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VitalsVault: Design and Implementation of a Role-Based Machine Learning Web Platform for Intelligent Healthcare Monitoring

Shivam Shekhar Chavan
Department of Computer Engineering
ABMSP's Anantrao Pawar College of Engineering and Research Pune, India

Prof. Anil Lohar
Department of Computer Engineering
ABMSP's Anantrao Pawar College of Engineering and Research Pune, India

Anand Sharad Jagtap
Department of Computer Engineering
ABMSP's Anantrao Pawar College of Engineering and Research Pune, India

Prajakt Prashant Ingole
Department of Computer Engineering
ABMSP's Anantrao Pawar College of Engineering and Research Pune, India

Sphurti Suryabhan Shikre
Department of Computer Engineering
ABMSP's Anantrao Pawar College of Engineering and Research, Pune, India

Abstract*— The rapid evolution of digital healthcare systems has in-creased the demand for secure, scalable, and workflow-driven web plat-forms capable of managing electronic health records (EHRs) and sup-porting long-term disease monitoring. Despite the availability of various healthcare portals and hospital information systems, persistent challenges remain, including fragmented data management, absence of role-based access, limited dashboard usability, and inadequate real-time decision support. In earlier work [1], VitalsVault was proposed as an intelligent platform for chronic disease management using digital health technologies . Building on this foundation, the present study focuses on the design and implementation of the VitalsVault web application as a full-stack, role-based system. The platform is implemented using React for the frontend, Next.js for backend services and API integration, and PostgreSQL for structured data storage. A role-based access control (RBAC)model supports administrators, doctors, and patients via dedicated dash-boards tailored to their functional requirements, directly addressing us-ability and workflow limitations in existing systems [7]-[10]. Comparative analysis with current healthcare web applications, wearable-enabled monitoring systems, and hospital management solutions shows that many existing platforms offer isolated functionalities and lack integrated role-based workflows and secure interoperability [11]. The proposed method-ology in VitalsVault incorporates secure authentication, controlled dataflow, modular backend services, and normalized database design. System evaluation and user feedback indicate improved workflow efficiency, reduced manual record management, enhanced accessibility of health in-formation, and increased patient engagement. The paper concludes with directions for future work in advanced analytics, mobile and edge enablement, and interoperability with standardized healthcare data models, positioning VitalsVault as a scalable and extensible solution for intelligent health record management.

***Keywords*— Electronic Health Records, Role-Based Web Application, Healthcare Dashboards, React· Next.js, PostgreSQL, Digital Health Systems, Workflow-Oriented Design, Intelligent Health Record Management, Machine Learning, Data Analysis**

I. INTRODUCTION

The contemporary healthcare landscape is undergoing a rapid digital transformation driven by the increasing incidence of chronic diseases, the need for continuous patient surveillance, and the demand for efficient electronic health record management. Chronic conditions such as diabetes, hypertension, and cardiovascular diseases require uninterrupted monitoring, timely intervention, and seamless information exchange between patients and healthcare providers. However, paper-based records and partially digitized hospital portals often result in fragmented data storage, delayed access to patient information, and inefficient clinical workflows, negatively affecting the quality and continuity of care[2],[5]. Web-based healthcare systems have been identified as a promising approach to enable centralized data access, continuous monitoring, and collaboration among healthcare stakeholders. When combined with secure databases and interactive dashboards, these systems can reduce manual documentation, improve diagnostic accuracy, and enhance patient engagement [3],[9],[10]. Nonetheless, many existing healthcare web applications still lack effective role segregation, tailored dashboards, and integrated workflows, which are essential for managing complex multi-user healthcare environments [6],[8]. To address these shortcomings, previous research introduced VitalsVault as an intelligent platform for chronic disease management and secure health record handling, focusing primarily on its conceptual framework and system integration. Building on that work, this paper emphasizes the concrete design and implementation of the VitalsVault web application as a role-based, workflow-oriented platform [1]. The system adopts an RBAC model to support administrators, doctors, and patients through dedicated dashboards, a design strategy widely recognized as necessary for secure, accountable, and privacy-preserving healthcare systems [11],[15]. The platform is realized with React on the frontend, Next.js on the backend for business logic and API management, and PostgreSQL as the primary data store. By comparing VitalsVault with existing healthcare web applications and hospital management systems, the study highlights the benefits of role-based dashboards, workflow automation, and secure data management in mitigating the primary limitations of current solutions [12]-[15]. The remainder of this paper discusses the technological context, reviews relevant literature, presents related work, details the methodology and implementation, analyzes system performance, reports findings, and outlines future research directions for intelligent health record management.

