

FGM Track: A Web-Based Appointment and Payment System for Faye Gumabay-Magalona Dental Clinic using Rule-Based Algorithms and Integrated Data Analytics

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ABSTRACT

Manual processes for appointment scheduling and payment tracking in small dental clinics often lead to human error, inefficiency, and reduced patient satisfaction. This developmental research introduces FGMTrack, a web-based appointment and payment management system designed to address these administrative challenges through digital automation. Grounded in the principles of system efficiency and workflow optimization, the study integrates a rule-based scheduling algorithm to detect and prevent double-bookings while automatically managing time-slot availability in real-time. In addition, its data analytics component provides actionable insights into appointment trends, unpaid balances, and overall operational performance, supporting data-driven decision-making for clinic administrators. The system applies the ARIMA (AutoRegressive Integrated Moving Average) model to forecast future revenue by analyzing past financial records and booking patterns. This predictive approach enhances the clinic's ability to anticipate income variations, allocate resources effectively, and support data-driven management decisions (Box et al., 2016; Hyndman & Athanasopoulos, 2021; Chatfield, 2000).

The system was developed for the Faye Gumabay-Magalona Dental Clinic, which previously relied on manual scheduling and payment recording. Following a developmental design approach, the system was built using the Agile Software Development Life Cycle (SDLC) with HTML, CSS, JavaScript, PHP, and MySQL to ensure scalability and reliability. Evaluation surveys conducted by users, administrators, and IT experts, guided by the ISO/IEC 25010 software quality model, assessed the system's functional suitability, usability, and performance efficiency. Results showed high user satisfaction and better performance compared to manual methods, confirming FGMTrack's effectiveness in improving administrative efficiency and service delivery. Future improvements will focus on mobile access, AI-driven analytics, and multi-branch support to enhance scalability and long-term sustainability.

Keywords: FGMTrack, Rule-Based Algorithm, Web-Based System, ISO 25010, Dental Clinic, Data Analytics, ARIMA, PHP, Appointment Scheduling, Conflict Detection.

INTRODUCTION

Many dental professionals struggle to balance patient care with administrative tasks. Small clinics often rely on paper logs and spreadsheets for appointments and billing. According to Dental King Software (2023), this can cause errors, delays, and poor record management, which reduce efficiency and patient satisfaction. The World Health Organization (2020) highlights that digital tools can improve record accuracy and reduce administrative workloads. They also enhance overall service quality. For small and medium-sized dental clinics, adopting digital solutions is essential to modernize operations and improve patient care.

Dr. Faye Gumabay-Magalona began her dentistry career in 2005 and initially ran a home-based clinic. After Typhoon Ondoy destroyed much of her equipment, she worked as an associate dentist to rebuild her practice. Between 2010 and 2017, she expanded her expertise in orthodontics and reopened her clinic in 2018. Experiencing difficulties with manual recordkeeping inspired her to implement a digital management solution.

This study presents FGMTrack, a web-based appointment and payment tracker system that integrates a rule-based algorithm, data analytics, and revenue forecasting to streamline clinic operations. The rule-based module automates patient balance updates and detects scheduling conflicts, while the analytics component provides insights into appointment frequency, payment history, and service performance. The ARIMA model supports financial forecasting by analyzing historical revenue data, allowing the clinic to anticipate trends and make data-driven decisions.

This study aims to design and develop a web-based system that improves the management of dental appointments, balances, and payments. Specifically, it seeks to:

- Develop a scheduling module that allows dentists to add, edit, and manage appointments with conflict detection and calendar visualization.
- Implement a rule-based balance and payment tracking mechanism.
- Enable online appointment requests subject to admin approval.
- Integrate a data analytics dashboard for appointment and revenue summaries.
- Apply the ARIMA model to forecast clinic revenue.
- Evaluate the system's functionality, usability, and reliability based on the ISO/IEC 25010 software quality standard.

Scope

The scope of this system covers a smart dental appointment and balance tracking platform designed for small dental clinics and independent practitioners. It supports key functions such as appointment scheduling, patient tracking, therapy documentation, and balance monitoring. One of its core features is the balance tracker, which allows clinic staff to record full or partial payments and automatically compute running balances. Another key component is the calendar interface with conflict detection, which prevents double bookings and ensures efficient time management. The system also includes a reminder function that enables dentists to send automated email notifications for upcoming appointments. Its rule-based algorithm further enhances scheduling accuracy by checking availability and updating records in real time.

