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Hospital Queuing System with Smart Kiosk

Peter John N. Paver[1] Dr. Richard M. Pabelona Jr.[2]
[1] *Data Controller II,*
Teresita L. Jalandoni Provincial Hospital,
Barangay Lantad, 6116 Silay City, Negros Occidental, Philippines.
[2]*Associate Professor II,*
College of Industrial Technology,
Main Campus, 6115 Talisay City, Negros Occidental, Philippines.

ABSTRACT
This study designs and develops a Hospital Queuing System with Smart Kiosk for hospitals. Specifically, it aims to create a system with the following technical features: dynamic queuing number display on screens and kiosks, serving time extension, and concern prediction using decision-tree classification. The study also aims to test the functionality of these features, evaluate the system's usability in terms of usefulness, information quality, interface quality, and overall usability, and to develop a user manual. The research utilizes Developmental and Descriptive research design following the PASUC VI model for Software Designing and Development. Test cases were conducted to evaluate the identified technical features. The Post-Study System Usability Questionnaire (PSSUQ), a standardized research instrument, was used to assess the system's usability. Results of the study revealed that the Hospital Queuing System with Smart Kiosk is highly acceptable, 100% functional, and operational. It is deemed highly acceptable in terms of usability, including system usefulness, information quality, interface quality, and overall usability. The user manual is designed to help users effectively operate the system. The system can be used in hospitals to improve patient satisfaction and organize the queuing procedure.

KEYWORDS: *Hospital Queuing System, Smart Kiosk, Usability Evaluation, Dynamic Queuing Display, Decision-Tree Classification.*

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I. INTRODUCTION

In recent decades, healthcare systems have grappled with an unprecedented surge in demand, necessitating ongoing improvements and fine-tuning of operational processes and quality control methods. These facets are now recognized as pivotal elements within the broader framework of service quality, particularly amidst the current healthcare landscape. Unorganized queues represent a harrowing experience, especially when one's health hangs in the balance. The mismanagement of waiting lines only serves to compound the inherent stress of hospital visits.

Hyun Lee (2011) aptly articulates the distressing dichotomy between routine queues and those endured within the context of healthcare. While waiting in line for a morning coffee may be an inconvenience, the stakes are markedly higher when one's health is on the line. Unfortunately, the normalization of lengthy wait times within healthcare settings has become a regrettable reality for many. This normalization not only perpetuates the frustration and anxiety experienced by patients but also reflects a systemic failure in prioritizing patient-centric care.

The queue management system is considered one the most important and crucial approach in improving the service quality by minimizing the length and the time of each waiting line, which lead the company to have more competitive advantages by solving the problems relating to the waiting lines (Habbache & Maiza, 2021).

Hospital overcrowding is a result of the significant population growth, making it challenging for hospital management systems to regulate or reduce patient waiting times while receiving medical care. The doctors mentioned a number of tests during the course of treatment in order to diagnose the illness and provide the appropriate care. We must therefore wait in line to evaluate this test in its entirety. Before receiving treatment, a patient must wait until the entire patient has finished. Unnecessary waiting time does not only waste patient's time

but also gives frustration while waiting. It would be more convenient if a patient could get the estimated waiting time in real time. (Patil & Thakur, 2019).

The researcher developed a Hospital Queuing System with Smart Kiosk. The system comprised a web-based management application and a smart kiosk. Since web programs are accessed via network, they do not require downloading. The smart kiosk provides convenience and control to users by being prominently displayed that allows for easy self-service tasks and reduces the need for assistance from staff.

Objectives of the Study

This study aimed to design and develop a Hospital Queuing System with Smart Kiosk with the following technical features; dynamic queuing number display on screen and kiosk, serving time extension, and concern prediction using decision-tree classification.

II. Materials and Methods

The Research Design

In this study, the researcher utilized the framework of Technology Development research and descriptive designs. The goal of development research is to systematically examine the products, tools, processes, models, and systems in order to provide reliable, usable information to practitioners, theorists, and researchers (Richey & Klein, 2005). The focus of this research is to design and develop a Hospital Queuing System with Smart Kiosk that aligns with the objectives of the study and follows the PASUC VI design on Software Designing and Development model..

On the other hand, the researcher used the descriptive statistics method to collect and interpret data that will help explain and validate the results of this study to verify whether or not the system could actually benefit the organization. Kaliyadan and Kulkarni (2019), stated that descriptive statistics try to describe a summary of data in the form of mean, median, and mode and attempt to characterize the relationship between variables in a sample or population. The development of the system based on the Rapid Application Design (RAD) Model.

