

# Innovate, Automate, Elevate: Web-Based Solutions for Business Process Enhancement in Clinic Appointment System

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## Abstract

In an era defined by technological innovation, this study presenting a comprehensive exploration of design principles and functionalities that govern the development of clinic appointment management through the lens of cutting-edge web-based architecture. The research encompasses the entire developmental spectrum, addressing key components such as system architecture, user interface design, functionality and database integration, elucidating how these components synergize to streamline business processes. Real-world case studies and practical implementations are examined to illustrate the adaptability and effectiveness of the proposed system, showcasing its capacity to revolutionize scheduling processes, reduce wait times, and enhance overall patient satisfaction. Experts analysed the system to validate its design and functionality. User evaluation also been conducted using System Usability Scale (SUS) and the result is 72.5 which indicate the system is good. This study incorporates to the growing body of knowledge in healthcare informatics by providing insights into the strategic fusion of technology and business processes, providing valuable guidance for healthcare administrators, practitioners, and technology developers looking to leverage web-based solutions for improved clinic management.

## 1. Introduction

The critical role of Business Process Improvement (BPI) in organizations is underlining its significance in enhancing efficiency, productivity, and overall performance. Kovach et al. (2023) support this assertion, suggesting that BPI contributes to streamlining operations, reducing costs, and improving customer satisfaction, which are paramount for organizational success. In response to the evolving needs of modern dental healthcare management, this paper delves into the comprehensive development and testing phases of the Dental Clinic Appointment System (DCAS). The DCAS stands as a pivotal advancement in dental care administration, providing a web-based solution aimed at streamlining and improve the appointment process. This system is designed to enhance efficiency by facilitating online booking capabilities, ultimately saving valuable time through its intuitive website functionality.

This paper offers a detailed exploration of the DCAS, shedding light on its core features such as queue scheduling and appointment notifications. Emphasis will be placed on elucidating the user-centric flow of the DCAS, catering to the distinct roles of doctors, patients, nurses, and administrators. Through a systematic analysis, we will unveil the diverse tasks these users can seamlessly execute with the aid of the DCAS, highlighting its significance in optimizing the overall dental care experience. The development and implementation of the DCAS exemplify a proactive approach to business process improvement in the context of dental healthcare administration. Further discussion of this study covers related works, system development, system testing, discussion and conclusion.

## 2. Related Works

According to the case study that we investigated, the current manual business process for dental appointment systems involves clinic management organizing appointments based on treatment type, duration, and convenient dates and times (Mahmod, 2023). The process includes sending confirmation letters and reminder notes to patients, with the option to reinstate cancelled slots on the day of the appointment. The clinic relies on reminders to gauge continued interest or the need for rescheduling. Due to manual handling, issues have arisen, such as nurses struggling to make calls during busy periods, difficulties reaching patients, and inaccuracies in appointment information. Delays in the process could adversely affect the clinic's reputation and customer satisfaction, potentially impacting client numbers.

Previous research has highlighted the inefficiency of paper-based documentation in current settings, as demonstrated by Wulandari et al. (2021). The necessity for document preservation and the manual registration process for children necessitates significant effort from parents, resulting in time-consuming procedures. Weber et al. (2005) emphasise the time-consuming nature of paper-based systems versus computer-assisted methods. Human errors in data entry, as noted by Barchard & Pace (2011), might jeopardise data accuracy, making the recorded data less valuable. Weber et al. (2005) highlight the potential for wrong data entry by identifying four problems in paper-based data recording, including incorrect data entry. Cai & Zhu (2015) also emphasise data inconsistency as a result of data alterations. The overall discussion underscores the drawbacks of paper-based documentation and the advantages of transitioning to computer-assisted systems for enhanced efficiency and accuracy in data management.

Business Process Improvement (BPI) is a strategic method used by management to improve the efficiency and effectiveness of current business processes. Processology (2023) defines the BPI technique as a systematic sequence of processes that includes identifying, mapping, documenting, evaluating, and redesigning the targeted business process. This comprehensive approach ensures a thorough awareness of the current condition of the process and makes it easier to identify opportunities for improvement. By aligning with BPI principles, the DCAS represents a forward-looking solution designed to enhance efficiency, streamline operations, and improve the overall patient experience. Its web-based nature, focus on online booking, and emphasis on user-friendly functionality collectively contribute to its role as a pivotal advancement in dental care administration. The next section deliberates on the DCAS development processes.

