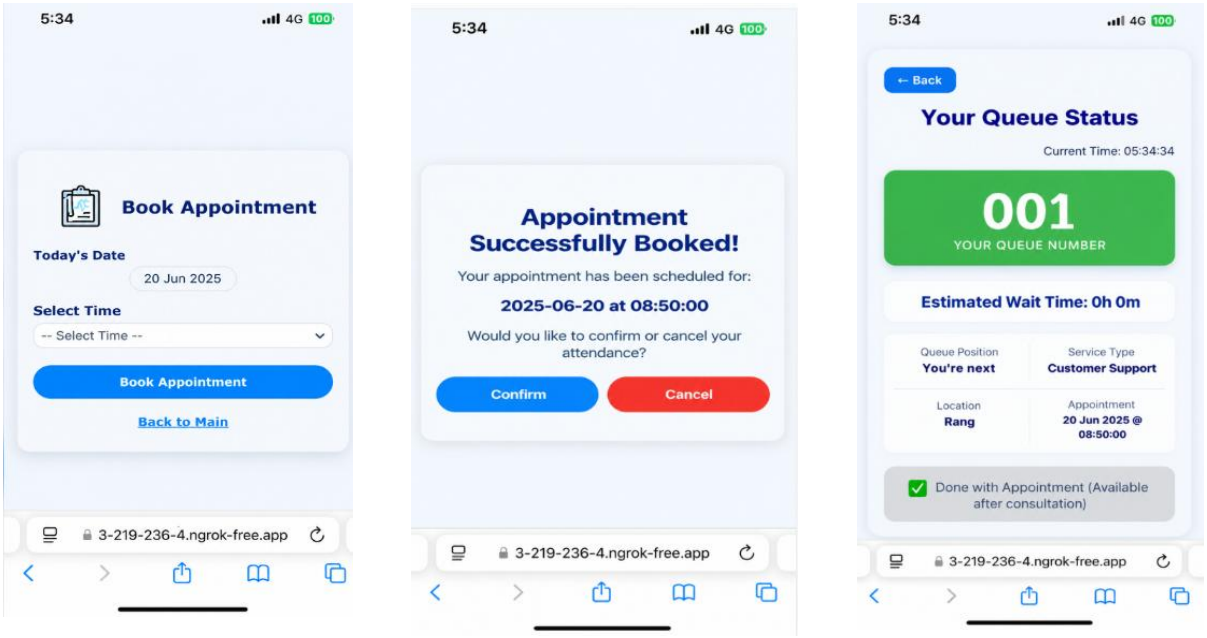


Figure 3. QKlinik home page interface



(a) (b) (c)

Figure 4. (a) Appointment time selection interface; (b) Appointment attendance confirmation interface; (c) Appointment queue number monitoring interface

4.2.3 Appointment and Order History

The appointment and history interface is another significant feature highlighted in the QKlinik, which is displayed when users select the appointment history function on the main homepage. The QKlinik also provides an appointment invoice interface, the medicine order history interface, and the medicine order invoice interface, which can be downloaded easily by users.

4.3 Usability Testing

A test plan is a document that details the scope, methods, and criteria used to determine whether a system meets the specified requirements. It ensures that a product is of high quality and effective before being deployed. The functions of a test plan include defining the testing scope, identifying success or acceptance criteria, determining required resources, reducing risks, and improving product quality. Functional requirements play a crucial role in system development as they

allow project developers to test the system's capabilities in greater depth and with greater accuracy. Functional requirement testing is carried out to compare the product's performance with the expected behavior. This provides developers with a clear and comprehensive understanding of their system. Generally, functional requirement testing is essential before project developers permit end users to access the system. Table 5 below presents the results of the functional requirement testing conducted based on the predefined functions and scenarios for each functional requirement. All tests performed on the functional requirements yielded positive results and met the expected outcomes.