The admin (dentist) has full access to all system features, including managing appointments, updating patient records, and monitoring billing transactions. The patient, on the other hand, can only request appointments through the system and does not have an account or personal dashboard. The system provides an admin dashboard that displays key summaries and visual reports, including:

- Metric Boxes, each displaying a metric (Patients, Appointments, etc.)
- Appointment Calendar
- PDA Dental Chart
- Revenue Overview
- Treatment Popularity

LIMITATION

This study focuses on a simple scheduling algorithm and does not cover advanced or adaptive methods. The system is limited to appointment and billing management, not a full EMR/EHR platform. It is designed for single-clinic use, not large or multi-branch institutions. Email integration is dependent on the available APIs or added costs. Medical records like X-rays and prescriptions are excluded, and internet access is required to use the web-based system.

THEORETICAL FRAMEWORK

The following set of ideas, models, and concepts is used to help better explain and understand the focus of this research:

Rule-Based Algorithms for Scheduling and Conflict Detection - Rule-based algorithms are computer instructions that follow specific, pre-set rules and conditions to manage scheduling tasks. This includes checking for

overlapping appointments (conflicts in timetables), organizing patient appointments, and automatically assigning time slots. These rules prevent two appointments at the same time (double bookings), keep schedules organized, and improve how efficiently a clinic operates.

According to Pinedo (2016), scheduling theory provides the logical and mathematical foundation for the optimal use of resources such as time, staff, and space. The rule-based algorithm:

- Automatically detects and prevents appointment conflicts.
- Ensures fair and organized allocation of time slots.
- Supports quick decision-making during booking and rescheduling.

Data Analytics and Data-Driven Decision Making (DDDM) - Data analytics allows clinic staff to monitor patient payment behavior, service history, and appointment trends. Through DDDM, the clinic uses these insights to make informed decisions that enhance operational efficiency and financial management.

Based on systems theory (Wilkinson, 2011), a clinic is seen as an interconnected system where data flow and feedback promote continuous improvement. In the system, DDDM is used to:

- Track patient balances and identify overdue payments.
- Detect frequent no-shows or priority patients for follow-up.
- Generate reports that support financial forecasting and staff planning.

AutoRegressive Integrated Moving Average (ARIMA) model analyzes historical revenue data to predict future financial performance, enabling the clinic to anticipate income fluctuations and make informed decisions by recognizing patterns, trends, and seasonal variations.

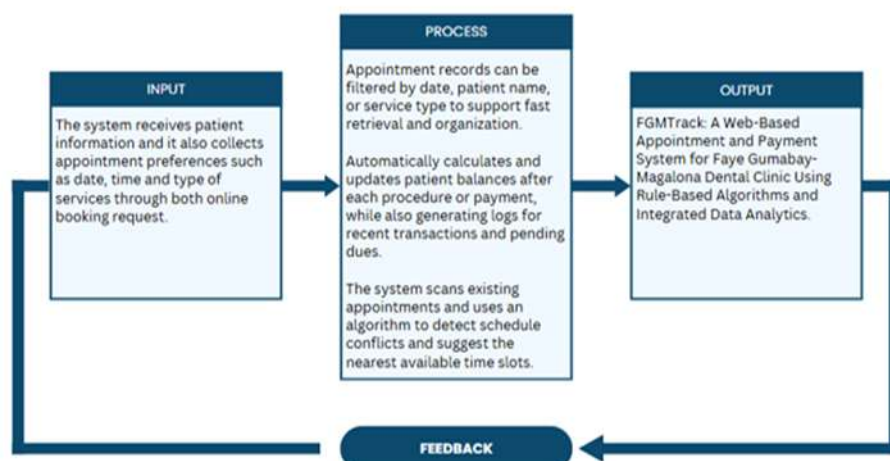
The ARIMA model aligns with predictive analytics theory, which uses historical data to anticipate future trends. It is applied to:

- Forecast upcoming revenue, enabling the clinic to plan finances and resources in advance.
- Recognize seasonal patterns in patient appointments, helping improve staff scheduling and optimize resource allocation.
- Deliver analytical insights that guide long-term strategic decisions, such as expanding services or adjusting business approaches based on projected financial performance.

