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DEVELOPMENT OF A WEB-BASED VETERINARY APPOINTMENT MANAGEMENT SYSTEM

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ABSTRACT

The continuous advancement in information and communication technologies has necessitated digital transformation in veterinary healthcare, yet many clinics still rely on manual appointment scheduling and record-keeping systems that lead to inefficiencies, missed appointments, and data inconsistencies. This study addresses these critical challenges by developing a comprehensive web-based Veterinary Appointment Management System that integrates secure client-pet databases, real-time scheduling capabilities, and role-based access control to enhance operational efficiency and service delivery in veterinary practices. The system was developed using a modern technology stack comprising Next.js for the responsive frontend interface, Flask API for robust backend services, and MySQL for secure database management. The implementation employed JWT-based authentication with multi-factor authentication capabilities, role-based access control (RBAC) for administrators, veterinarians, staff, and pet owners, and AES-256 encryption for data security. The development process followed structured system design principles with comprehensive testing phases including unit testing, integration testing, and user acceptance testing to ensure functionality, security, and usability standards. The implemented system successfully delivered all core functionalities including secure user authentication, real-time appointment scheduling with conflict resolution, comprehensive pet profile management with medical history tracking, automated notification systems, and administrative oversight capabilities. User acceptance testing demonstrated high satisfaction rates across all user roles, with the

system effectively streamlining clinic workflows, reducing administrative burden, and improving data accessibility. Performance evaluation confirmed optimal response times, robust security measures, and scalable architecture suitable for small to medium-sized veterinary practices. The Veterinary Appointment Management System represents a significant advancement in veterinary practice digitization, successfully addressing operational inefficiencies through secure, user-friendly technology integration.

KEYWORDS: Development, Veterinary, Appointment, Management System, Digital Veterinary Administrator System (DVAS)

INTRODUCTION

The continuous advancement in information and communication technologies (ICT) has reshaped service delivery across various sectors, including healthcare. In the veterinary field, digital transformation is gaining momentum with the adoption of web-based systems aimed at enhancing operational efficiency, client satisfaction, and clinical decision-making (Beyer, 2023). Veterinary clinics increasingly handle a wide range of services, ranging from diagnosis to pet care logistics, which require efficient management systems. Traditional manual approaches to appointment scheduling and record-keeping often lead to inefficiencies such as missed appointments, data inconsistencies, and limited access to client or patient history (Jaffar et al., 2021). Veterinary appointment scheduling, in particular, plays a crucial role in ensuring timely treatment, optimal resource utilization, and better client experience. Yet, many clinics still rely on manual or semi-digital processes that are prone to errors and administrative delays. Several studies have proposed digital platforms to streamline appointment booking, automate notifications, and support secure record management (Sains & Maklumat, 2025; Iqbal et al., 2023). These innovations have proven successful in improving service delivery and promoting operational efficiency, especially when designed to accommodate specific veterinary workflows.

One of the significant challenges facing veterinary clinics is managing client and pet information securely while allowing flexibility in modifying or canceling appointments. The need for user-friendly systems that also maintain high security standards has been emphasized in systems like DVAS, which incorporated role-based access control and zero trust architecture to prevent unauthorized access (Syafiqah et al., 2025). Security is not only essential for protecting sensitive data but also for building trust among users, especially pet owners concerned about the privacy of their information.

Moreover, appointment scheduling systems are more effective when integrated with additional features such as alerts, reminders, and real-time updates. Research by Groves et al. (2025) on communication preferences in veterinary care showed that clients value clarity, timely updates, and collaborative service models. Hence, systems that accommodate these user expectations are more likely to achieve higher adoption rates and satisfaction levels. Similarly, Iqbal Ramadhani Mukhlis et al. (2023) demonstrated that systems developed with usability standards (like ISO/IEC 9126) significantly improved learnability and trust among users.

Despite growing digital transformation in healthcare, many veterinary clinics still rely on manual or semi-digital systems for appointment booking and client data management. These outdated methods often lead to inefficiencies such as double bookings, missed appointments, data inconsistency, and limited communication between pet owners and veterinary staff (Sains & Maklumat, 2025). In such settings, administrative delays not only reduce service efficiency but also negatively affect client satisfaction and overall care delivery (Jaffar et al., 2021). In the existing efforts, many current systems still lack essential features like flexible appointment management, secure client data handling, and vendor-role authentication, especially in developing regions. For instance, the system developed by Sains and Maklumat (2025) addressed several process inefficiencies in veterinary clinics but did not explicitly discuss limitations such as scalability or broader integration capabilities.