A proper research design, which a researcher adopts before data collection begins in order to legitimately accomplish the research objective, is necessary for a successful research project. The goal of research design is to transform a problem into data that can be analyzed to produce accurate answers to research questions at the lowest possible cost (Asenahabi, 2019).

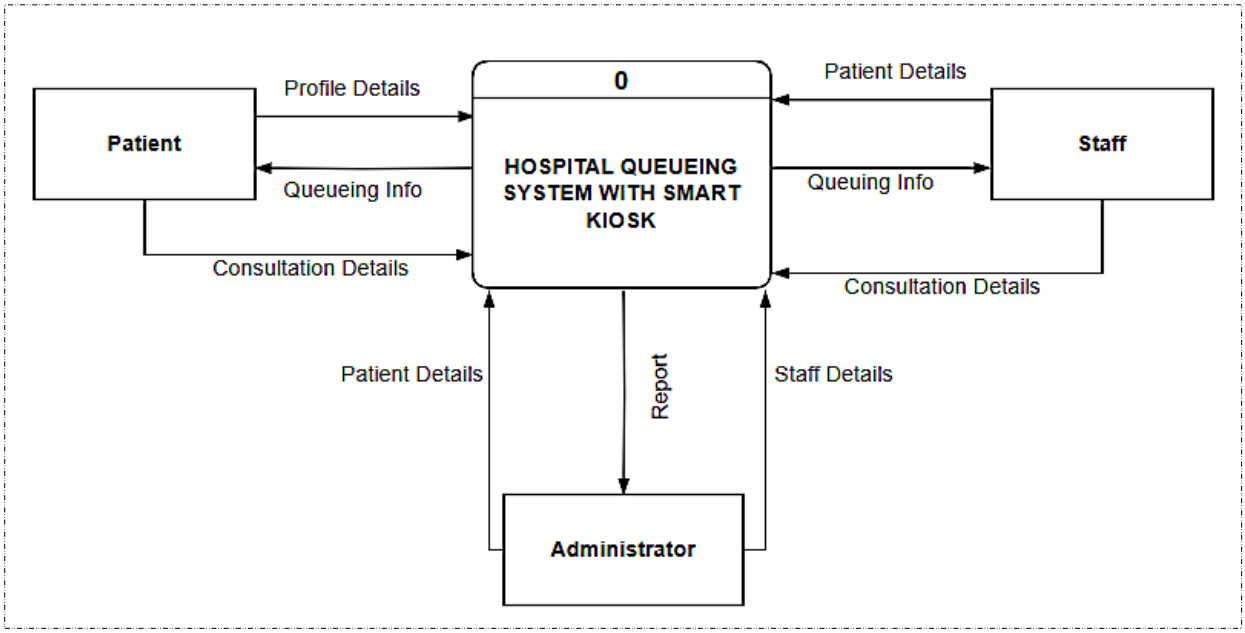
The research design is the "backbone" of the research protocol because it offers the elements and the strategy needed to complete the study successfully. It is similar to a technique that provides a list of steps and instructions for preparing a process.