## 3. System Development

The system development methodology used to develop DCAS is an adapted waterfall model from Royce (2021) with focus on four phases: requirement analysis, design, implementation, and testing as shown in Fig. 1. Waterfall is suitable for projects with stable and well-understood requirements, where changes are unlikely to occur during the development process (Pargaonkar, 2023). In this section, we will explain in detail each of the phases involve to develop DCAS.

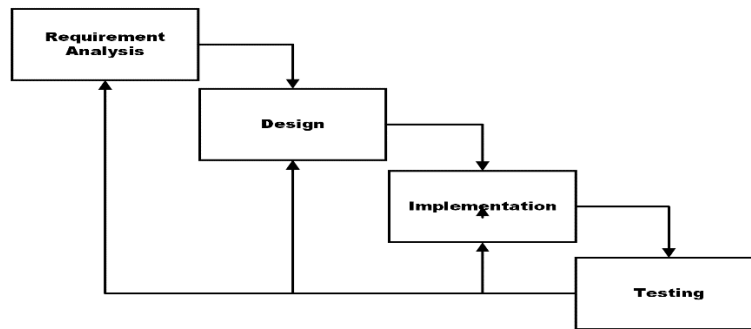


Fig. 1 Adapted waterfall model

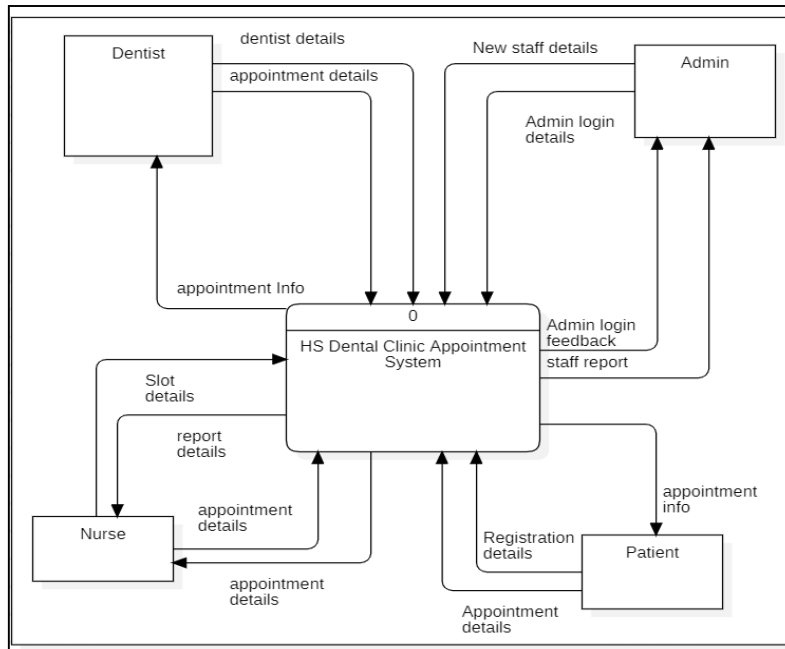
The requirement analysis process involves gathering and establishing project requirements, as well as understanding what the system is supposed to do and what functionality are required. In this study we used Lean Canvas Model to eliminate even more pointless data and time-consuming processes. Fig. 2 shows illustrates the DCAS lean canvas model that detail the information related to clinic appointment process for finding the gap. The Lean Canvas model provides a concise and visual framework for startups to outline their business ideas, making it easier to communicate and iterate on their value proposition (Razabillah et al., 2023).