Another critical challenge lies in the lack of a centralized, secure system for managing client and pet records. Many veterinary clinics struggle with scattered or paper-based records that make it difficult to track patient history, appointment details, and treatment updates. Without a unified digital system, service quality and decision-making can be compromised, especially during emergencies or follow-up consultations (Syafiqah et al., 2025). Moreover, existing systems often fail to offer user-friendly features such as the ability to reschedule or cancel appointments, receive timely notifications, or interact easily with veterinary staff. Studies have shown that clients place a high value on flexible, clear, and transparent service interactions (Groves et al., 2025). Yet, many current veterinary systems lack real-time appointment alerts or automated reminders, leading to missed appointments and poor client engagement.

Security and trust are additional concerns. Systems without proper role-based access or administrative controls are vulnerable to unauthorized access, data breaches, and misuse of sensitive information. The Digital Veterinary Administration System (DVAS), for instance, demonstrated that integrating role-based access and zero trust architecture greatly improves security and user confidence (Syafiqah et al., 2025). However, such secure frameworks are rarely adopted in smaller veterinary settings due to cost, complexity, or lack of technical expertise.

Furthermore, usability remains a persistent issue. Without adherence to usability standards and user testing protocols, systems often fail to meet the expectations of clinic staff and pet owners. Research by Mukhlis et al. (2023) showed that systems designed with ISO/IEC 9126 usability metrics achieved higher satisfaction and better adoption rates, proving the importance of intuitive and accessible interfaces.

Lastly, most existing platforms do not support multiple user types or provide customizable dashboards for different roles such as veterinarians, receptionists, and pet owners. This limitation reduces workflow efficiency and makes it difficult to track appointment histories or manage clinic operations in real time (Jaffar et al., 2021).

The proposed Veterinary Web-Based Appointment Management System (VWAMS) seeks to close these gaps by offering a secure, adaptable, and user-centric platform for scheduling appointments. It will feature separate dashboards for pet owners and veterinary staff, a secure client-pet database, and real-time appointment alerts. The platform will also incorporate admin-controlled approval for user access, thus ensuring data integrity and operational security. Inspired by the successes and limitations of prior works (e.g., Jaffar et al., 2021; Sari et al., 2023), this system aims to provide a robust and scalable digital infrastructure for veterinary practice management.

1. LITERATURE REVIEW

Syafiqah et al. (2025) proposed a secure Veterinary Information Management System (VIMS) incorporating role-based access control and a zero-trust architecture to enhance security in veterinary practices. The system was designed using a prototyping model and handled data interactions from five key user groups: doctors, pharmacists, helpdesk personnel, administrators, and pet owners. Techniques such as Role-Based Access Control (RBAC) and Zero Trust Architecture were implemented to prevent unauthorized access, detect invalid

inputs, and maintain detailed logs. Their findings confirmed that the system effectively safeguarded operations across all modules and achieved high user satisfaction. Although limitations were not explicitly discussed, this study sets a benchmark for integrating robust access control mechanisms in veterinary platforms.

In another approach, a study by Arifah and Muhammad (2023) developed a web-based online appointment booking system using the waterfall model to streamline scheduling in veterinary clinics. The platform was implemented with Visual Studio Code and XAMPP and tested with real users. It demonstrated ease of use and improved appointment management, although it lacked a payment gateway, prompting a recommendation for future inclusion of online banking services. This study provides foundational insight into online veterinary appointment systems and highlights the importance of user-centric scheduling features.

Sari et al. (2023) focused on enhancing customer satisfaction and administrative efficiency by creating an Android-based mobile application for K1 Veterinary Clinic. Developed with Kotlin and an MVVM architecture under the waterfall model, the app underwent user testing and significantly improved the transparency of veterinary services. It successfully addressed key administrative bottlenecks, especially concerning cost clarity and usability. Although the study didn't elaborate on its limitations, its relevance lies in showcasing how mobile apps can support client-centered veterinary service delivery.

Corah et al. (2019) explored how appointment lengths are structured in UK-based small animal veterinary clinics. Using a descriptive survey-based methodology, the study gathered input from various clinics to analyze trends in scheduling practices. Findings revealed that most appointments were limited to 10–15 minutes, with flexible scheduling options often available. Interestingly, longer consultations usually incurred no additional charge, and nurse-led consults were commonly offered free of cost. This work provides valuable insights into time allocation practices and helps inform design decisions for appointment modules in veterinary systems.

Groves et al. (2025) investigated client communication preferences during veterinary clinical decision-making. Conducted as a cross-sectional survey of 1,614 pet owners in Canada, the study used hierarchical Bayesian modeling to evaluate preferences across preventive, general, and urgent care scenarios. Clients preferred collaborative engagement with veterinarians, transparent cost explanations, and clear option recommendations. While demographic bias

was acknowledged (most respondents were female and financially stable), this study highlights the growing need for empathetic, transparent, and context-aware communication interfaces in veterinary applications.