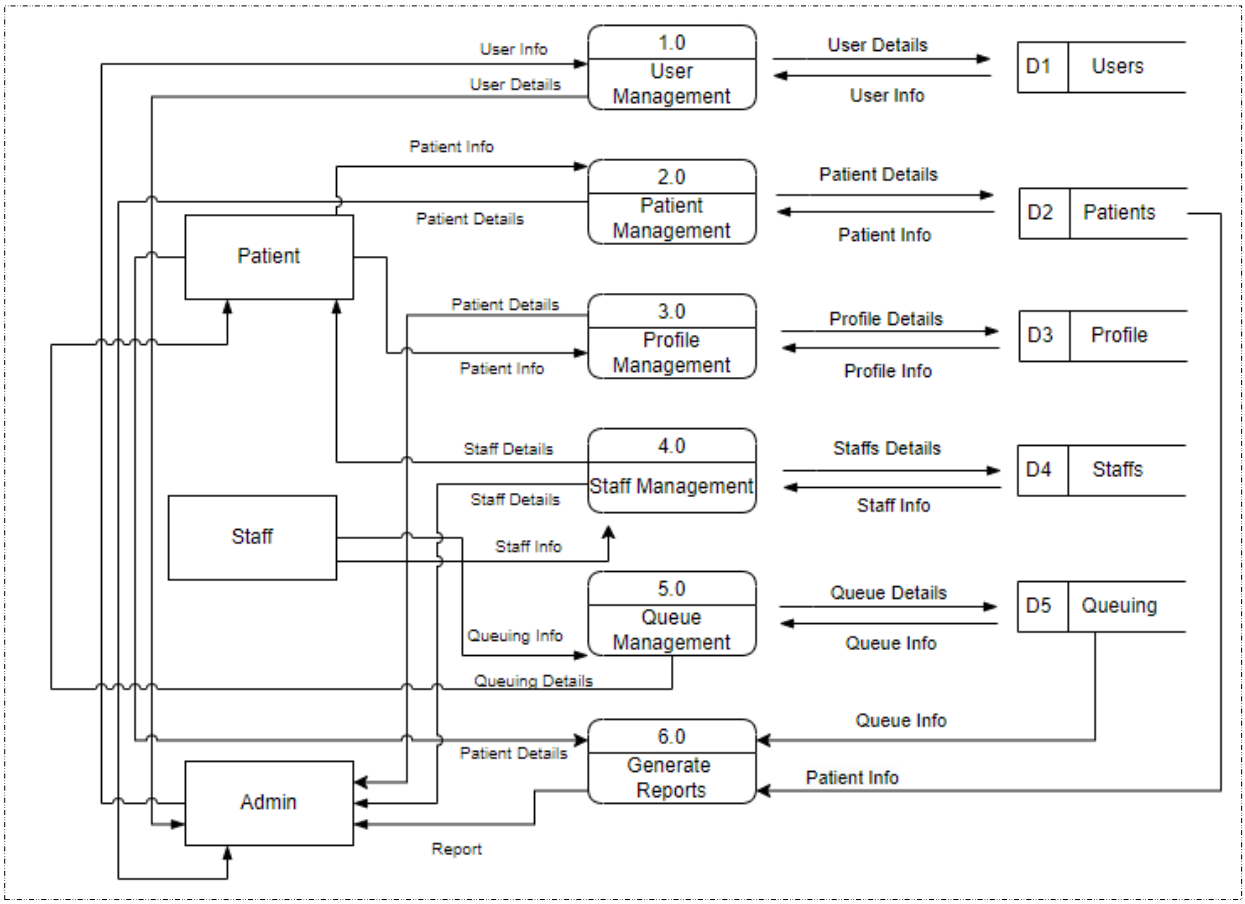
Context Diagram

Figure 1 shows the Context diagram of the system its high-level depiction of the system's interactions with external entities. It delineates the boundaries of the Hospital Queuing System with Smart Kiosk and identifies key external entities with which it interacts. This diagram serves as a foundational visualization for understanding the system's scope and its relationships with its environment.

The second part of Figure 1 is the Data Flow Diagram, which is illustrates the flow of data within the system, emphasizing the interactions between various components and external entities. This diagram provides a structured representation of how data moves through the system, from input sources to processing activities and output destinations, facilitating a comprehensive understanding of system functionality.

Figure 1. Block Diagram





Hardware and Software Requirements

The system is web-based, and in order to manage its contents and provide a user-friendly interface to users, it needs a network infrastructure. Additionally, the system will be configured using a user-server model, which calls for a particular configuration for both the user unit and the server.

Table 1. User Computer Requirements

Hardware	Specification
RAM	2GB or higher
Hard Disk	1GB free space
GPU	Any
Screen Size	1366x768 or higher
Operating System	Windows 7 or equivalent
Browser	Google Chrome or equivalent

Table 1 shows the user computer requirement, hardware and specifications include at least 2GB of RAM, 1GB of available hard disk space, and a screen resolution of 1366x768 pixels or higher. The operating system should be Windows 7 or an equivalent, and the preferred web browser is Google Chrome or a similar browser. These requirements ensure that user computers have adequate resources for basic computational tasks and web-based applications.

Table 2. User Tablet/Kiosk Requirements

Hardware	Specification
CPU	Quad Core
RAM	8GB
ROM	1GB free
GPU	Any
Screen Size	HD+ or higher
Operating System	Android 6 (Marshmallow)/ iOS or newer
Browser	Google Chrome/Safari or equivalent

Table 2 presents the user tablet/Kiosk requirements on hardware and its specifications. The system requires a Quad Core CPU, 8GB of RAM, and at least 1GB of free ROM. The screen resolution should be HD+ or higher. The operating system should be Android 6 (Marshmallow) or iOS or newer, and the preferred web browsers are Google Chrome, Safari, or their equivalents. These specifications ensure that tablets or kiosks can handle more demanding applications and provide a high-quality user experience.