<b>PROBLEM</b> <ul style="list-style-type: none"> <li>There is no online system that specifically dedicated for patient to use to make appointment process easier.</li> <li>May have high probability to make mistakes when key in data information and inconsistency or redundancy of data because of manual appointment process.</li> <li>There is no structure booking process.</li> </ul>	<b>SOLUTION</b> <ul style="list-style-type: none"> <li>Provide an online platform which is an appointment system where it can be booking appointment anytime and anywhere and 24 hours.</li> <li>Next, can save time, cost, mistake data can be avoided.</li> <li>Develop a system that provide data accuracy and systematic process.</li> </ul>	<b>UNIQUE VALUE PROPOSITTON</b> <ul style="list-style-type: none"> <li>Improve performance</li> <li>Simplify patient consent to transfer.</li> <li>Reduce lead time that required for transfer record.</li> <li>Fast delivery of appointment process faster and systematic.</li> <li>View the range of treatment cost.</li> <li>Simple appointment process.</li> </ul>	<b>UNFAIR ADVANTAGE</b> <ul style="list-style-type: none"> <li>Specifically designed for appointment of services for Kinik Happy Smile</li> </ul>	<b>CUSTOMER SEGMENTS</b> <ul style="list-style-type: none"> <li>Dental clinic</li> <li>Plan to expand into other fields where transfer of medical record is required</li> <li>Budget Customers</li> <li>Happy patient for the booking appointment process.</li> <li>Public people find the best and getting fast appointment and not complicated process of booking an appointment.</li> <li>Nurse, doctor, patient</li> </ul>
	<b>KEY METRICS</b> <ul style="list-style-type: none"> <li>Monthly booking Appointment</li> <li>Remark/notification</li> <li>patient history record</li> </ul>		<b>CHANNEL</b> <ul style="list-style-type: none"> <li>Social Media – Facebook, Instagram and tiktok</li> <li>Official website</li> <li>Email</li> <li>Telephone</li> <li>Word of mouth</li> <li>Share posting to timeline</li> </ul>	
<b>COST STRUCTURE</b> <ul style="list-style-type: none"> <li>Sales and marketing</li> <li>Ongoing maintenance such as tools needed for the dental treatment</li> <li>Machineries</li> <li>Consumables</li> <li>Equipment</li> <li>Salaries</li> <li>Advertising</li> <li>Developers</li> <li>Design system</li> <li>Hardware – Laptop</li> <li>Software - phpMyAdmin, Laragon</li> </ul>		<b>REVENUE STREAMS</b> <ul style="list-style-type: none"> <li>Appointment System</li> <li>Surgeries</li> <li>Treatments Services</li> <li>Consultations</li> <li>30 Day Free Trial @ RM25/per month</li> </ul>		

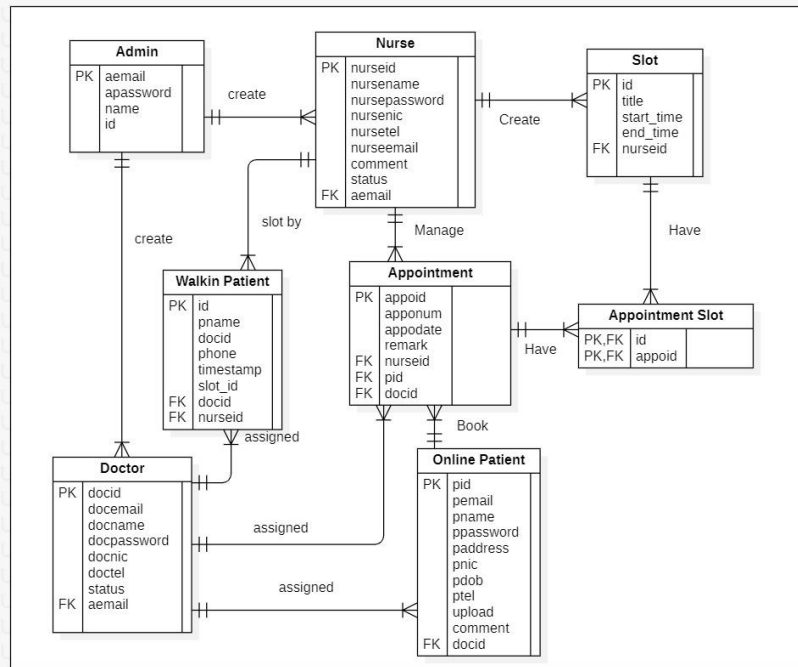
Fig. 2 Lean Canvas Model of DCAS

During the design phase, the system architecture involve database design and user interface are planned according to the requirements. It involves creating system specifications and determining how the components will function together. This system involves four entities: patient, dentist, nurse, and administrator, as illustrated in the Context Diagram (Fig. 3). The context diagram represents all external entities that may interact with the system. While to illustrate how different entities are related and how data is organized, we user Entity-Relationship Diagram (ERD) as in Fig. 4. This visual representation aids in the design, communication, and documentation of database systems. Schneiderman's Golden Rules (Shneiderman, 1987) were adapted for user interface design by incorporating five rules from system theory: strive for consistency, allow frequent users to use shortcuts, design dialogue to yield closure, provide simple error handling, and reduce short-term memory

load. It is critical that the user can quickly navigate and comprehend the website's simple design interface. These criteria assist designers construct intuitive, efficient, and user-friendly interfaces.