Sains and Maklumat (2025) created a digital platform for Elite Veterinary Clinic to replace paper-based systems and manage appointments, treatments, and customer records efficiently. Developed using PHP, MySQL, and Visual Studio Code under a prototyping and object-oriented framework, the system enhanced service delivery across various modules, including online payments and pet hotel bookings. Although limitations were not specifically discussed, the system's successful deployment underscores the benefits of transitioning from manual to digital veterinary management systems.

Iqbal et al. (2023) developed a prototype digital pet care application for Niz Petcare with the goal of improving customer trust and operational efficiency. Built using the CodeIgniter MVC framework, the system was evaluated through ISO/IEC 9126 usability metrics and achieved up to 89% in usability, learnability, and understandability. Despite a few recommended improvements from users, the system proved to be user-friendly and functional. This work reinforces the value of usability-focused design in veterinary digital solutions.

Perret et al. (2020) examined the link between veterinarian mental health and client satisfaction in Canadian companion animal clinics. Utilizing psychometric and post-appointment surveys across 60 veterinarians and 995 clients, their analysis employed multilevel regression models. Results revealed complex, non-linear relationships, sometimes indicating higher client satisfaction even when veterinarian mental health was lower. Although causality couldn't be firmly established, the study brings attention to the human factors behind veterinary service quality and their potential integration into digital support systems.

Jaffar et al. (2021) presented a veterinary clinic management system for V Care Animal Clinic aimed at improving appointment booking and information access. Built with PHP, MySQL, and Lucidchart under an iterative design model, the platform supported three user roles—admin, staff, and clients. It successfully enhanced operational efficiency and introduced features like automated reminders and treatment histories. Despite not detailing

system evaluation metrics or limitations, the study contributes a practical framework for multi-role veterinary systems.

Beyer (2023) analyzed how information and communication technologies (ICT) impact veterinary business models. Based on 102 in-depth interviews and literature reviews, the study applied the Business Model Canvas to assess components like customer relationships, service quality, and revenue streams. Findings showed that ICT innovations improved service efficiency and client satisfaction across various veterinary clinic types. While generalizability across countries might be limited, this research provides a comprehensive understanding of how business strategies and technological tools can be aligned in veterinary practice management.

Several researchers have explored different methodologies for developing veterinary management systems, integrating mobile platforms, secure appointment scheduling, and client–veterinarian communication strategies. Many studies have focused on improving clinic workflows through web-based systems, mobile apps, and centralized digital platforms that support treatment tracking, record keeping, and real-time booking. Some researchers have incorporated role-based access control, mobile-first designs, and system usability metrics to enhance performance and user satisfaction in veterinary healthcare delivery.

Despite these advancements, existing research exhibits certain limitations. A common challenge is the insufficient integration of secure payment gateways and digital wallets, particularly in systems designed for broader e-commerce or veterinary retail contexts. Additionally, while some platforms address appointment scheduling and health record management, issues such as poor user engagement, weak fraud prevention mechanisms, and the absence of end-to-end transaction capabilities remain unresolved.

2. MATERIALS AND METHODOLOGY

Modern web technologies such as Next.js for the front end, FastAPI for the back end, MongoDB for the database, and Cloudinary for picture storage were used in the development of the system. To create a safe and responsive platform, other tools like Celery with Redis for background job processing, JWT for authentication, and 2FA for increased security were incorporated.

The testing process included user acceptability testing with actual users in various roles in addition to unit and integration testing of the main components. The outcomes verified that the system achieves all specified goals, operates dependably across devices, and has an intuitive user interface. By providing a unified, secure, and scalable digital platform, this system strengthens the digital transformation of veterinary service delivery and commerce, empowering clinics and pet owners with more efficient, transparent, and reliable tools for interaction and transaction.

3. IMPLEMENATION AND DEPLOYEMENT

The thorough setup and testing of the Veterinary Clinic Management System are presented in this section. The system was created to meet the operational requirements of veterinary clinics by offering modules for managing medical records, staff and physician operations, pet management, profile management, appointment scheduling, and user authentication in a contemporary, web-based setting. The backend, which provides RESTful endpoints that accept frontend requests, was constructed using Flask, while the frontend was implemented using Next.js. Using secure JWT authentication and well specified API endpoints, frontend and backend integration was accomplished. Robust testing is also a part of the implementation to make sure the system works as planned. Screenshots of how the system works in practice by illuminating the main interfaces, workflows, and features implemented inside the system are shown in the next section.

4.1 System Architecture Integration

This objective centers on developing a secure, user-friendly web application that allows pet owners to schedule, modify, or cancel appointments, and receive real-time alerts and reminders. The solution provides a robust frontend and backend architecture prioritizing security, usability, and performance for all stakeholders. The integrated architecture demonstrates how all objectives and components work together to address veterinary management challenges and enable future growth. Microservices allow for independent scaling, and API gateways manage service communication and security. Service discovery, health monitoring, and failover guarantee high availability. Figure 4.1 shows the complete system architecture, including all components and integrations.