Table 3. Server Requirements

Hardware	Version
Apache Http Server	2.4*
PHP	7.3*
MySql	5.0*

Table 3 outlines the server requirements necessary for hosting and running the designated application or system. The hardware specifications include the Apache HTTP Server version 2.4*, PHP version 7.3*, and MySQL version 5.0*. These requirements serve as a guideline for system administrators and developers to ensure that the server environment is appropriately configured to support the application's functionality and performance needs.

Software Development Phases

The software development phases are anchored to the software development life cycle (SDLC) to meet software industry standards. The iterative process continues until the system will be completely develop the system fully operational and functional and the users will be satisfied. The following development phases outlined as follows.

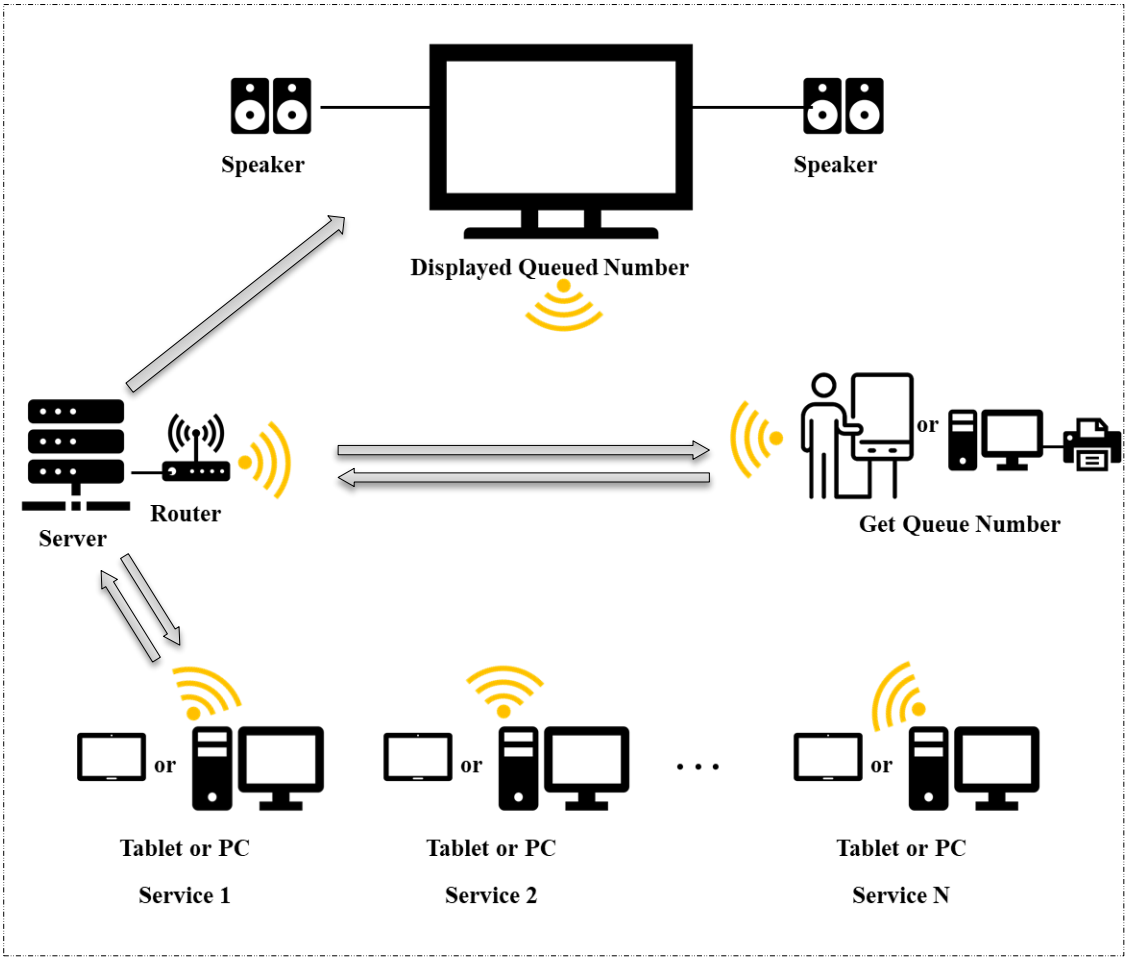


Figure 2. System Design Architecture

Figure 2 shows the basic overview of the Hospital Queuing System with Smart Kiosk. All pc or tablets and server are connected in one router or switch. Patients will first queue a number for services. The ticket with queuing information including a facilities' name, date and time of issue is issued by the thermal printer connected. The patient takes a ticket, and waits anywhere in the lobby to be called. Then services will queue or call the number to be served and will appear at the display monitor depending on what services patient chose. It shows how the system flows and provides information to the user.

Coding Phase

The programmer's creation of the codes in accordance with the specifications is one of the fundamental phases. The development of the hospital queuing system with smart kiosk will be based on the design and the needed functionalities of the end-user. It also includes the system's implementation, which will be examined to see if it will run smoothly and in synchronization. The system was evaluated by the researcher to see if it satisfies the necessary requirements. It also covers the coding, bug-fixing, and construction of the aforementioned system, including the features and technicalities required by the client. The PHP (PHP Hypertext Pre-processor) and JavaScript (JS) programming languages were used because it was necessary to create a web-based system. The fundamental components of the system interface were constructed using HTML by the programmer. After that, an advanced and more appealing design effect was added to the interface using Cascading Style Sheets.

The system's logic for button clicks and other events throughout the system lifecycle was developed using PHP. JavaScript was used to implement the web browser Authentication Application Programming Interface (API), and the authentication process was tied to a specific or any web browser.

Testing Phase

The researcher tested the system's functionality and usability with users to ensure that all of its components were functioning as expected and continued incorporating their feedback as the system was tested and retested for smoother and better performance. In this phase, it consists of the Initial Testing. The functionality of the Hospital