CONCEPTUAL FRAMEWORK

The Input–Process–Output (IPO) Model, which reflects the study's logical information flow, is used in the conceptual framework to show how the study is conducted to produce its output. The output's design and evolution are guided structurally by this concept.

Figure 1. Input-Process-Output Model



1. Input- Patients provide their personal details and choose their preferred appointment date, time, and service—either through an online booking request or manually entered by the staff.
2. Process- The system organizes appointment records by allowing filtering by patient name, date, or service type for easy management. It also automates tasks like updating and calculating patient balances after each procedure or payment.
3. Output- The FGMTrack system displays booked and available time slots through an interactive calendar, helping staff and patients manage schedules, avoid overlaps, and receive reminders and billing updates for better clinic efficiency.

Significance of The Study

Through this system, dental clinics can manage appointments and finances more easily, allowing more time for patient care. This study is beneficial to the following:

- Dentists/Clinic Owners – The system automates scheduling, payment tracking, and patient management, reducing administrative tasks. With fewer conflicts and accurate records, they can focus more on providing quality dental care.
- Dental Assistants and Staff – Automated reminders, easier appointment handling, and accurate billing improve workflow, reduce errors, and make daily tasks more efficient.
- Patients – Patients get timely reminders, clear billing details, and easier scheduling, resulting in fewer missed appointments and smoother transactions.
- Students/Professionals/Future Researchers – This study serves as a foundation for further research on algorithm-based healthcare scheduling, with potential improvements through analytics, surveys, and AI integration.

Review Of Related Literature

Machine learning has greatly enhanced healthcare scheduling. Alabdulkarim et al. (2022) showed that web-based ML models improve no-show predictions, saving time and resources. Similarly, Zhang (2023) noted that predictive tools reveal patient behavior, boosting satisfaction. Ala et al. (2022) emphasized that rule-based algorithms balance efficiency and patient care, supporting FGMTrack's automated conflict checking. Kumar and Singh (2022) added that AI-driven, cloud-based systems improve accuracy and remote management.

Lee and Chen (2020) found that SMS reminders increase attendance, highlighting the value of accessible tech. Zhang and Qi (2020) reported that rule-based scheduling reduces conflicts, while Silva and Mendes (2021) achieved high no-show prediction accuracy using Random Forest. Lee, Park, and Kim (2023) confirmed that flexible rule-based systems reduce clinic idle time.

In the Philippines, digital dental platforms like DevWerkz's Book Your Teeth show growing adoption. Elepaño et al. (2025) found that digital tools, including EHRs, improve service delivery—aligning with FGMTrack's goal of integrating appointment and payment management. Studies by Garcia and Tan (2021) and Flores and Bautista (2017) proved that SMS reminders enhance attendance and satisfaction. Villanueva (2019) and Villanueva & Cruz (2020) also showed that web-based systems increase transparency and reduce conflicts, supporting FGMTrack's design goals.

Synthesis

Studies show that dental clinics, both locally and internationally, face common challenges in appointment scheduling and record management, with many small clinics still relying on outdated methods like paper logs and spreadsheets. These lead to issues such as missed appointments, double bookings, and billing confusion. International research highlights the benefits of digital tools, structured scheduling systems, and AI-driven platforms in improving efficiency, accuracy, and patient satisfaction (Ala et al., 2022; Kumar & Singh, 2022). Locally, digital adoption is also rising through systems like Book Your Teeth and Electronic Health Records, which enhance service delivery (DevWerkz, n.d.; Elepaño et al., 2025). Studies by Villanueva (2019) and Cruz

and Santos (2021) further support the effectiveness of web-based scheduling and integrated billing, showing that even basic digital systems can significantly improve clinic operations.

METHODOLOGY OF THE STUDY

The research methodology used in this study is a developmental research design, a type of applied technology research that focuses on the creation, advancement, and assessment of technological solutions to current real-world problems. The creation of FGMTrack, a web-based application that improves the efficiency of appointment scheduling, client administration, and balance tracking in the dental clinic setting, is the research project in this instance.

Data collection measures variables and gathers information to understand the research problem and provide insights for analysis. In this study, primary data were obtained from system evaluations, where participants rated performance, effectiveness, and quality. Secondary data came from related literature and previous studies, providing background, best practices, and supporting references for system development and evaluation.