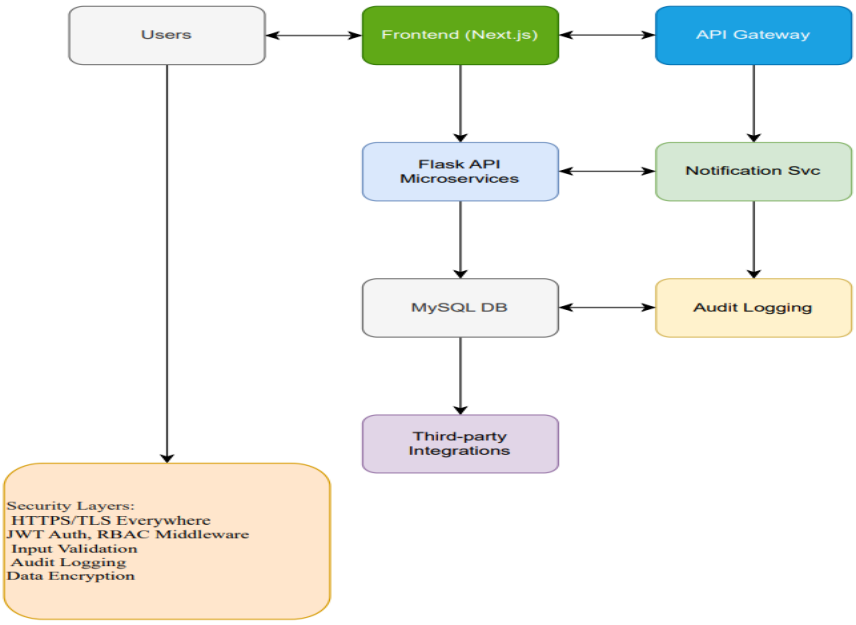

Figure 4.1: Integrated System Architecture for Veterinary Appointments Management System.

4.2 Frontend Implementation

The Veterinary Clinic Management System's frontend implementation was created with Next.js to provide an online application for veterinary clinics that is quick, scalable, and search engine friendly. Using Axios for HTTP requests and Cloudinary for image uploads, it interfaces with the Flask API backend. Tailwind CSS is used for responsive layouts and uniform style. In order to ensure smooth data flow between the frontend interface and backend endpoints, the frontend was modularized utilizing services and custom React hooks (Akawuku et al., 2025). This encouraged reusability and clarity in code management. Figure 4.1 depicts the whole authentication sequence, including the steps involved in user registration, 2FA verification, and token management in the frontend system.

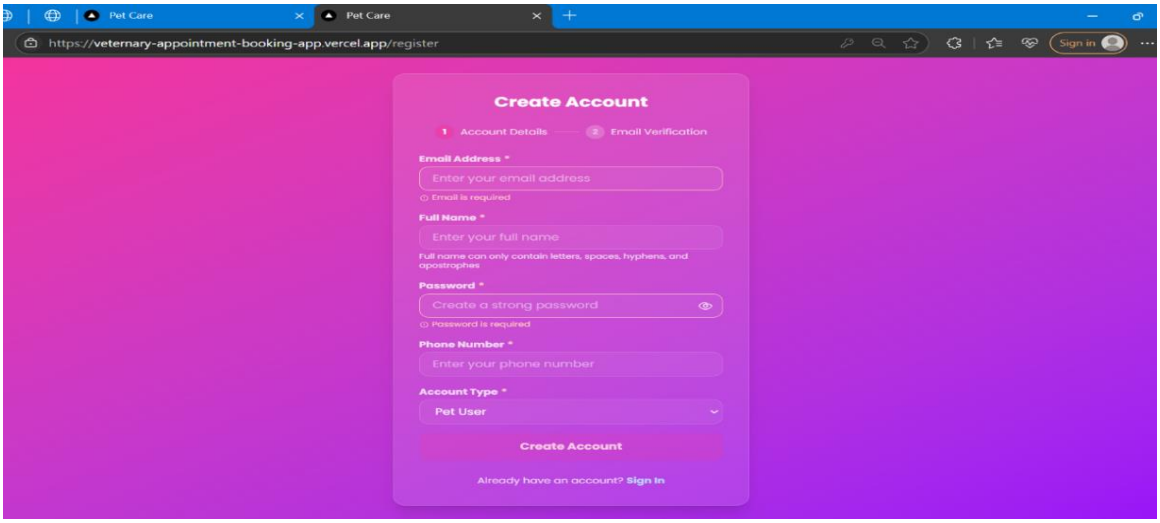

Figure 4.2: Interface for Registration and Login.

3.3 Dashboard Interface

These dashboards have a simple, user-friendly interface and are designed to employ API calls to present dynamic, user-specific data. Hooks (useAdmin, useStaff, useVeterinarians, etc.) are used to retrieve data, guaranteeing that changes are immediately reflected across the user interface and facilitating effective clinic administration.

