Development and Analysis of a Web-Based Management Information System for Dental Practices to Improve Healthcare Services

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KEYWORDS

Electronic Medical Record, Management Information System, Dental Practice, Website, healthcare services

ABSTRACT

Introduction: A website-based management information system is needed in dental practices as a public service center that is required to work quickly, precisely, and accurately. The performance of dental practices becomes more optimal with a computerized management information system.

Objectives: This study aimed to develop and analyze a web-based management information system for dental practices to improve healthcare services in Indonesia.

Methods: This is an action research design conducted at an independent dental practice in Kudus, Indonesia. The research utilized the waterfall method, which started with requirements analysis, design, implementation, testing, and deployment, as well as maintenance. The analysis was carried out using two methods: Black-Box Testing and User Acceptance Testing (UAT). The UAT percentage results were categorized into 5 sections: 0%-20% very unsatisfied, 21%-40% unsatisfied, 41%-60% neutral, 61%-80% satisfied, and 81%-100% very satisfied.

Results: Testing used the Black-Box Testing method on 17 menus, with results meeting the expected specifications and no errors detected during the testing. The User Acceptance Testing (UAT) indicated a 96% approval rate, which signified an excellent rating in users' assessment of the developed system.

Conclusions: Based on the results of the study, a web-based electronic dental practice management information system was proposed to meet the needs of dentists.

1. Introduction

Technological advancements in the current era of globalization are progressing at an extraordinary pace, particularly in the realm of information technology, which plays a crucial role in data processing [1]. The evolution of technology is often driven by various needs and demands from different aspects of human life, including the healthcare sector, where it is utilized to enhance the quality of healthcare services [2]. In healthcare, delivering patient services is paramount in meeting management requirements, especially in managing patient data [3]. The activities involved in processing data for patients seeking treatment from a dentist encompass several stages, from registration and recording medical histories to diagnosis and payment transactions, making precision and accuracy at each step critically important [4].

An information system is highly essential and crucial for dental practices as a public service center that needs to operate swiftly, accurately, and precisely. This aligns with the growth of dental practices and the simultaneous increase in the number of patients, which can lead to various service-related issues, such as reduced work efficiency in terms of time and effort [5]. The necessity of recording patient medical records can be effectively managed using a management information system. According to the Minister of Health Regulation Number 269/MENKES/PER/III/2008, medical records are categorized into two types: conventional medical records and electronic medical records [6]. Electronic medical records employ information technology to manage patient data through computerized systems [7]. As per the Minister of Health Regulation Number 24 of 2022, Article 3, Paragraph 1, Every Health Service

Facility is required to maintain Electronic Medical Records [8]. Consequently, having access to appropriate health record systems can assist medical professionals in identifying patients at risk of being underdiagnosed [9].

Based on this background, it is crucial to develop a system that leverages technological advancements to simplify the management and retrieval of patient data. Thus, researchers are keen to investigate the analysis and design of management information systems for web-based dental practices.

2. Methodology

This research involves research and development with an action research design conducted at an independent dental practice in Kudus, Indonesia. The research follows the waterfall methodology, which includes steps such as needs analysis, design planning, implementation, testing, application, and maintenance. Data collection and needs analysis were conducted through literature reviews and interviews with four key stakeholders: the practice owner, the attending dentist, a nurse, and administrative staff. These stakeholders provided insights into the requirements for a management information system in the independent practice. Subsequently, software design was created based on the needs analysis results.

The trial phase for the management information system involved a selected user logging in to the system, ensuring that the login process was smooth and error-free. Implementing the designed system is critical to ensure it is fully functional and ready for practical use. A properly prepared design, adhering to procedures, makes system utilization more efficient and aligns with user needs. Usability testing can determine the system's effectiveness, efficiency, and user satisfaction.

The evaluation stage assesses whether the system operates correctly, using Black-Box Testing and User Acceptance Testing (UAT). Black-Box Testing ensures that the software functions as intended by running all application features to verify their outcomes meet expectations [10]. UAT, conducted at the final testing stage, validates that the system meets user expectations and requirements. This involved a questionnaire with four respondents from the dental practice, using a Likert scale where responses ranged from 1 (strongly disagree) to 5 (strongly agree). The UAT results were categorized into five satisfaction levels: 0%-20% very dissatisfied, 21%-40% dissatisfied, 41%-60% neutral, 61%-80% satisfied, and 81%-100% very satisfied.