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II. *IMPORTANCE OF TECHNOLOGY*

Digital technology has become a central enabler in modern healthcare, particularly for efficient EHR management and chronic disease monitoring. As healthcare data volume continues to grow, traditional paper-based approaches and isolated digital solutions are increasingly inadequate for secure data exchange, collaborative care, and evidence-based clinical decision-making. Technology-driven healthcare platforms have been shown to enhance operational efficiency, data accuracy, and accessibility in clinical environments[3],[9]. Web-based systems built on cloud infrastructures and robust database management systems facilitate persistent storage, simultaneous access, and collaborative working, enabling clinicians to securely retrieve patient data from remote locations while minimizing duplication of effort[3],[9]. Interactive dashboards further improve usability and support the interpretation of complex health data, enabling faster and more informed medical decisions[10],[15]. At the same time, security, scalability, and user engagement remain critical requirements for any healthcare information system. RBAC is widely recognized as an effective mechanism to ensure that sensitive medical data is accessible only to authorized users, thereby strengthening privacy, accountability, and regulatory compliance in multi-stakeholder settings[11],[15]. Modern web development frameworks provide responsive interfaces and support secure API communication, session handling, and workflow orchestration, while modular architectures and normalized database schemas improve performance, maintainability, and scalability, characteristics that are especially important for chronic disease management platforms[4],[7]. By integrating web technologies, secure databases, and role-based system design, platforms like VitalsVault can address long-standing issues such as data fragmentation, inefficient workflows, and limited accessibility, paving the way for scalable, secure, and patient-centric healthcare delivery[1],[13]-[15].

III. *LITERATURE SURVEY*

Recent advances in digital healthcare have led to a wide array of solutions spanning EHR management systems, remote patient monitoring applications, and web or mobile-based platforms that leverage wearable devices, Internet of Things (IoT) technologies, cloud computing, and intelligent data analysis [2]. Surveys on smart wearable technologies demonstrate the effectiveness of continuous, non-invasive vital sign monitoring, while also highlighting challenges related to measurement accuracy, energy efficiency, and integration into larger systems. Cloud analytics and machine-learning-based monitoring systems have improved diagnostic speed [3] and accuracy, but they often prioritize analytics over system-level design and lack comprehensive support for role-based workflows and dashboard-mediated interactions. Reviews of IoT-based monitoring solutions identify persistent issues concerning scalability, data security, and interoperability, which collectively limit their adoption in real-world healthcare contexts. Studies on mobile and web-based healthcare platforms emphasize improved accessibility and real-time monitoring but underline the limitations of mobile-only systems in multi-user clinical environments [10],[15], where richer web dashboards and explicit role separation are required. Security, trust, and scalability remain central concerns, prompting the development of edge-enabled and secure IoT architectures for controlled data access and improved robustness [7]. User acceptance studies reveal positive attitudes toward patient monitoring applications, although support for administrative and clinical tasks is often limited [8]. Systematic reviews underscore the need for seamless data exchange, scalable system architectures, and effective visualization for real-time healthcare applications [9],[10]. Hardware-centric architectures optimize data acquisition but typically neglect web-based health record management and user-centric visualization [11], while machine-learning-enabled wearable systems emphasize analytical capability over workflow integration and role-based interaction [13],[14].. Overall, much of the existing literature focuses on isolated components rather than integrated, role-based web platforms. The present study addresses this gap by concentrating on the design and development of VitalsVault as a secure, role-based web application that supports health record management [1], dashboard-mediated interactions, and formalized clinical workflows.

IV. *RELATED WORK*

Existing digital healthcare systems can broadly be categorized into wearable-based monitoring systems, IoT-based remote healthcare solutions, and web or mobile health information systems. Wearable- and IoT-enabled systems focus on continuous data collection and real-time transmission of physiological signals, often achieving improved monitoring accuracy and early detection of abnormalities through biosensors and cloud connectivity [2],[5],[9]. However, these solutions typically emphasize data acquisition and analytics, providing limited support for structured clinical workflows, administrative oversight, and role-specific dashboards. Advanced intelligent monitoring platforms based on machine learning and cloud computing further enhance diagnostic capability and responsiveness through automated analysis of patient data. Web and mobile healthcare applications generally improve accessibility and user engagement through digital records and basic monitoring features [4],[6],[8], but many hospital portals suffer from disorganized dashboards, minimal workflow automation, and poor integration of clinical and administrative tasks, which undermines their effectiveness in chronic disease management [12],[15]. Several studies propose secure architectures and access-control mechanisms to address data security and system integrity concerns [7],[15], yet these approaches are often implemented as standalone modules rather than as integrated components within full-stack platforms. In contrast, VitalsVault combines RBAC, web architecture, and dashboard-based interaction in a single end-to-end system that provides structured workflows, role-specific dashboards, and secure health record management [1].