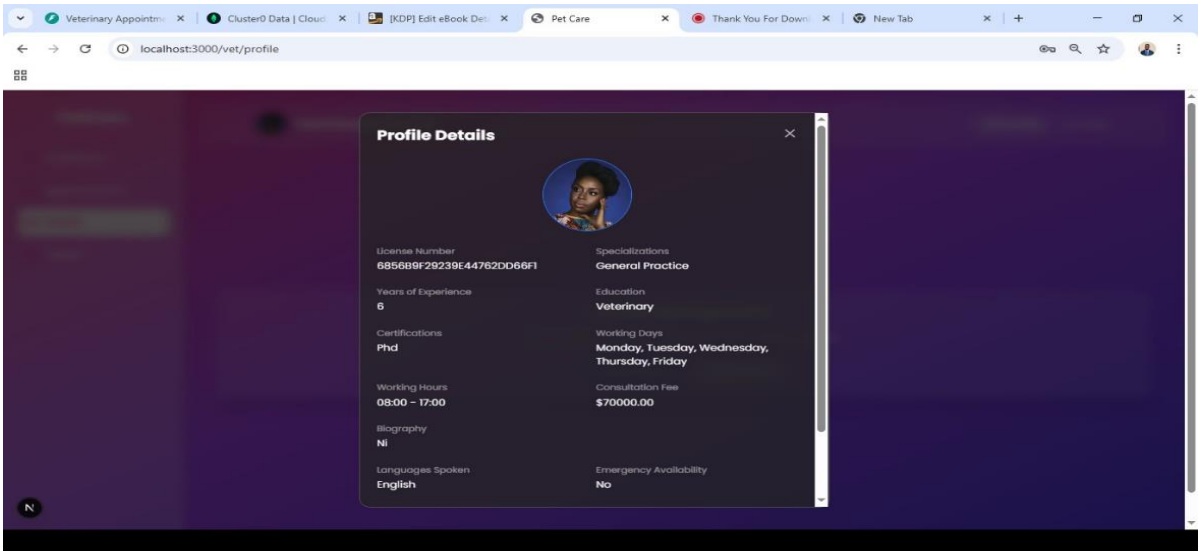

Figure 4.2: The Veterinary Clinic Administration System's user dashboard interface showing navigation, administration choices, and user-specific data.

4.4 Appointment Management Module

The appointment booking interface is shown in Figure 4.3. It includes a structured form for gathering appointment information and real-time interaction with backend services to verify slot availability and safely record bookings.

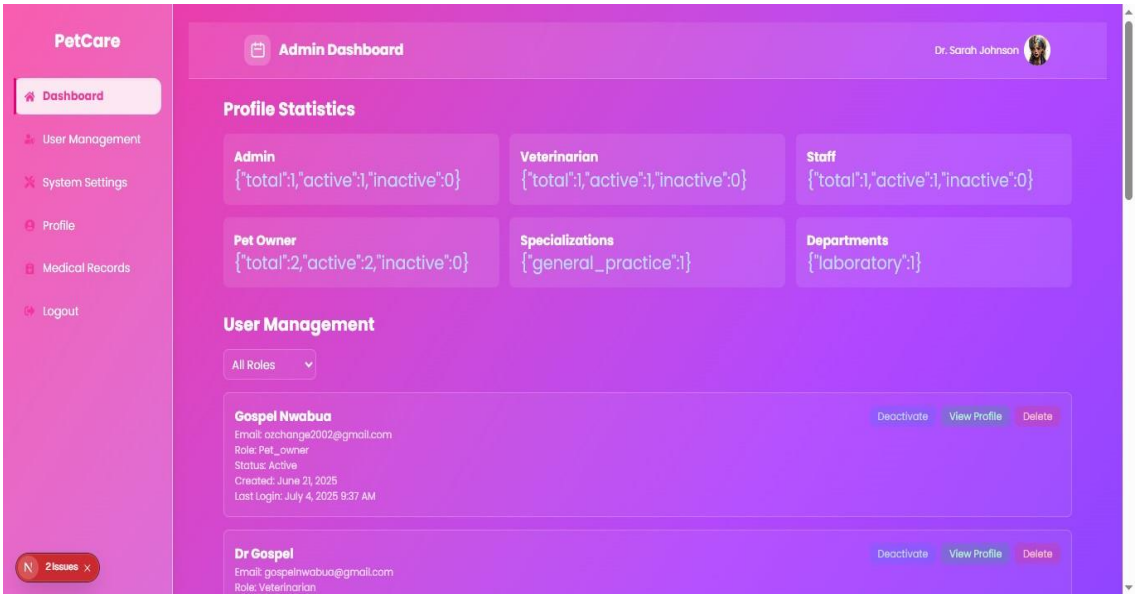

Figure 4.3: A structured form for creating appointments is displayed on the appointment booking interface, which also guarantees real-time system validation of available slots.