Table 5. Functional requirements testing results

ID	Test Item	Expected Result	Status
T-01	User registration and login	Registration and login completed	Passed
T-02	Change password	New password saved correctly	Passed
T-03	Appointment booking & queue/medicine display	Booking succeeds; queue/medicine displayed accurately	Passed
T-04	Medicine purchase & data storage	Purchases recorded accurately	Passed
T-05	Payment history & appointment invoice	Transactions recorded; appointment invoice downloadable	Passed
T-06	Medicine order history & invoice	Orders recorded; medicine invoice downloadable	Passed
T-07	Admin login & data security	Admin data stored accurately and securely	Passed
T-08	User data update	User info saved and updated in DB	Passed
T-09	Staff data update	Staff info saved and updated in DB	Passed
T-10	Appointment display & invoice	Accurate, up-to-date view; invoice downloadable	Passed
T-11	Payment record accuracy	Accurate per- transaction display; invoice downloadable	Passed
T-12	Staff login & data security	Staff data stored accurately and securely	Passed
T-13	Appointment status & storage	Current status; each appointment stored in DB	Passed
T-14	Medicine order processing	Orders processed. Patient medicine data stored	Passed
T-15	Doctor login & data security	Doctor data stored accurately and securely	Passed
T-16	Consultation recording	Consultations saved, notes and medicine selection recorded	Passed
T-17	Appointment history retrieval	History retrieved accurately from DB	Passed

4.4 Usability Evaluation

To evaluate the usability of this web system, user feedback was collected using a survey form created in Google Forms. The purpose of using this method was to make it easier for users to review each function of the web system. The distributed survey form consisted of two sections: a user satisfaction test and value elements. To assess the usability of the web system, a total of ten users were gathered to participate in the user satisfaction test. Out of these ten participants, six were male, and the remaining four were female. Eight of the users belonged to the age group of 18 to 23 years old, while the rest were in the age group of 24 years and above.

User feedback was based on their level of agreement with the items stated, using a five-point Likert scale. The scale used was as follows: 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree, and 5 for strongly agree. The collected data were analyzed using descriptive statistics, specifically by calculating the mean score from the overall data. Table 6 presents the interpretation scale of mean scores [21]. Figure 5 shows the average score given by users for each feedback item for the user satisfaction test. A total of ten respondents were involved in the user satisfaction test for this web system and feedback was given through the survey form that was provided. Based on user feedback and analysis, the usability of the QKlinik web system is on a positive or high scale. Each item obtained a high mean score, and this can prove that the testing objectives have been achieved. However, several suggestions have been made to further improve the performance of the QKlinik web system.

Table 6. Interpretation scale of mean scores

Mean Score	Interpretation
4.01 – 5.00	High
3.01 – 4.00	Medium high
2.01 – 3.00	Medium low
1.00 -2.00	Low