Queuing System with Smart Kiosk based on its technical features was tested using the test cases, and the Final Testing wherein the system's usability was evaluated by utilizing a standard Post-Study System Usability Questionnaire.

Functionality Testing

To ensure that the system operates according to the functional requirements and taking into consideration the design principles, functional testing is to be carried out (Dowson, 2015).

A functionality test was carried out to evaluate every feature of the software program by supplying suitable input and comparing the result to the functional requirements. The program under test was tested for functionality, security, user/server connection, and other areas.

Test cases were used to test the system's functionality. It assisted the user in validating the system by assigning a rating to each test case, along with the expected and actual results, a pass/fail choice, and a comments section that provided context for the rating. See the test case form in Appendix B.

The test cases were demonstrated to each respondent in actual form for their evaluation and requested to accomplish the evaluation form. The purpose of the study was explained to the respondents by the researchers.

Usability Testing

To test the usability of the system the standard Post-Study System Usability Questionnaire (PSSUQ) was used and administered to the respondents of the study.

The PSSUQ has three versions, with the first two having 18 and 19 questions, respectively. It is the most widely used by many researchers on system development and design. It is used to measure users' satisfaction with their perception of a website, software, system, or product right after the study (Lewis, 2018).

The third version of the PSSUQ was used in this study and has 16 questions with four categories each, see PSSUQ form in Appendix A: system usefulness, information quality, interface quality, and overall usability. It uses a 7-point Likert scale and includes a final not applicable option at the end. It should be noted that in a Likert-type Seven-point Scale where 1 is the highest with the interpretation of "Very High Acceptable" and 7 as the lowest interpreted as "Highly Not Acceptable."

The users evaluate the usefulness of the system by determining whether the system exhibits ease of usage, simplicity, and learning, and can successfully and efficiently complete the task using the system. These are the question numbers 1 to 6.

Information quality is assessed by the users by examining the interaction of the system through the feedback of the system to them such as displays of error messages and steps to fix a problem within the system, and how the information within it is easy to comprehend and supervises the completion of the task. This is question number seven (7) to twelve (12).

Interface quality is assessed by the users by looking at the level of meeting their needs based on the system's features or capabilities. These are question number thirteen (13) to sixteen (16).

The last part is the overall usability of the system is evaluated by the users by asking them to describe their overall subjective reaction to using the system.

The PSSUQ was given to each respondent during the actual demonstration for their individual evaluation. The researchers had explained the purpose of the study and respondents were requested to be objective with their answers.