The well-organized handling of appointment data inside the Veterinary Clinic handling System is reflected in Figure 4.4, which displays the appointment management interface where users may view, change, reschedule, or cancel current appointments.

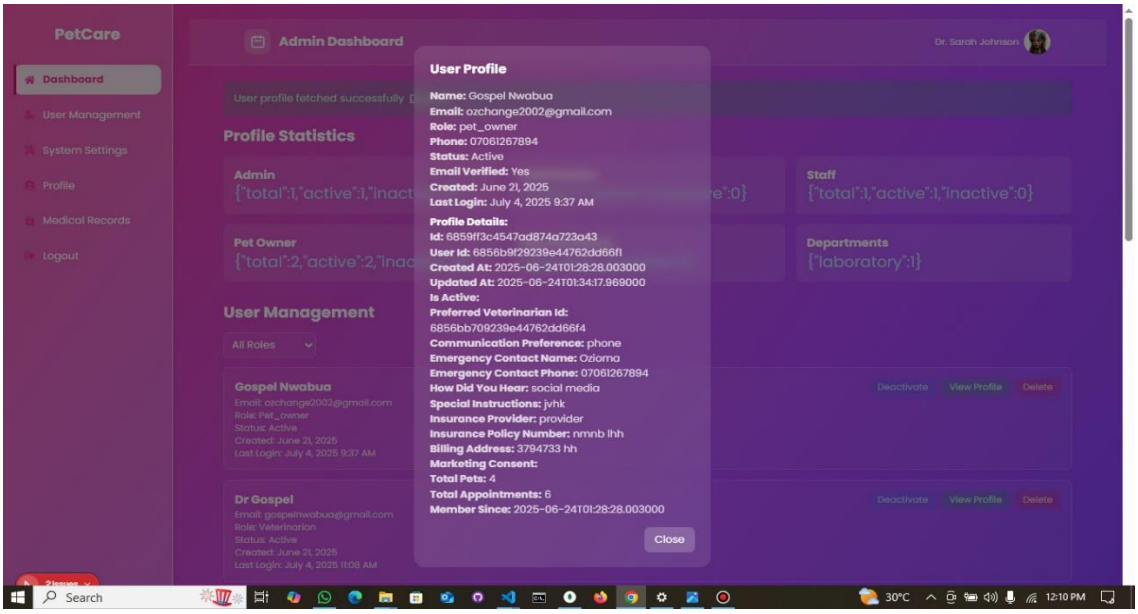

Figure 4.4: An appointment management interface that supports effective clinic operations by showing users how to view, change, reschedule, or cancel appointments.

4.5 Pet Management Module

The Pet Management Module ensures correct and current information for efficient care delivery inside the Veterinary Clinic Management System by facilitating the efficient addition, updating, deletion, and restoration of pet data by physicians and staff. With the help of Cloudinary integration, users may upload images for visual reference and add pets by entering basic information like name, breed, age, species, and owner details.