**Fig. 3: Context Diagram of DCAS**



**Fig. 4 Entity Relationship Diagram of DCAS**

The implementation phase is where the actual coding or development of the system takes place. The last phase entails testing to identify and correct any problems or faults, as well as ensuring that the system meets the required standards and functions effectively. DCAS was created to enable patients plan appointments and streamline the manual business process. This system has three types of users: patients, nurses, and dentists. Every user has a unique interface, and the system's functionality varies accordingly, as illustrated in Fig. 5, Fig. 6, and Fig. 7.

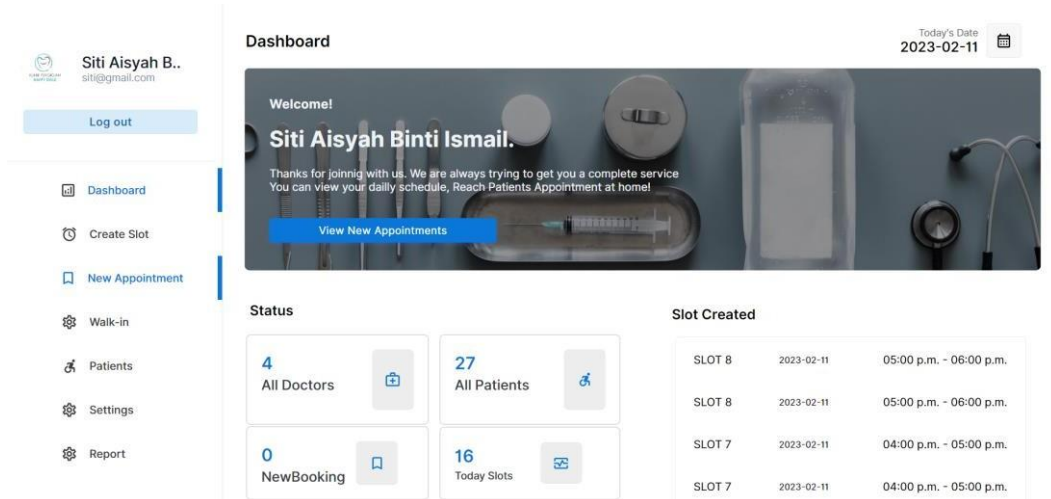


Fig. 5 Dashboard Interface for Nurse

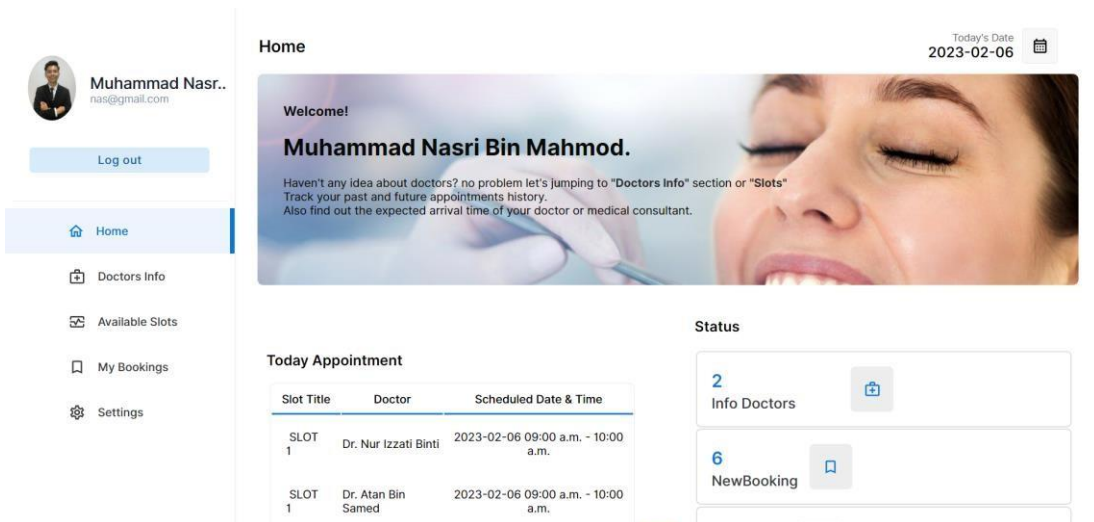


Fig. 6 Dashboard Interface for Patient

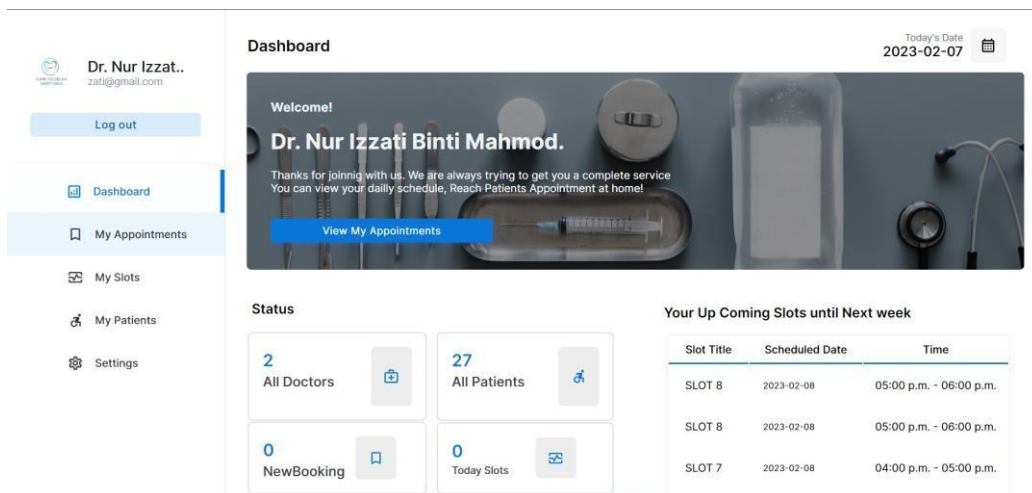


Fig. 7 Dashboard Interface for Dentist

#### 4. System Testing

The last phase in the Waterfall model is system testing, which aims to assess the entire system as a whole, with software functioning as only one part in a larger context. The goal is to ensure that all of the many components, modules, and subsystems collaborate smoothly to achieve the defined goals and objectives. Hamilton (2024) emphasised the importance of system testing in guaranteeing programme integration with the wider system. In this study, we applied functional testing and expert assessment testing to the system. Functional testing will ensure that each function in the system works properly and as intended by developers and testers who will go through the entire system in detail. Table 1 displays the sample of the patient module test plan, which included six modules.