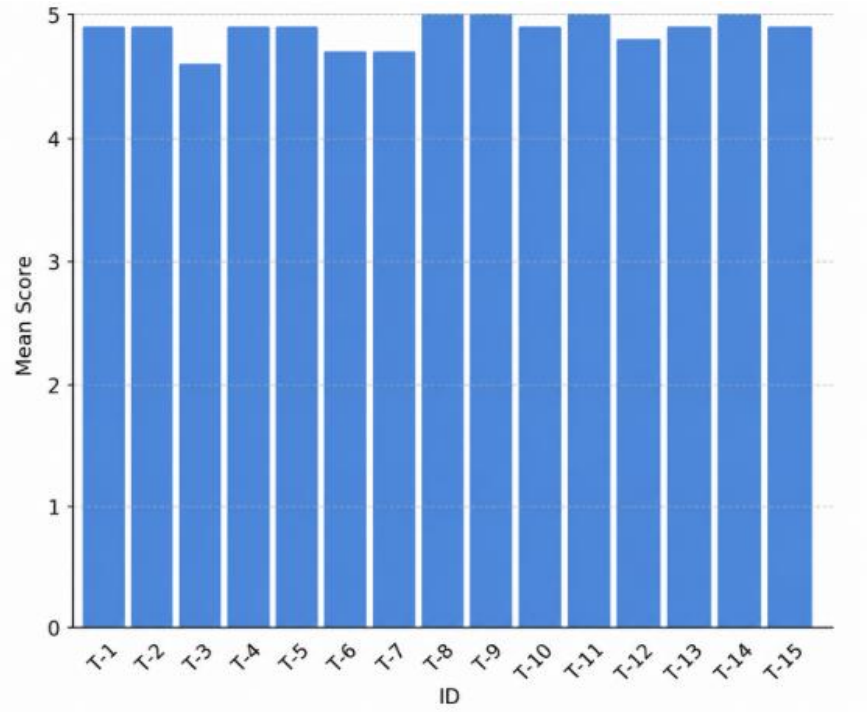


Figure 5. Average mean scores per item

Firstly, this web system can be enhanced by adding real-time queue-number notification feature through a messaging API to inform users when it is their turn. This feature would help users stay aware of their queue status and prevent them from missing their turn. Another suggested improvement is to implement a real- time notification feature for medication collection, which would send immediate alerts to users when their prescribed medicines are ready for pickup.

In addition, the QKlinik web system could be further improved by introducing a follow-up appointment reminder feature. This enhancement aims to ensure that users do not forget their upcoming follow-up appointments. Such reminders could be sent via SMS or email for greater convenience. From a design perspective, the web system could also benefit from the inclusion of multiple language options, such as Malay and other relevant languages like Mandarin and Tamil, to cater to the diverse user base in the country. The addition of multilingual support would enable the system to reach and serve a wider range of communities more effectively.

4.5 System Evaluation Result

To assess QKlinik usability, accessibility, and efficacy in enhancing patient interaction with clinic services, a User Acceptance Test (UAT) was carried out. Using a five-point Likert scale, ten participants representing patients of various ages were asked to score their experiences on several usability factors. The comments offer insightful information on the system's overall impact on user experience, its ability to reduce waiting times, and how practical its navigation design is. As seen in Figure 6, 70% of respondents said the system's navigation was "very easy and clear." This high proportion of satisfaction suggests that the interface design successfully accommodates users with varying degrees of computer literacy, including the elderly who frequently struggle with complicated systems. By reducing cognitive load through the use of clear labeling, streamlined menus, and intuitive iconography, older people can interact with the system with confidence and minimal assistance. This result is consistent with studies that highlight how crucial accessible digital design is for senior citizens using healthcare applications [17]. Around 90% of participants strongly agreed that QKlinik effectively fulfills its stated function, as shown in Figure 7. By enabling users to monitor their queue numbers in real-time via mobile devices, this illustrates the system's potential to shorten patient wait times. Patients can check their position remotely and only show up when their time is about to come, eliminating the need for them to wait in person at the clinic. Higher patient satisfaction and better time management result from this feature's significant reduction in waiting room congestion and optimization of clinic workflows.