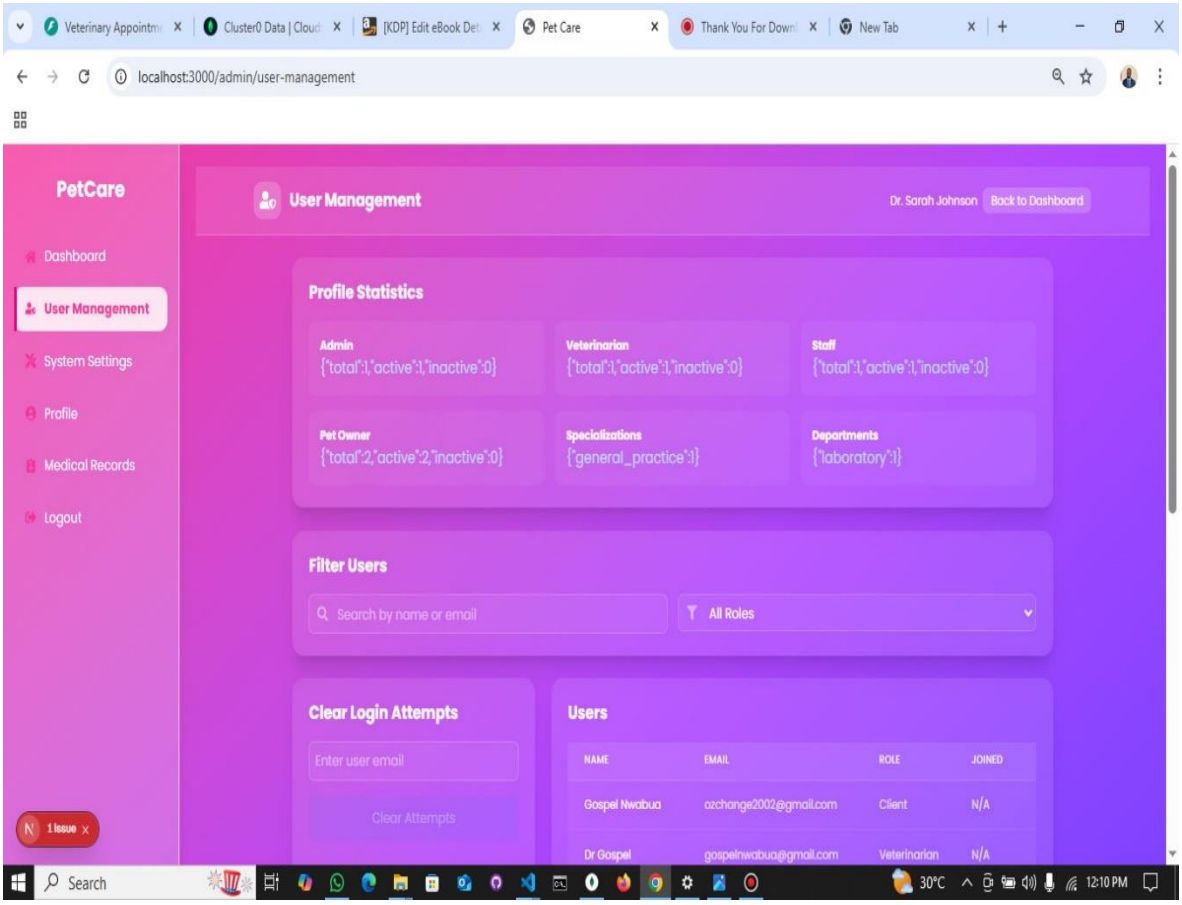

Figure 4.5: Pet profile interface with clear data fields and photo upload for easy record keeping.

The pet profile page, as seen in Figure 4.5, offers organized fields for storing and inputting pet information, including the ability to upload photos for simpler identification during medical consultations. In a similar vein, Figure 4.6 shows the comprehensive view of a pet's file, showing how staff members and veterinarians may easily get vital data like breed, age, and medical history, guaranteeing preparedness for consultations and treatment planning.

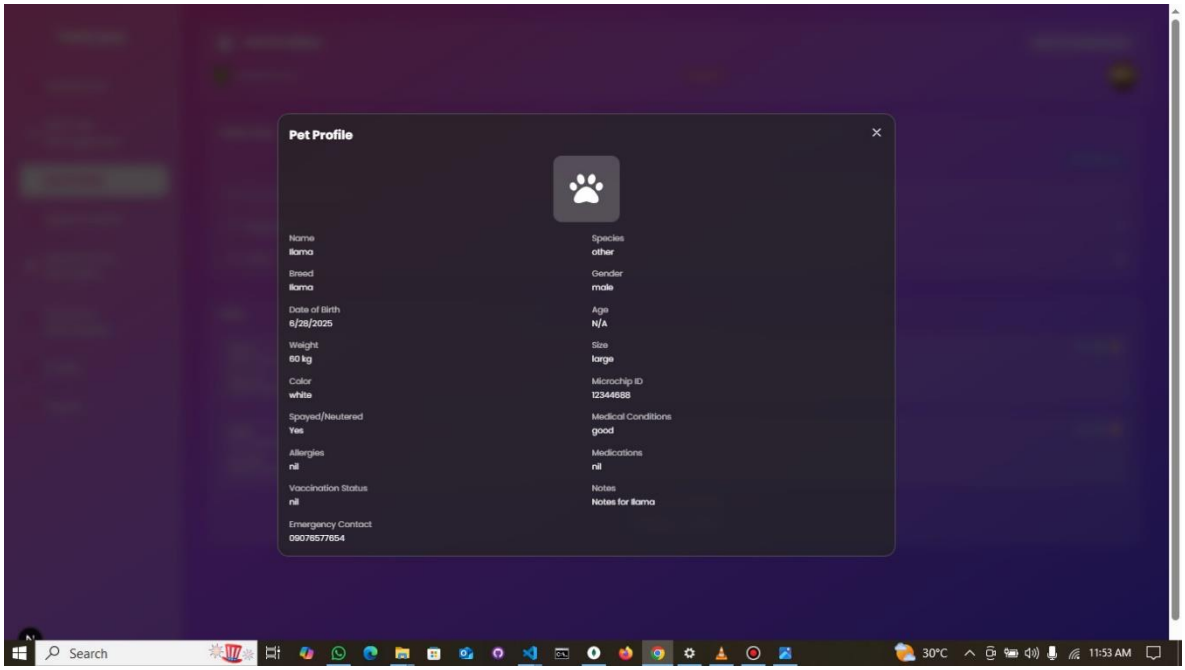

Figure 4.6: Pet details view showing complete pet data for consultations.