**Table 1 Test Plan Result for Patient**

No	Task	Developer	Tester
		Date	Date
1	Make registration		
2	Login to the system		
3	Updated patient profile		
4	Book Slot Appointment		
5	View booking Appointment details		
6	Logout from the system		

Once the system had passed the functional testing stage, DCAS underwent expert assessment. Three software development experts were chosen to conduct the review based on the Shneiderman Golden Rules, perceived usefulness, satisfaction, consistency, ease of use and user interface. Table 2 depicts the expert testing results on the eight golden rules, while Table 3 provides the outcome of expert evaluation on perceived usefulness.

**Table 2 The Result of Expert Evaluation on Eight Golden Rules**

SECTION F: EIGHT GOLDEN RULES				
NO.	Description	Feedback		
		Expert 1	Expert 2	Expert 3
1	Does the system allow you to recover from input errors?	Yes	Yes	Yes
2	Do you think all the Golden Rules are being applied to the system? (refer guideline)	Yes	Yes	Yes
3	Overall, are you satisfied with implementation of Eight Golden Rules of Interface Design by Ben Shneiderman in the system? (refer guideline)	Yes	Yes	Yes
Suggestion				
<ul style="list-style-type: none"> <li>• Very Good</li> <li>• 6 golden rules have been implemented.</li> <li>• Can be improve with complex errors.</li> </ul>				

**Table 3 The Result of Expert Evaluation on Perceived Usefulness**

SECTION A: PERCIEVED USEFULNESS				
NO.	Description	Feedback		
		Expert 1	Expert 2	Expert 3
1	In your opinion, do you think the system enables you to complete your task more quickly?	Yes	Yes	Yes
2	Do you think the system helps the user to accomplish tasks in a better way?	Yes	Yes	Yes