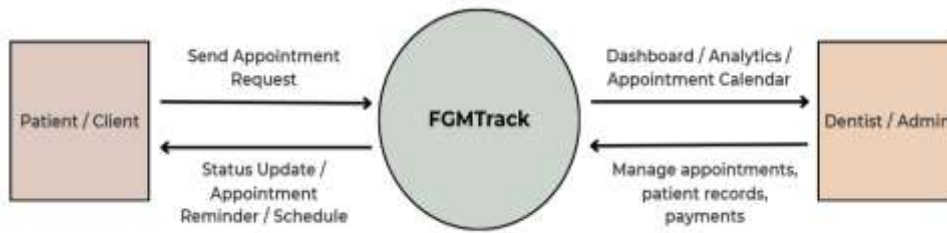
The System Development Life Cycle (SDLC) is a project management methodology used to plan, design, develop, test, and deploy information systems or software products efficiently. It provides a structured process that guides every stage of system creation—from conception and development to implementation and ongoing maintenance.

Figure 2: SDLC Agile Model



The FGMTrack system was developed using the Agile Software Development Life Cycle (SDLC), a flexible, iterative approach that guides the creation of software through structured phases. During the requirements phase, key features such as appointment scheduling and balance tracking were identified. In the design phase, the system structure and user interface were planned, incorporating elements like conflict detection. The development phase involved building core modules, including the calendar and reminder system, with continuous feedback from stakeholders. In the testing phase, functionality and reliability were verified, followed by deployment, where main features such as booking and billing were launched. Finally, in the review phase, user feedback and system performance were evaluated to improve accuracy, efficiency, and overall usability.

Figure 3: Context Diagram



The diagram identifies three main entities: the Patient/Client, the Dentist (Admin), and the system platform itself. Information flow begins when the Patient/Client submits an appointment request through the web interface. The system processes the request, detects scheduling conflicts using its rule-based algorithm, and sends confirmation or reminders as needed.

Meanwhile, the Dentist (Admin) reviews the request, approves or modifies appointments, updates patient records, and monitors payments. The system also manages all administrative transactions between patients and the dentist. This coordinated flow ensures efficient communication, accurate recordkeeping, and smooth clinic operations.

Respondents of the Study

The simple random sampling could be applied to ensure that each potential respondent within the target population has an equal and unbiased chance of being selected. Under this method, respondents from both the user group (students and customers) and the technical group (professionals and administrators) would be randomly chosen from an existing list of users and staff associated with the system. This approach minimizes selection bias and increases the representativeness of the data, allowing the findings on system usability, security, and performance efficiency to reflect the perspectives of the entire user population accurately.

A total of 502 respondents participated in the system evaluation through Google Forms, ensuring comprehensive feedback aligned with the ISO 25010 software quality standards. The 480 users, composed of students and customers, assessed the system's usability, security, and performance efficiency, representing the end-user experience. Meanwhile, the 20 technical professionals and 2 administrators/staff evaluated the system's functionality, reliability, and compliance, providing expert validation of its technical quality and performance.

Development and Evaluation Procedure

The development of the FGMTrack system involved the use of various tools and technologies to ensure both a functional back-end and a user-friendly front-end. The front-end is built using HTML, CSS, and JavaScript, which provide the structure, style, and interactive features of the interface. For the back-end, PHP and MySQL are used to manage server-side operations and data handling. To enhance the system's design and functionality, several libraries and frameworks are integrated, including Tailwind CSS (for styling), ApexCharts (for data visualization), FullCalendar and DataTables (for scheduling and tables), jQuery (for interactivity), Just-Validate (for form validation), and PHPMailer (for sending emails). The development process is supported by tools such as Visual Studio Code, NPM, Composer, Git, GitHub, and XAMPP, which are used for coding, dependency management, version control, and local server testing.

To evaluate the system, the study adopted a two-part approach using a single evaluation form based on ISO 25010 quality standards. This standard evaluates the system across several key criteria:

- **Functional Suitability** - Ensures that the system performs its intended tasks, such as scheduling appointments, detecting conflicts, recording balances, and sending reminders.
- **Usability** - Assesses how easy the system is to navigate, ensuring that even non-technical users can use it without confusion.
- **Performance Efficiency** - Measures the system's speed and responsiveness, especially when handling

multiple users or heavy data loads.