3. Results and Discussion

Observations were conducted at the Pradila Dental Studio, an independent clinic, focusing on the administrative procedures for recording medical records. These records were documented in three formats: on a medical record sheet form, in a book, and on Google Sheets or spreadsheets. The clinic's income and expenditure data were recorded manually in both books and Google Sheets, while the pricing for treatments was printed to facilitate the payment process for staff. Interviews were conducted by asking various questions regarding the desired system features. Below is the interface design, which is a crucial aspect of application design as it pertains to the appearance and user interaction with the application. The application’s interface design is as follows:

Table 1. Menu List of the Dental Electronic Medical Record

Menu list	Sub Menu	Information	Actor
Login		Enter *username* and *password*	Super admin, admin, doctor, nurse
HR Management	Doctor	Enter name, address, SIP, *cellphone number* , photo	Super admin
	Nurse	Enter name, address, *cellphone number* , photo	Super admin
	User	*Users* who can access the management information system are 2 *users* , namely super admin and admin	Super admin
Patient Management	Patient	Enter the medical record number, name, gender, address, place of birth, photo before the procedure and photo after the procedure	Super admin, admin, doctor, nurse

	Medical records	Enter the date of visit, patient name, complaint, objective examination, supporting examination, diagnosis, action, information, current control, next control, costs, treating doctor and assistant, photos before and after treatment	Super admin, admin, doctor, nurse
	Diagnosis	Enter diagnosis and information	Admin, doctor, nurse
	Maintenance	Input maintenance actions and information	Admin, doctor, nurse
Financial management	price list	Enter the type of treatment and price of treatment	Super admin
	Employee Incentives	Enter the employee's name, working hours and employee salary	Super admin
	Income	Enter the date, type of income, amount and information	Super admin
	Expenditure	Enter the date, type of expenditure, amount and description	Super admin
Drug Management and Logistics	Drug	Enter the name of the drug, amount of drug and information	Super admin
	Tool	Enter the name of the tool, number of tools and description	Super admin
	Material	Enter the name of the ingredient, quantity of ingredient and description	Super admin
Log out		To exit the information system	Super admin, admin, doctor, nurse

Source: Author

To access the electronic medical record information system at Pradila Dental Studio, users must download and activate XAMPP, which connects to the website at localhost/e-dentalmedicalrecord1/. This process displays the medical record information system interface, along with the initial program screen. Below is a depiction of the resulting system interface:

Figure 1. Login Page Display of the Dental Electronic Medical Record

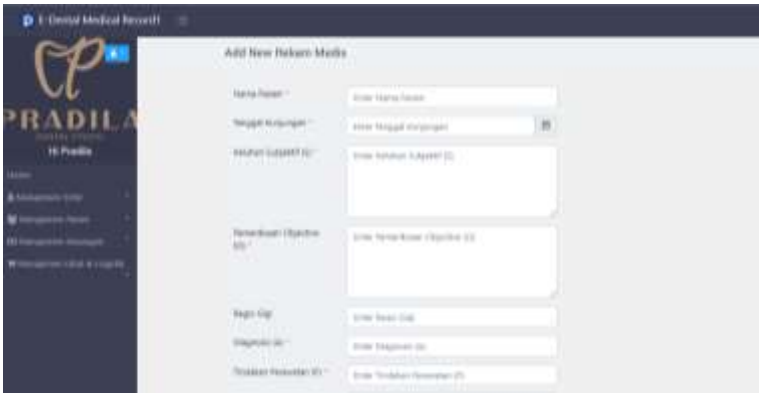

Figure 2. Input Data for the Dental Electronic Medical Record

Evaluation is carried out using the Black-Box Testing and User Acceptance Testing (UAT) methods to find out whether the system is running well or not. The first test uses the black-box method by checking input and output to see the suitability of system functions in relation to user needs.

Table 2. Black-Box Testing Results

	ch Steps	**or**	**Status**
***Login* Page**	Enter the registered *username* and *password*	Displays the menu page	/
View Menu	Select a menu, and click on each desired submenu	Displays according to menu selection	/
Doctor Menu	Enter the doctor menu and enter the doctor's data	Displays doctor data	/
Nurse Menu	Enter the nurse menu and input nurse data	Displays assistant data	/
User Menu	Enter the system user menu	Displays user data	/
Patient Menu	Enter the patient registration menu and enter patient data	Displays patient data	/
Medical Records Menu	Enter the medical record menu and input medical record data	Displays medical record data	/
Diagnostic Menu	Enter the diagnosis menu and input diagnosis data	Displays diagnosis data	/
Maintenance Menu	Enter the maintenance menu and input maintenance data	Displays action data	/
Price List Menu	Enter the price list menu and enter price data	Displays price data	/
Employee Incentive Menu	Enter the employee incentives menu and enter employee incentive data	Displays employee incentive data	/
Input Menu	Enter the income menu and input income data	Displays income data	/
Production Menu	Enter the expenditure menu and input expenditure data	Displays expenditure data	/
Medication Menu	Enter the drug menu and enter drug data	Displays drug data	/
Tools Menu	Enter the tool menu and input tool data	Displays tool data	/
Ingredients Menu	Enter the ingredients menu and input ingredient data	Displays material data	/
***Log out* menu**	Check the exit process from the system	Exit the system	/

Source : Author

The second test using User Acceptance Testing (UAT) was carried out by respondents consisting of administrative officers, dental nurses and dentists who served at the dentist's independent practice.