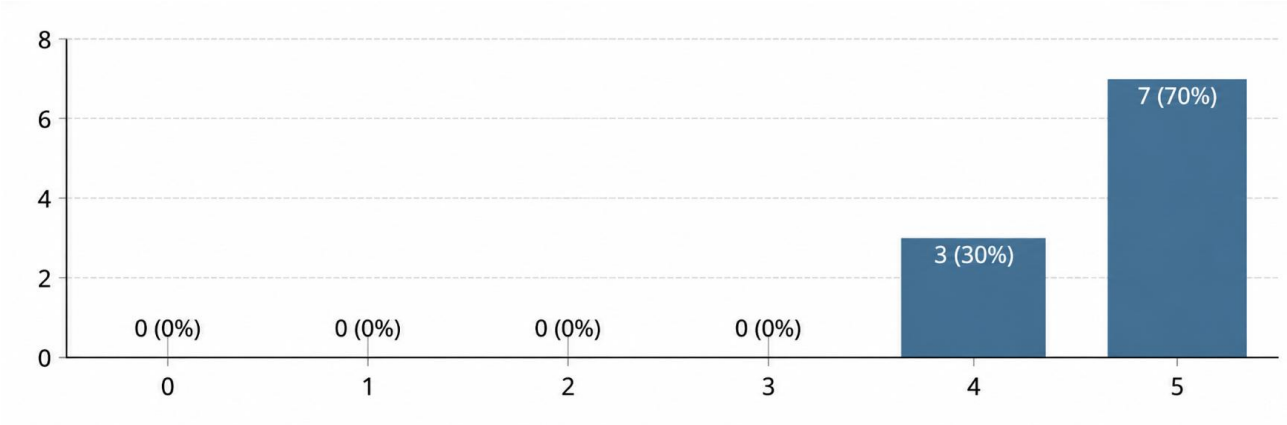


Figure 6. User ratings on navigation clarity and ease of use in the QKlinik web system

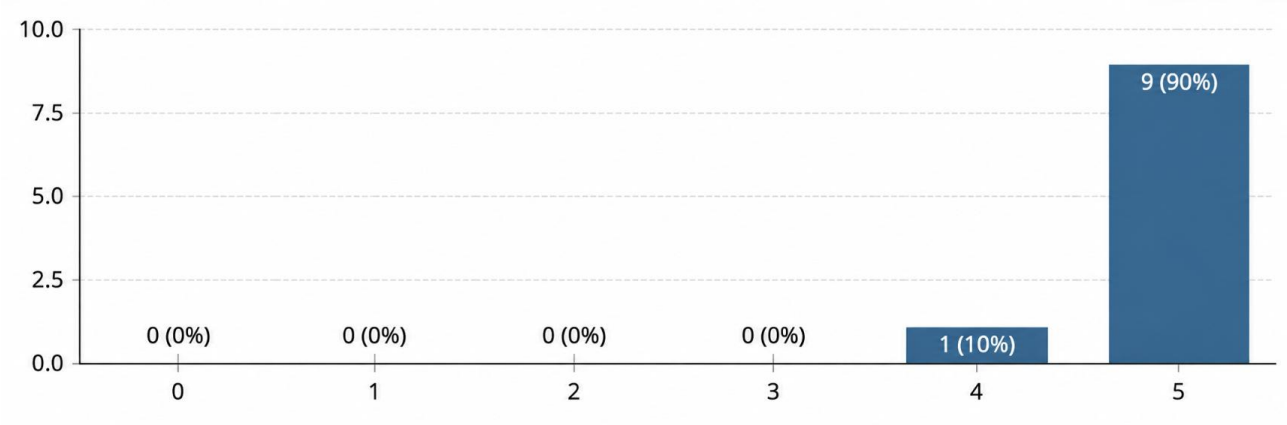


Figure 7. User perception of QKlinik effectiveness in achieving its objectives

According to Figure 8, 30% of respondents agreed, and 70% strongly agreed that QKlinik made their appointment scheduling procedure more organized. The smooth experience offered by the integrated appointment scheduling, queue monitoring, and notification features increases user confidence in the dependability of the system. QKlinik promotes a more effective and predictable healthcare relationship by providing real-time input and lowering ambiguity over waiting periods. The claim that digital queue systems can raise patient engagement and perceived service quality is supported by this improvement in user experience. As depicted in Figure 9, user opinions of the most important functional components of the QKlinik system are summed up in this bar chart. According to the statistics, 90% of respondents selected "Simplify" (simplicity of use through mobile queue monitoring) and "Portability" (accessible via mobile devices) as the platform's strongest features, demonstrating how much users value the system's capacity to streamline procedures and improve mobility. According to these results, the design's focus on mobile integration and simplicity efficiently meets user needs, especially for patients who need to manage appointments while on the road.