III. RESULTS

Technical Features of the System

The first objective of the study was to design and develop a Hospital Queuing System with Smart Kiosk. The researcher was able to determine the appropriate design for outline usability of the study.

Login Page for Administrator and Staff. This page is where the Administrator and Staff gain access to the system it will grant them to access to the main page. This initial login step is crucial for securing the system and ensuring that only authorized personnel can access sensitive information and administrative functions.

Queue Display Page that manages the patient's waiting experience. When the service is ready to serve new patient, the staff can control the order number to be presented on screen, notifying the patients for their turn. By presenting real-time updates, the system helps streamline patient flow and reduces uncertainty and wait times in the service area. This functionality ensures that patients are informed promptly and can be ready when their turn arrives, enhancing the overall efficiency of the service process.

Queuing Page where the staffs can manage the queuing of Consultation. User able to view the basic information and complaint of the patient, recall, next que, stop que and able to see pending number of patients waiting. This

functionality enables efficient management of patient flow and ensures that staff are well-informed about each patient's status and needs.

Transaction Page where the user is able to select between Laboratory and Consultation on the system according to what service they need. The system is able to predict what kind of consultation they need; it depends on what they select on the list of chief complaints. This feature helps streamline the process by directing users to the appropriate service and ensuring that their specific needs are efficiently addressed.

Generated Queue Number of Patient, the sample generated queued number of the patients from the system. After reviewing all entered information, it will automatically be printed. The queuing receipt contains the type of service, queued number and the current date and time. This receipt includes crucial details such as the type of service requested, the queued number assigned to the patient, and the current date and time. This automated process ensures accuracy and efficiency in managing patient queues and provides them with clear information about their status and expected wait times.

Functionality of Technical Features of the System

The second objective of the study was to test the functionality of the system based on its technical features using a test case.

The test case results of the Hospital Queuing System with Smart Kiosk among end-users and IT experts in terms of system usefulness, information quality, interface quality and overall satisfaction using the parameters of PSSUQ-3.

Table 4. Summary of the test results on the Functionality of System

No.	Features	Results	Remarks
1	Dynamic queuing number display on screen and kiosk	100%	Passed
2	Serving time extension	100%	Passed
3	Concern prediction using decision-tree classification	100%	Passed

Table 4 shows the summary of the functionality testing which indicates that all features and functions, are based on the responses of the expert which indicated that the system passed all functionality test. All features are working based on the test cases conducted on the system which can be seen in Appendix A and B. This comprehensive testing process ensures the reliability and effectiveness of the system in delivering its intended functionalities.

Usability of the System

The third objective of the study is to evaluate the usability of the developed system in terms of system usefulness, information quality, interface quality, and overall usability. The results of the usability of the developed system are shown in tables 6 to 10 using the 3rd version of the PSSUQ. The questionnaire uses the 7-Likert Scale with 1 interpreted as very highly acceptable and 7 as highly not acceptable. Thus, it means that a mean score closer to one indicates a higher level of acceptableness as compared to mean scores close to 7.