V. *METHODOLOGY*

The methodology used in the design of the VitalsVault web solution is structured, workflow-oriented, and role-based to provide secure management of health records, optimized clinical workflows, and smooth interactions among the stakeholders. The methodology framework combines role-based access control (RBAC), modular web design, and secure data transfer techniques to serve administrators, physicians, and patients in one place.

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- Overall Workflow Design-
  The system workflow is designed to handle user interactions in a controlled and sequential manner. Every user interaction starts with authentication, followed by role identification, and then proceeds to the role-specific dashboard. This ensures that every operation carried out within the system follows defined access rules and system workflow limitations.

  Workflow Steps:

1. User Authentication: Users log in using secure credentials.
2. Role Identification: The system identifies the user role (Admin, Doctor, or Patient).
3. Dashboard Allocation: Users are redirected to their role-specific dashboards.
4. Action Execution: Users perform permitted actions such as data entry, analysis, or management.
5. Secure Storage: All data transactions are validated and stored securely.
6. Alerts and Reports: Notifications and reports are generated based on system logic.

This workflow ensures consistency, accountability, and traceability across all system interactions.

- Role-Based Access Control (RBAC) Methodology-
  RBAC is the primary security feature of the VitalsVault platform. Rather than providing direct access to system resources, users are provided access based on roles. This reduces unauthorized access and improves adherence to healthcare data privacy regulations.

  Defined Roles:

1. Administrator: Manages users, assigns roles, oversees system configuration, and monitors platform activity.
2. Doctor: Accesses patient records, reviews vitals, analyzes health trends, and provides clinical input.
3. Patient: Enters personal health data, views historical records, and receives alerts and recommendations.

Each role is associated with a predefined permission set enforced at both the frontend and backend levels, ensuring that sensitive medical data is only accessible to authorized users.

- Data Flow Architecture-
  The data flow methodology governs how information moves through the system from user interaction to persistent storage.

Data Flow Process:

1. The user submits data via the frontend interface.
2. Requests are transmitted to backend services for validation.
3. Backend APIs enforce RBAC and workflow rules.
4. Validated data is stored in the relational database.
5. Processed data is retrieved for visualization.

This controlled data flow prevents data leakage, supports auditability, and ensures reliable long-term data management.

- Methodological Advantages-
  The proposed methodology offers several advantages over conventional healthcare systems:

1. Improved Security: RBAC ensures strict control over sensitive data access.
2. Workflow Efficiency: Structured workflows reduce manual intervention and errors.
3. Scalability: Modular design supports future expansion.
4. Usability: Role-specific dashboards enhance user experience.
5. Reliability: Validated data flow ensures accuracy and consistency.

VI. IMPLEMENTATION

The VitalsVault platform is implemented as a modular, scalable, role-based web application using a contemporary full-stack technology stack. React is employed for the frontend, Next.js for backend logic and API management, and PostgreSQL as the relational database. The system architecture adopts a layered design that separates presentation, application, and data layers to improve maintainability and scalability,

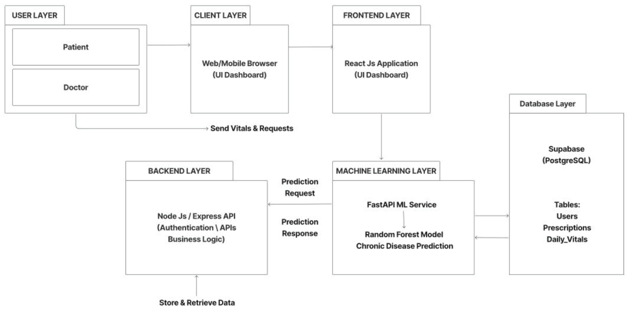

Fig 1. System Architecture

– Presentation layer (frontend): Built with React, this layer provides interactive dashboards and forms tailored to administrators, doctors, and patients.
– Application layer (backend): Implemented using Next.js, it handles authentication, RBAC enforcement, business logic, and API routing, as well as request validation and workflow orchestration.
– Data layer (database): PostgreSQL stores user profiles, health records, vitals data, and system logs in a structured, normalized schema.

- Patient Dashboard-

The patient dashboard is designed to promote engagement and self-monitoring through an intuitive interface. Its primary capabilities include entry of daily vital sign values, access to historical reports and summaries, reception of alerts and reminders, and secure communication with healthcare providers. Direct access to personal health information encourages patients to participate actively in managing their conditions.