- Reliability - Checks the system's consistency and stability during regular use, making sure it doesn't crash or lose data.
- Security - Evaluates how well the system protects sensitive information, allowing only authorized access and maintaining patient privacy.

This combined evaluation approach provided insights into both user satisfaction and system performance, helping to identify areas for improvement while confirming the system's effectiveness in a real-world clinic setting.

Data Analysis Plan

The FGMTrack system was evaluated using the ISO/IEC 25010 Software Quality Model. This framework assesses key software attributes, including functionality, usability, performance efficiency, reliability, and data security. It was chosen because it aligns with the system's objectives of improving accuracy and efficiency in small dental clinics. Using this model, the researchers ensured that the system's quality was measured according to globally recognized software evaluation standards.

To interpret the feedback gathered through Google Forms, the researchers utilized statistical tools that quantified both user and expert responses for objective analysis. The Weighted Mean was applied to compute the average level of agreement for each ISO 25010 criterion, helping determine the consistency of ratings across various quality dimensions. This approach provided a clear and measurable representation of how the respondents perceived the system's usability, reliability, and security.

A Simple Random Sampling method was employed to ensure that every respondent had an equal chance of being selected, promoting fairness and reducing bias in the data collection process. A 4-point Likert Scale was also used to measure user satisfaction, ranging from "1" (Strongly Disagree) to "4" (Strongly Agree), to translate qualitative opinions into quantifiable results. The combined use of these methods ensured that the findings were both statistically valid and aligned with the ISO 25010 model, providing an accurate reflection of the system's overall performance and user acceptability.

The System

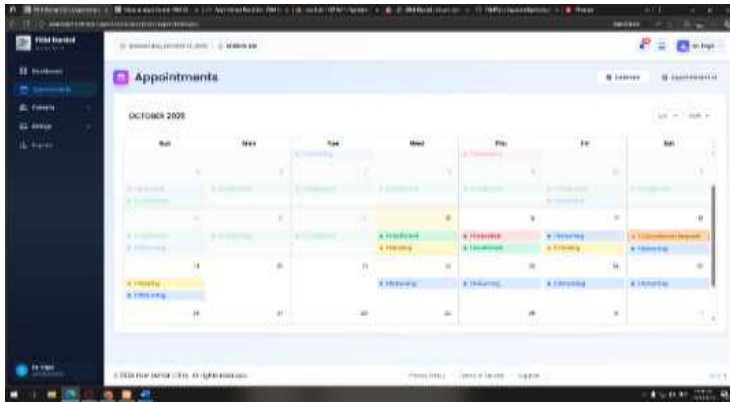
FGMTrack is a web-based appointment and payment management system designed to streamline dental clinic operations through automation and data analytics. The system features a rule-based scheduling algorithm that automatically detects appointment conflicts, manages time-slot availability, and updates patient balances after each visit. Patients can book appointments as guests, while administrators use a dashboard to monitor appointments, balances, and inquiries in real time. A key component is the ARIMA model, which analyzes historical financial data to forecast clinic revenue over a 1–4 4-year period. This predictive capability supports informed planning and resource allocation. The system was developed using HTML, CSS, JavaScript, PHP, and MySQL, with Tailwind CSS and FullCalendar for a responsive, user-friendly interface. Its quality and performance were evaluated using the ISO/IEC 25010 software quality model, confirming that FGMTrack enhances administrative efficiency and improves patient service delivery.

Figure 4. Admin Dashboard



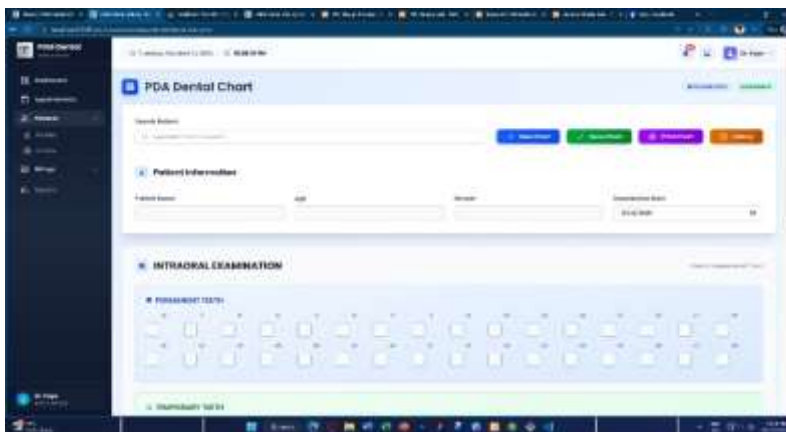
The admin dashboard is the central hub for administrators. It provides real-time metrics on patients, appointments, treatments, and revenue. Quick-action controls and a line chart help track trends in new and returning patients.