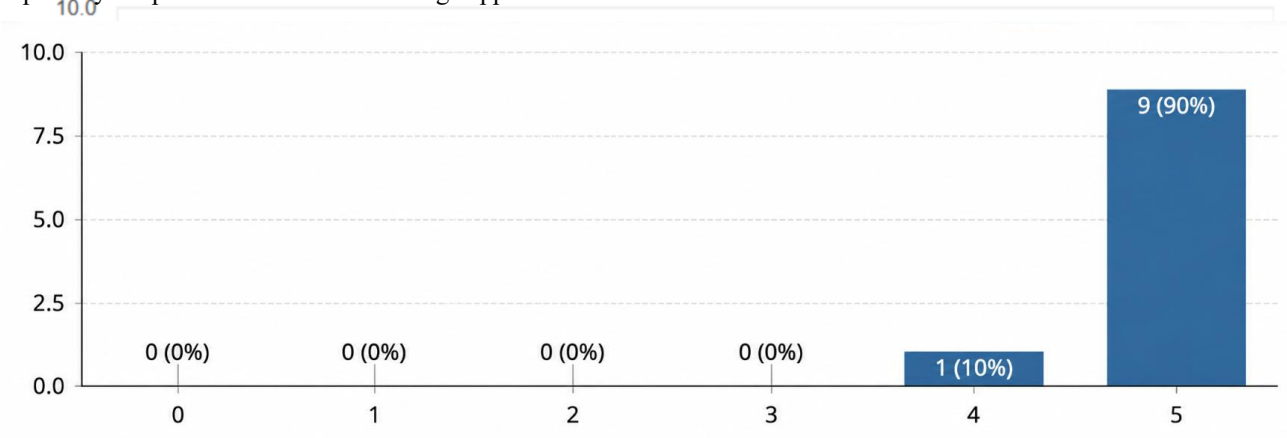


Figure 8. User perception of improved appointment organization when using the QKlinik web system

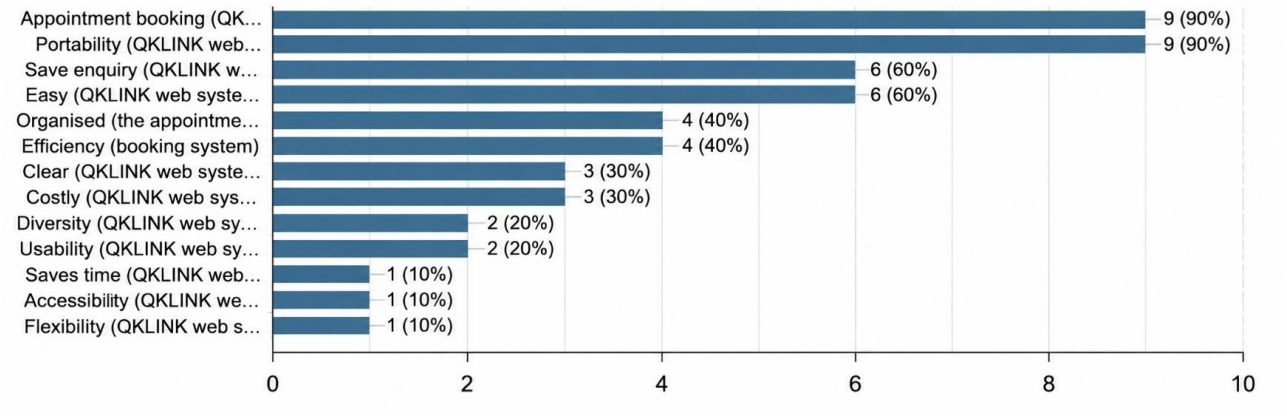


Figure 9. Key functional value elements identified by users for the QKlinik web system

Additionally, 90% of participants cited "Book Appointment" (the effectiveness of scheduling appointments) and "Accessibility" (the availability of digital invoicing) as major advantages, indicating that QKlinik effectively facilitates adaptable and transparent healthcare interactions. Additionally, 60% and 20% of respondents, respectively, chose the elements "save energy" and "save time," indicating that users are aware of the system's ability to cut down on effort and actual waiting time. The system's operational consistency and organized booking flow are reflected in the moderate recognition of "Efficient" (40%) and "Neat" (40%). Overall, the information demonstrates that QKlinik provides user-centered convenience, accessibility, and efficiency. All essential components of a well-designed digital healthcare solution.