3	Overall, do you think the system is useful to complete your task?	Yes	Yes	Yes
Suggestion/Comment				
<ul style="list-style-type: none"> <li>• Very Good with confirmation features.</li> <li>• The slot booking can be improved to prevent similar time slot booking for different doctors, unless there is reason for redundant bookings (Ex. Parent -1 slot, child - 1 slot on the same time with different doctors)</li> </ul>				

Next, we assessed system usefulness by conducting a survey. The survey items were adapted from Brooke (1996) System Usability Scale (SUS). Fig. 8 displays a sample of survey results, including a bar graph depicting users' confidence in utilising the DCAS. The percentage of respondents who strongly agree was 40.5%, while 51.4% agreed that the user is highly confident in utilising DCAS. Overall, DCAS received a 72.5 on the system usability scale during user evaluation. According to the standard guidelines for interpreting SUS scores, this system testing received a B range, which is considered good. The results of functional testing, expert evaluation, and questionnaires reveal that all functions are working well. The system will be refined and improved based on all of the expert opinions and suggestions.

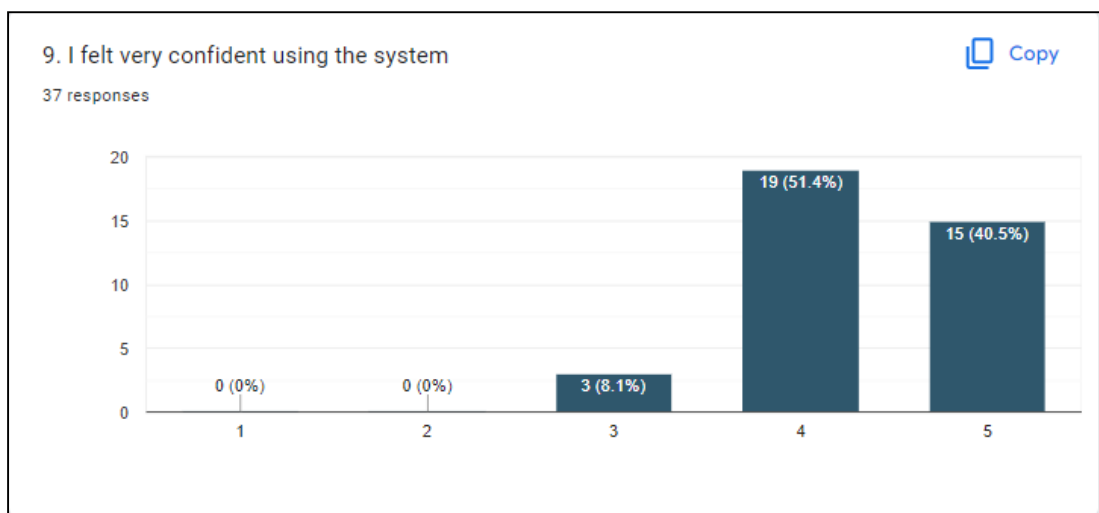
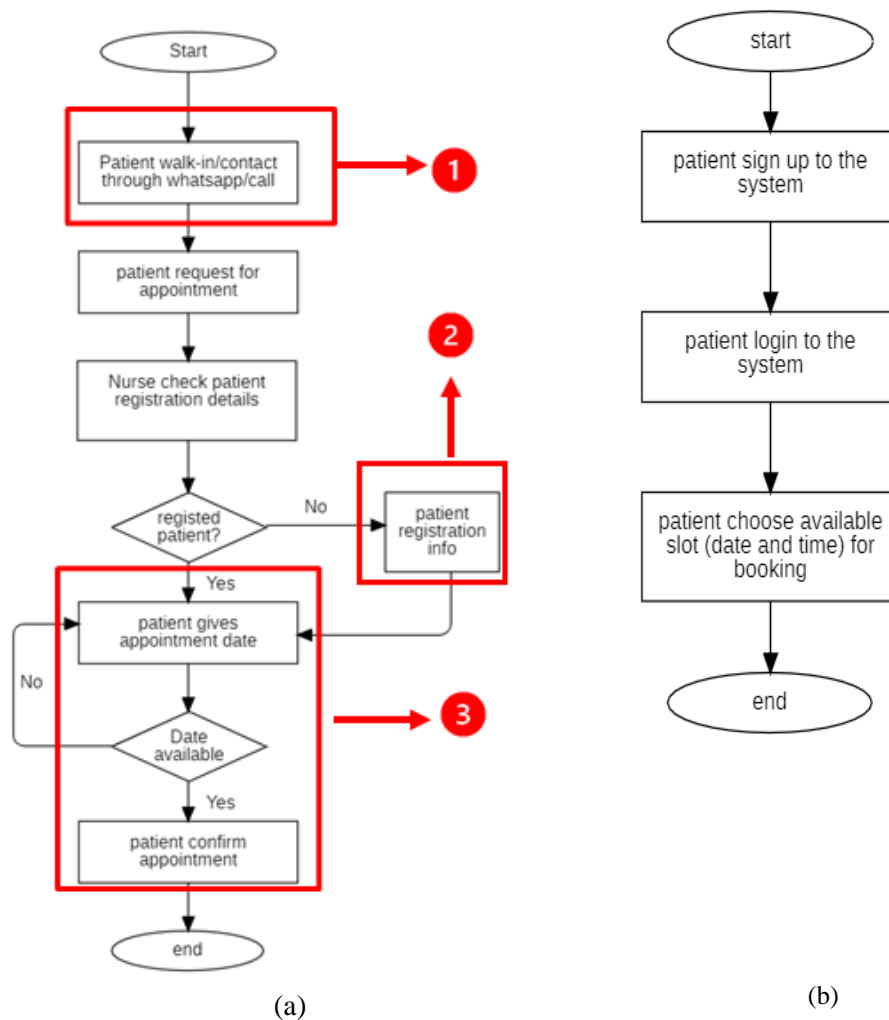