Figure 5. Appointment Calendar (Admin)



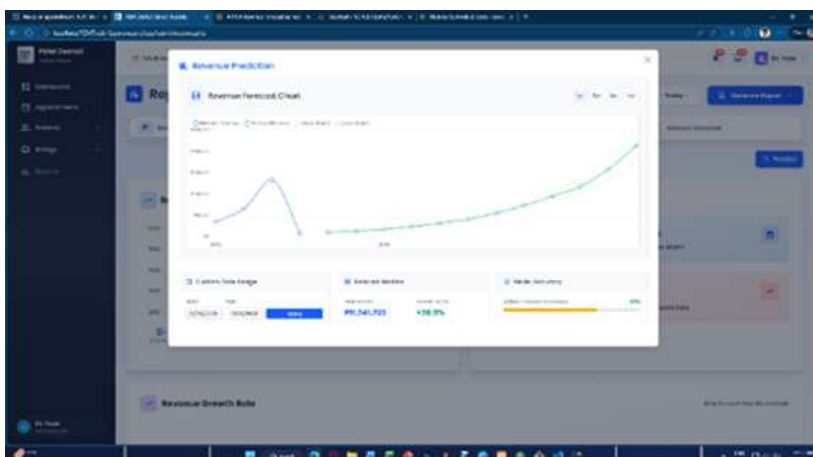
The appointment interface lets administrators manage patient schedules using calendar and list views. They can confirm or reschedule appointments, send notifications, and cancel bookings. The system automatically updates appointment statuses, ensuring organized and accurate scheduling.

Figure 6. PDA Dental Chart (Admin)



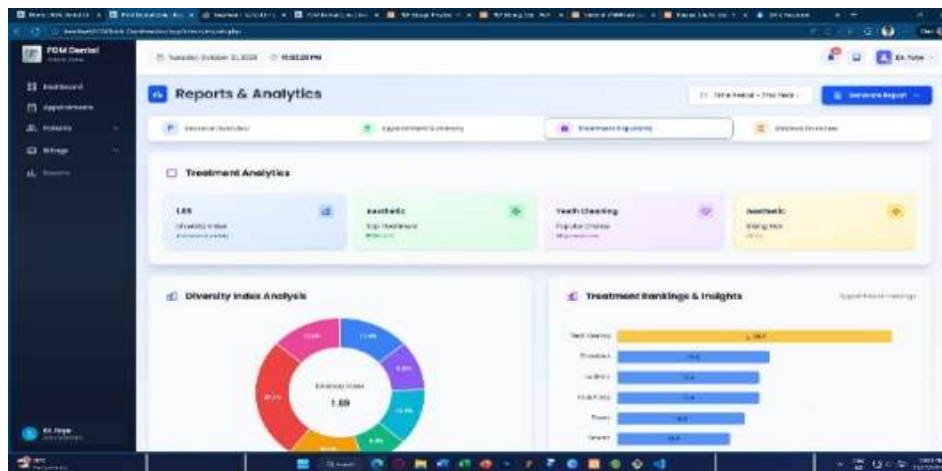
The dental chart interface digitally replicates a traditional chart. It allows interactive tooth selection, color-coded condition tracking, and viewing of treatment history. A PDF export feature enables the generation of digital dental records.

Figure 7. Revenue Prediction (Admin)



This interface displays projected clinic revenue over 1–4-year period using the ARIMA model. Administrators can view predicted trends, analyze seasonal patterns, and use the insights to support financial planning and resource allocation.

Figure 8. Treatment Popularity (Admin)



The treatment popularity interface provides analytics on frequently requested procedures, trends, and performance metrics. This information allows administrators to assess service demand and optimize clinic resources based on patient data and treatment patterns.