4.6 System of Notification and Reminder

The Veterinary Clinic Management System's Notification and Reminder System is intended to automate crucial user communications, such as reminders for vaccinations and appointment scheduling. By using backend background activities to verify upcoming appointments and vaccine due dates, this system reduces missed appointments and ensures timely immunizations by swiftly informing pet owners and staff via email alerts.

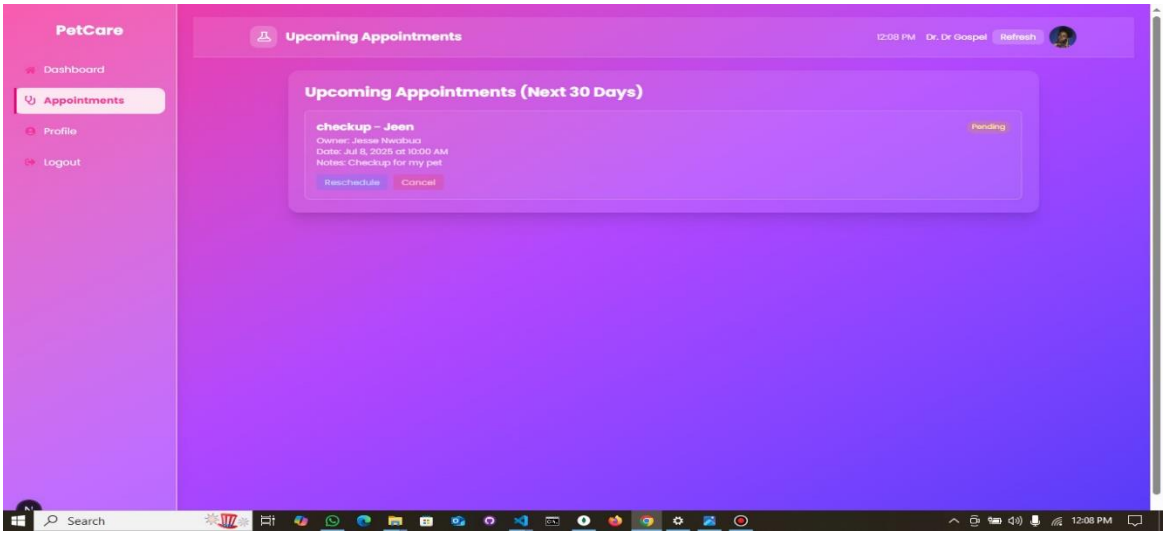

Figure 4.7: Dashboard view displaying notifications and appointment reminder.

In order to enhance the operational workflow in veterinary clinics, this research concentrated on the development and deployment of a web-based veterinary management system. The research was driven by the need to solve inefficiencies in appointment scheduling, pet medical record monitoring, and role coordination between administrative staff, veterinarians, and support workers. Gaps such the absence of centralized medical history keeping, secure user administration, and real-time scheduling were found during an evaluation of the current systems. These deficits led to the establishment of four main goals: (i) creating a safe authentication system with role-based access control, (ii) putting in place modules for managing medical records, appointments, and pets, (iii) offering administrative tools for user and security supervision, and (iv) to test and evaluate the system's performance and usability.

4. CONCLUSION AND RECOMMENDATIONS

In conclusion, developing a digital veterinary appointment management system tailored to the specific needs of clinics and clients addresses critical challenges in scheduling efficiency, data security, and client engagement. This project will contribute to improved service delivery, enhanced client satisfaction, and more streamlined operations in veterinary settings. Drawing insights from existing research and practices, the system will serve as a modern, practical solution to ongoing issues in veterinary care delivery.

Several suggestions are made for enhancing the Veterinary Management System and directing its future adoption in light of its successful deployment and evaluation:

a. Veterinary Clinic Adoption: Veterinary clinics should think about putting in place digital management systems similar to the one used in this study in order to streamline manual procedures, enhance appointment scheduling, and keep accurate pet medical data.
b. Channel Integration for Communication: Adding SMS or WhatsApp connection for warnings and appointment reminders can improve the system. This would decrease the number of missed appointments by enhancing communication between pet owners and clinic employees.
c. Training for End Users: Proper orientation and training should be provided to administrative staff, veterinarians, and support staff to ensure the system is used effectively and its full potential is realized.
d. Government and Institutional Support: Veterinary associations and educational institutions should support the development and adoption of systems like this in animal

health facilities and veterinary schools, as it promotes digital transformation and efficiency in service delivery.

In order to improve system security, accuracy, and user experience, future studies on the web-based face attendance monitoring system will investigate the use of sophisticated machine learning techniques, including artificial intelligence (AI). AI might be used to dynamically improve facial recognition and its performance in various settings, including illumination and a range of facial features (e.g., accessories, facial hair).

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