Fig. 8 Questionnaire Results from Number 9

## 5. Discussion and Conclusion

In response to the changing demands of contemporary dental healthcare management, this paper explores the extensive development and testing phases of the Dental Clinic Appointment System (DCAS). Serving as a crucial advancement in dental care administration, the DCAS offers a web-based solution focused on optimizing and enhancing the appointment process. Geared towards improving efficiency, the system facilitates online booking capabilities, ultimately saving valuable time through its user-friendly website functionality. Within the context of this discussion, the DCAS was conceived through the implementation of BPI strategies. The primary objective of DCAS is to tackle existing issues and inefficiencies in business operations.

The initial step in this process involves providing a detailed description of the current business process to comprehend its complexities and identify any shortcomings. Subsequently, a thorough investigation is conducted to uncover inefficiencies or bottlenecks that might hinder optimal performance. Adhering to BPI principles, the DCAS emerges as a forward-thinking solution striving to enhance efficiency, streamline operations, and elevate the overall patient experience. Its web-based nature, focus on online booking, and commitment to user-friendliness collectively establishes it as a pivotal milestone in dental care administration. Fig. 9 depicts the process improvement that has been accomplished using the DCAS System. The physical processes had been replaced by the system. However, there are several limitations to this system that can be improved, such as providing patients with advance notice of impending consultations or treatments and allowing customers to conduct online transactions through the system.



**Fig. 9 Comparison of DCAS's proposed business process (b) with its current business process (a)**

In conclusion, the significant implementation of business process improvement in the dental care appointment system not only enhances operational efficiency but also elevates the overall patient experience. By streamlining workflows, reducing waiting times, and optimizing resource allocation, the implementation of these improvements not only benefits the dental care providers but also contributes to a more seamless and patient-centric healthcare environment. Previous research by Guan et al., (2020) and Christina & Yasa (2021) also support the advantages of online booking system contributes to a more eco-friendly premise and give the positive effects on customer satisfaction, especially through improved registration and scheduling processes. Ultimately, the integration of effective business process improvements in the appointment system fosters a stronger foundation for sustainable growth, improved patient satisfaction, and better overall healthcare outcomes within the dental care sector.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Mahmod M.N, Mohamed H.; **data collection:** Mahmod M.N; **analysis and interpretation of results:** Mahmod M.N, Mohamed H., Mokhtar R; **development of system and testing phase:** Mahmod M.N; **manuscript preparation:** Mokhtar R., Mahmod M.N. All authors reviewed the results and approved the final version of the manuscript.*

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