Assessment: Summary of Respondents on The System

The system was evaluated by three respondent groups: (a) users, (b) administrators/staff, and (c) technical experts, totaling 502 participants. The demographic distribution shows each group’s sample size and percentage.

Table 1. Distribution of Respondents

Respondents (groupings)	Size (n)	Percentage
Users	480	96%
Administrator/ staff	2	0.40%
Technical	20	4%
Total (n)	502	100%

Table 1 shows the distribution of respondents in the system evaluation. Users made up 96% of participants, administrators/staff 0.40%, and technical experts 4%. Most feedback came from users, while administrators/staff provided insights on management and usability, and technical experts assessed functionality and performance.

Table 2. Summary and Comparison of Respondents’ Assessment Based on ISO 25010 Standards

Criteria (ISO25010)	Respondents (502)					
	Users (480)		Administrator/Staff (2)		Technical (20)	
	WM	VI	WM	VI	W	VI
1. Functional Suitability	3.4	SA	3.9	SA	3.7	SA
2. Usability	3.5	SA	3.9	SA	3.7	SA
3. Performance Efficiency	3.5	SA	3.9	SA	3.8	SA
4. Reliability	3.4	SA	3.9	SA	3.7	SA
5. Security	3.5	SA	3.9	SA	3.8	SA
Overall Average Mean	3.5	SA	3.9	SA	3.8	SA

Table 2 presents a summary and comparison of the system’s evaluation results based on the ISO 25010 criteria.

Results show that users rated the system 3.5, administrators/staff 3.9, and technical experts 3.8, all with a “Strongly Agree” interpretation. This indicates that the system effectively meets its purpose, demonstrating strong functionality, efficiency, reliability, and security for dental clinic operations.

Ethical Considerations

The study guarantees the confidentiality and integrity of the data obtained from participants. Information provided by respondents is secure, and no personally identifiable information is shared without permission. Respondents are allowed to leave the study at any moment without facing any consequences, in accordance with the principles of voluntary participation. Complete compliance to data security protocols guards against abuse and illegal access to information. Lastly, to preserve the study's integrity, all results are presented truthfully and accurately, free from presumptions or manipulation.

Summary

FGMTrack is a web-based appointment and payment system developed for the Faye Gumabay-Magalona Dental Clinic to improve the management of patient appointments, payments, and records. Its main goal is to streamline operations through automation—tracking patient balances, detecting scheduling conflicts, and securely storing client information. The system uses rule-based algorithms for scheduling and reminders, while data analytics helps identify patient trends, overdue payments, and service usage.

Using the ISO/IEC 25010 software quality model, both user and technical respondents evaluated the system’s usability and effectiveness. Results showed that it improved appointment handling, reduced manual errors in balance tracking, and provided useful insights for decision-making. Overall, the study benefits clinic owners and users by offering a user-friendly platform that reduces administrative tasks and enhances service quality and productivity.

CONCLUSION

The study identified three respondent groups: (a) users, (b) administrators or staff, and (c) technical experts. Results showed that all groups rated the FGMTrack system as “Strongly Agree” (SA) across all ISO/IEC 25010 criteria, indicating high functionality, usability, performance efficiency, reliability, and security. The users gave an overall mean of 3.5 (SA), the administrators or staff rated it 3.9 (SA), and the technical experts rated it 3.8 (SA). These findings confirm that the system meets software quality standards and is considered functional, user-friendly, efficient, and secure, effectively improving clinic operations through accurate and reliable appointment scheduling and payment tracking.

RECOMMENDATION

Future researchers and developers are encouraged to improve and expand the Dental Clinic Scheduling and Financial Tracking System to better support clinic operations. Enhancements may include advanced scheduling algorithms for stronger conflict detection and the addition of EMR/EHR features like patient records, x-rays, and prescriptions.

For larger clinics, it is recommended to integrate multi-branch support, role-based access, and secure cloud storage to ensure scalability. Developing a mobile app and adding multilingual support could improve accessibility for both patients and staff. Future studies may also explore adding communication tools, such as in-app chat, automated SMS, and email notifications, to enhance patient–clinic interaction and provide timely updates.

Additional improvements could enhance the system’s reliability, security, and long-term effectiveness. These include incorporating artificial intelligence for predictive analytics to support decision-making and resource planning, providing offline backup options to ensure data accessibility during downtime, and implementing regular updates based on user feedback to continuously improve system performance.

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