Table 5. PSSUQ-3 Norms (means and 99% Confidence Interval

	PSSUQ (Current)			*PSSUQ (Original)*			*CSUQ (Original)*		
Item	*Lower Limit*	*Mean*	*Upper Limit*	*Lower Limit*	*Mean*	*Upper Limit*	*Lower Limit*	*Mean*	*Upper Limit*
Q1	2.60	**2.85**	3.09	3.36	**4.00**	4.64	3.12	**3.30**	3.48
Q2	2.45	**2.69**	2.93	3.40	**4.02**	4.64	3.36	**3.54**	3.72
Q3	2.58	**2.85**	3.11	3.07	**3.73**	4.40	2.73	**2.91**	3.09
Q4	2.86	**3.16**	3.45	3.53	**4.15**	4.76	3.09	**3.27**	3.45
Q5	2.79	**3.06**	3.34	3.37	**3.98**	4.59	3.05	**3.23**	3.41
Q6	2.40	**2.66**	2.91	2.75	**3.41**	4.07	2.77	**2.95**	3.13
Q7	2.07	**2.27**	2.48	2.92	**3.57**	4.22	3.61	**3.82**	4.03
Q8	2.54	**2.86**	3.17	na	**na**	na	3.40	**3.61**	3.82
Q9	3.36	**3.70**	4.05	4.38	**4.93**	5.48	4.58	**4.79**	5.00
Q10	2.93	**3.21**	3.49	3.64	**4.18**	4.73	3.82	**4.03**	4.24
Q11	2.65	**2.96**	3.27	3.87	**4.48**	5.09	3.94	**4.15**	4.36
Q12	2.79	**3.09**	3.38	3.42	**4.02**	4.63	4.11	**4.32**	4.53
Q13	2.37	**2.61**	2.86	3.15	**3.79**	4.43	3.95	**4.13**	4.31
Q14	2.46	**2.74**	3.01	2.81	**3.43**	4.04	3.70	**3.88**	4.06
Q15	2.41	**2.66**	2.92	3.02	**3.55**	4.08	3.43	**3.61**	3.79
Q16	2.06	**2.28**	2.49	2.32	**2.91**	3.51	3.01	**3.19**	3.37
Q17	2.18	**2.42**	2.66	2.37	**2.92**	3.47	3.02	**3.20**	3.38
Q18	2.51	**2.79**	3.07	2.44	**3.00**	3.56	3.47	**3.68**	3.89
Q19	2.55	**2.82**	3.09	3.10	**3.69**	4.29	3.13	**3.31**	3.49
SysUse	2.57	**2.80**	3.02	3.26	**3.81**	4.36	3.19	**3.34**	3.49
InfoQual	2.79	**3.02**	3.24	3.58	**4.06**	4.54	3.95	**4.13**	4.31
IntQual	2.28	**2.49**	2.71	2.42	**2.93**	3.43	3.17	**3.35**	3.53
Overall	2.62	**2.82**	3.02	3.30	**3.76**	4.22	3.43	**3.61**	3.79

Table 5 shows the PSSUQ Norm. The PSSUQ Norm is a PSSUQ Mean score database that is collated from other systems. The standard provides a comparison reference to the System being studied if their product is comparable or better than the rest (with a 99 percent confidence interval). To conform to the industry requirements, the mean achieved by the System should be within the specified mean ranges in PSSUQ Norm.

Table 6. PSSUQ Evaluation Results

Criteria	Average (Mean)
1. Overall, I am satisfied with how easy it is to use this system	1.10
2. It was simple to use this system.	1.20
3. I was able to complete the tasks and scenarios quickly using this system.	1.20
4. I felt comfortable using this system.	1.25
5. It was easy to learn to use this system.	1.30
6. I believe I could become productive quickly using this system.	1.20
7. The System gave error messages that clearly told me how to fix problems.	1.55
8. Whenever I made a mistake using the system, I could recover easily and quickly.	1.60
9. The information (such as online help, on-screen messages, and other documentation) provided with this system was clear.	1.45
10. It was easy to find the information I needed	1.40
11. The information was effective in helping me complete the tasks and scenarios.	1.25
12. The organization of information on the system screens was.	1.40
13. The interface of this system was pleasant.	1.25
14. I liked using the interface of this system.	1.30
15. This System has all the functions and capabilities I expect it to have.	1.50
16. Overall, I am satisfied with this system.	1.10
Overall Mean	1.32

Table 6 shows the results of the survey from the respondents. After computing the mean of the different subscales, the strength of deviation of whether the system is within the accepted standard was then normalized to the PSSUQ Norm showed in Table 5.

Table 7. System Usefulness of the System

Criteria	Average (Mean)
Overall, I am satisfied with how easy it is to use this system	1.10
It was simple to use this system.	1.20
I was able to complete the tasks and scenarios quickly using this system.	1.20
I felt comfortable using this system.	1.25
It was easy to learn to use this system.	1.30
I believe I could become productive quickly using this system.	1.20
System Usefulness (SysUse)	1.21

Table 7 shows the summary of responses from items 1 to 6 of the usability questionnaire. These items were the basis for identifying the System Usefulness (SYSUSE). Item 1 achieved the highest perceived mean indicating that most of the respondents are overall satisfied with how easy it is to use the system.Based on the means from items 1 to 6, the System Usefulness of the Hospital Queuing System with Smart Kiosk is 1.21. Comparing this value to the PSSUQ Norm, the developed system is within the required industry standard of 2.80 indicating that the quality of the system bears the ability to satisfy stated or implied needs.