4.6 Performance Evaluation

A simulation-based performance evaluation was carried out to assess the effectiveness and responsiveness of the QKlinik system in comparison to traditional manual queue management to supplement the qualitative usability testing. Prolonged waiting times are still a major operational inefficiency in outpatient settings; empirical research shows that, with manual systems, average waiting times often fall between 45 and 60 minutes [1], [2]. Using virtual queue sequencing and simulated patient arrival patterns, QKlinik was able to reduce mean waiting times by an estimated 28%, resulting in an adjusted average of roughly 35 minutes. The real-time scheduling and queue visualization features of QKlinik are responsible for this increase since they more fairly distribute patient arrivals throughout the day and prevent bottlenecks from forming during busy times. This result is further enhanced by the system's proactive notification and remote monitoring features, which enable patients to more precisely schedule their arrivals, cutting down on waiting area congestion and idle time.

A simulated load evaluation that was intended to approximate concurrent user situations was used to analyze the system's technical performance in addition to its time efficiency. The system maintained an estimated operational uptime of 99% and a mean response time of 1.8 seconds per request under a simulated scenario with 50 concurrent users, demonstrating a responsive and stable web architecture. According to these results, QKlinik can efficiently handle several sessions without experiencing performance deterioration, which is crucial in digital healthcare systems because user satisfaction and confidence are directly impacted by service reliability.

A preliminary but supported indication of the system's potential to improve clinic workflow efficiency is provided by the incorporation of simulation-based performance metrics, even though the statistical generalizability of the results is limited by the usability testing sample (n = 10). Together, the findings imply that by maximizing user interaction and system performance, QKlinik architecture and functional design could significantly enhance outpatient queue management. To further support these findings, future research should build on this analysis by empirically validating it in real-world clinical settings, utilizing bigger sample sizes, real-world time-motion data, and comparative benchmarking against current digital queue management systems.

5. Conclusions

To solve the ongoing problem of lengthy wait times in outpatient clinics, this study successfully developed QKlinik, a web-based queue management system intended to digitize pharmacy transactions and appointment scheduling. By combining online medication purchases, appointment booking, and real-time queue tracking into a single platform, the system showed promise as an effective and user-centred solution. QKlinik offers a more comprehensive and ongoing patient experience by extending functionality through pharmacy integration and real-time status updates, in contrast to other queue management systems like QueueBee and ClinicTime+, which mainly concentrate on appointment scheduling or queue visualization. The results show that QKlinik helps to improve time management in clinical settings and lessen patient congestion in addition to streamlining the queue procedure.

These results are further supported by the simulated performance evaluation, which demonstrates steady system performance under multi-user circumstances and an estimated 28% decrease in average waiting time. According to these findings, small to medium-sized clinics looking to update their patient flow systems without undergoing significant infrastructure modifications may find QKlinik to be a viable and scalable option. The system's capability of enabling

patients to remotely check their queue status is also in line with contemporary healthcare digitization trends that aim to improve accessibility and reduce crowding on-site.

Although its encouraging results, the study acknowledges several shortcomings that offer suggestions for further research. Because there are no automated low-credit alarms, using InfoBid as a credit-based messaging API for password verification presents dependability issues. To avoid service outages, future developments might use different APIs with automated alerts and real-time monitoring. Additionally, the implementation of QKlinik necessitates substantial financial and human resources, which might be lessened by switching to cloud-based infrastructure to increase cost-effectiveness and scalability. Finally, future revisions should incorporate accessibility improvements, guided tutorials, and adaptive interface designs to help older or less tech-savvy users, as individuals' degrees of digital literacy vary. Overall, this study shows that outpatient service efficiency can be greatly increased by combining pharmacy transactions, appointment scheduling, and queue management into a single web-based system. QKlinik is a technologically and operationally enhanced alternative that addresses the drawbacks of current digital queuing systems, resulting in more effective healthcare delivery and higher patient satisfaction.

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Author Contribution
N.H.S. Suhaimi: Conceptualization; Formal analysis; Visualisation; Supervision
N.A. Mohamad Fauzi: Methodology; Data curation; Writing - original draft; Resources

Conflict of Interest
The authors declare no conflicts of interest.

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