Tabel 3. User Acceptance Testing (UAT) Respondent Results

No	**Question**	**SA**	**A**	**N**	**D**	**SD**
1	Is the layout and appearance of the management information system easy to understand?	3	1	0	0	0
2	Is the management information system easy to use (user friendly)?	3	1	0	0	0
3	Does this management information system meet all previously determined functional requirements?	4	0	0	0	0

4	Does this management information system provide convenience as an operational system?	3	1	0	0	0
5	Does this management information system run smoothly and stably when used?	3	1	0	0	0
Total Score		16	4	0	0	0

Source: Author

Tabel 4. Score Calculation

Score	Frequency	Total
1	0	0
2	0	0
3	0	0
4	4	16
5	16	80
Total Score		96

Source: Author

Based on the calculation results that the highest value is 100, the presentation is carried out using the following formula:

$$\textbf{UAT Precentage} = \frac{\textbf{Total Score}}{\textbf{Highest Score}} \times \textbf{100\%}$$

$$= \frac{96}{100} \times 100\%$$

$$= 96\%$$

The research explores the development of a web-based management information system utilizing PHP and MySQL to enhance operational efficiency at Pradila Dental Studio, an independent clinic that formerly relied on manual record-keeping through books and paper. This system aims to resolve issues related to manual record-keeping such as data loss, inaccuracies, and inefficiencies in administrative processes. Additionally, it aims to comply with government regulations regarding electronic medical records, as stipulated in Permenkes No. 24 of 2022 and Permenkes No. 269 of 2008, which mandate that all healthcare facilities must implement electronic medical records[11].

The implementation of this web-based management information system offers significant benefits. First, it enhances patient safety by reducing the risk of duplicate examinations and ensuring continuity of care. With the computerized system, patient medical data can be accessed quickly and easily, facilitating healthcare professionals in providing appropriate and timely care to patients. Additionally, the system supports efficient service planning, reduces patient wait times, and improves coordination among healthcare providers, thereby enabling better and more coordinated healthcare delivery[12], [13].

Another significant advantage of the system is the increased efficiency in managing patient data and clinic operations. Administrative staff no longer need to engage in time-consuming and error-prone manual record-keeping, as all data can be recorded and managed electronically. The system simplifies the creation of reports, retrieval of patient data, and management of medical histories, all of which can be done quickly and accurately. Consequently, the system not only enhances work efficiency but also provides ease in managing data and information within the clinic[14], [15].

The system's development process began with identifying user needs through observations and interviews with the clinic owner and staff. The collected data were used to design a system that meets the clinic's specific needs and specifications. Key features developed include patient identity recording, logging of examination results, management of equipment and material stocks, and

recording of clinic income and expenses. Based on user feedback, improvements and additional features were made, such as the inclusion of tooth region data, medication prescriptions, insurance status, and employee incentive recording. These features are designed to facilitate administrative processes and ensure that all critical data can be accessed quickly and easily[16], [17].

The system was rigorously tested using black-box testing and User Acceptance Testing (UAT). Black-box testing, which focuses on testing the system's functionality without considering its internal structure, confirmed that all 17 menus in the system operated according to expected specifications, with a 100% success rate and no bugs detected. User Acceptance Testing, which involved four respondents, assessed user satisfaction with the system. The results showed that three out of four respondents strongly agreed that the layout and interface of the Pradila Dental Studio information system website were easy to understand and use, that the system operated smoothly, and that it provided convenience as an operational tool. All respondents strongly agreed that the system met all the pre-determined functional requirements. The UAT results revealed a satisfaction rate of 96%, indicating that the users were generally very satisfied with the system. However, some deficiencies were noted, such as the lack of a total sum in the income and expenditure menu and a restriction on photo file size during user registration, which needs to be increased from 3MB to 5MB[18], [19].

The overall results from the UAT provide an overview of the feasibility of this web-based management information system in meeting user needs and its acceptance by users. The test outcomes suggest that the system is ready for implementation and that it supports the enhancement of effectiveness, productivity, and efficiency in healthcare services, which is currently a focus of government attention. The findings of this research align with those of Mochammad Choirur Roziqin in 2022, who studied a Web-Based Medical Record System and found that such systems make processes easier and allow for automatic recording and reporting. They also correspond with Dewi Lestari's 2019 research on the Analysis and Design of Dental Clinic Service System Applications, which concluded that a good management information system simplifies service processes and enhances the time efficiency and accuracy of record-keeping in dental clinic services[20], [21].

However, the research does have limitations. Additionally, the study involved only four respondents and was limited to Pradila Dental Studio, making it insufficient to comprehensively represent the broader potential user base or fully depict the actual situation. Further research with a larger sample size and broader scope is necessary to gain a more comprehensive understanding of the system's effectiveness and acceptance

4. Conclusion and future scope

This research has produced a computerized management information system whose design is in accordance with user needs. Produced several menus including HR management, patient management, financial management, as well as drug and logistics management which have been implemented and evaluated involving testing using the black box testing method for 17 menus with specification results as expected and no errors detected during testing. User acceptance testing (UAT) shows an approval level of 96%, which indicates a very good category in user assessment of the system being built. Thus, the development of this system is expected to make a significant contribution in improving service quality, improving medical data management and helping improve the performance of Pradila Dental Studio staff.

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Author contributions

All the authors have contributed equally to the conception and design of the study, drafting the article or revising it, and approving the version to be submitted

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