Table 8. Information Quality of the System

Criteria	Average (Mean)
The System gave error messages that clearly told me how to fix problems.	1.55
Whenever I made a mistake using the system, I could recover easily and quickly.	1.60
The information (such as online help, on-screen messages, and other documentation) provided with this system was clear.	1.45
It was easy to find the information I needed	1.40
The information was effective in helping me complete the tasks and scenarios.	1.25
The organization of information on the system screens was clear.	1.40
Information Quality (InfoQual)	1.44

Table 8 shows the summary of responses from items 7 to 12 of the usability questionnaire. These items were the basis for identifying the Information Quality (INFOQUAL). Item 11 achieved the highest perceived mean score indicating that the information was effective in helping me complete the tasks and scenarios. Based on the mean score from items 7 to 12, the Information Quality of the Hospital Queuing System with Smart Kiosk is 1.44. Comparing this value to the PSSUQ Norm, the developed system is within the required industry standard of 3.02 indicating that the quality of the system bears the ability to satisfy stated or implied needs.

Table 9. Interface Quality of the System

Criteria	Average (Mean)
The interface of this system was pleasant.	1.25
I liked using the interface of this system.	1.30
This System has all the functions and capabilities I expect it to have.	1.50
Overall, I am satisfied with this system.	1.10
Interface Quality (IntQual)	1.29

Table 9 shows the summary of responses from items 13 to 16 of the usability questionnaire. These items were the basis for identifying the Interface Quality (INTERQUAL). Item 16 achieved the highest mean score indicating that most of the respondents overall satisfied with the system.
Based on the mean score from items 13 to 16, the Hospital Queuing System with Smart Kiosk is 1.29. Comparing this value to the PSSUQ Norm, the developed system is within the required industry standard of 2.49 indicating that the quality of the system bears the ability to satisfy the stated or implied needs.

Table 10. Subscale of the Usability of the System

Subscales	Criteria Covered in PSSUQ-3	Average (Mean)	Interpretation
System Usefulness	Items 1 to 6	1.21	Very Highly Acceptable
Information Quality	Items 7 to 12	1.44	Very Highly Acceptable
Interface Quality	Items 13 to 16	1.29	Very Highly Acceptable

System Overall Usability	All Items	1.32	Very Highly Acceptable

Table 10 displays the level of usability of the system as grouped according to its subscales: system usefulness, information quality, interface quality, and overall usability. The developed system has resulted with System Usefulness from items number 1 to 6 a result of 1.21, 1.44 for items 7 to 12 for Information Quality, and 1.29 for items 13 to 16 for Interface Quality, and System Overall Usability measured from all of the item numbers 1 to 16 have a result of 1.32. These are all interpreted as very highly acceptable.

The Overall Usability of the System obtained a mean score of 1.32 which interpreted that the respondents are very highly acceptable, that they are all satisfied with all the features of the system and that it has the capacity to meet the stated or implied requirements.The PSSUQ results serve as the basis of the acceptability of the system.
The PSSUQ results serve as the foundation for the acceptability of the system, and the overall usability of the system received a mean score of 1.32, interpreted that the respondents are very highly acceptable that they are all satisfied with all of the features of the Hospital Queuing System with Smart Kiosk and that it has the capacity to meet the stated or implied requirements.

The following are the findings of the study:

1. The Hospital Queuing System with Smart Kiosk was developed with following technical features: dynamic queuing number display on screen and kiosk; serving time extension; and; concern prediction using decision-tree classification.

2. The functionality of the Hospital Queuing System with Smart Kiosk based on the technical features was tested using test cases and is functional according to the technical features and helpful to the end users.

3. The level of usability of the system was evaluated the mean score of 1.32 implies that they are all satisfied with all the system's features and that it can meet the stated or implied requirements in terms of; System Usefulness, Information Quality, Interface Quality, and Overall Usability.

4. The User Manual for Hospital Queuing System with Smart Kiosk was developed as the output of the study and consists of a step-by-step procedure of the system

IV. CONCLUSIONS

In assessment of the preceding findings, the following conclusions are made:

1. The Hospital Queuing System with Smart Kiosk has distinct technical features which allow the following: dynamic queuing number display on screen and kiosk which can control the order number to be presented on screen; serving time extension which is the time required to serve a patient; and concern prediction using decision-tree classification in which the system can able to predict what service the patient need according to their complaint.

2. Using a test case, the Hospital Queuing System with Smart Kiosk is 100% pass, and it is functional and operational.

3. The Hospital Queuing System with Smart Kiosk has high usability index and is acceptable in terms of usability, including system usefulness, information quality, interface quality, and overall usability.

4. The Hospital Queuing System with Smart Kiosk user manual was developed to provide assistance and guidance related to the usage of the software system.

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