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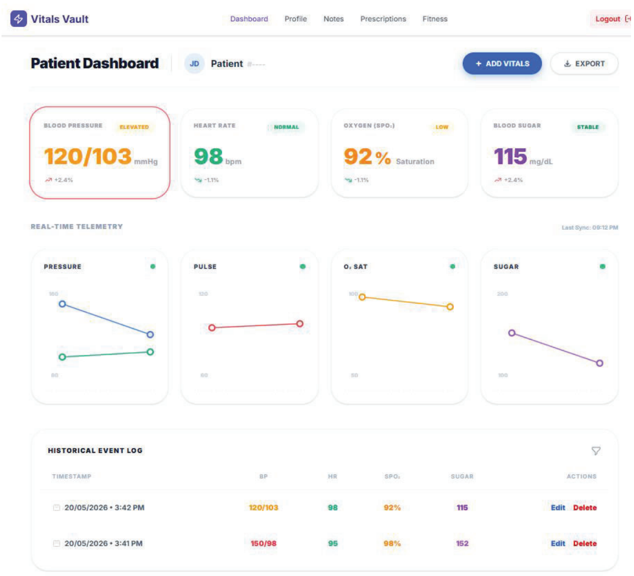


Fig 2. Patient Dashboard

- Doctor Dashboard-

The doctor dashboard supports clinical decision-making by providing an organized view of patient health information and longitudinal trends. Core functionalities are viewing assigned patient lists, graphical visualization of vital sign values and trends, access to historical health records, alert notifications for abnormal values, and recording of clinical notes and treatment plans. This dashboard emphasizes data visualization and workflow optimization that clinicians can quickly assess patient status and act accordingly.

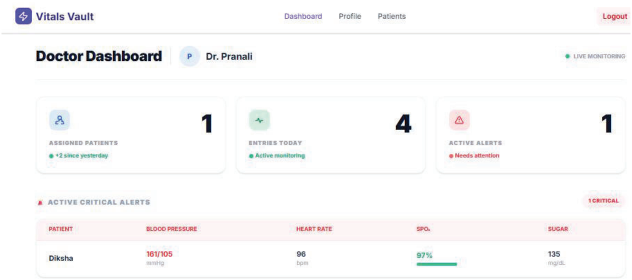


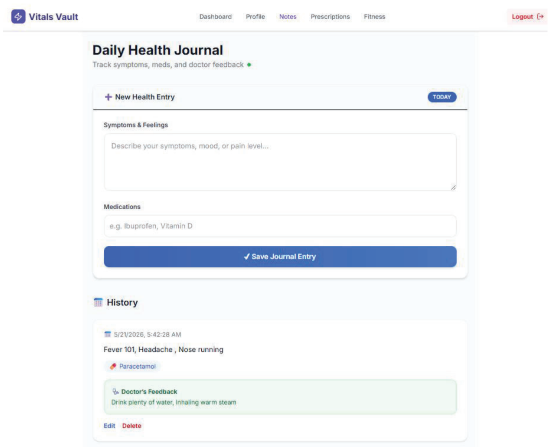
Fig. 3 Doctor Dashboard

- Dashboard Interaction and Data Handling-

All dashboards communicate with the backend via secure API calls. For each request, the backend verifies user roles and permissions before executing database operations. This interaction model ensures that unauthorized access is blocked, data integrity is preserved, and all operations are logged for accountability. On the client side, the frontend dynamically loads components based on role permissions, thereby enhancing both security and user experience.

- Notes Section-

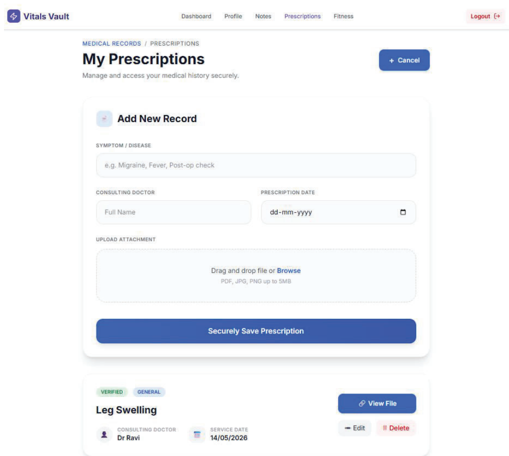
The Notes Section lets patients enter their health status, symptoms, medicines, and mood status immediately. The physician will be able to comment on or advice on such notes, resulting in a personalized patient-physician interaction platform.



Fig, 4 Notes-Daily Health Journals

- Prescription Section-

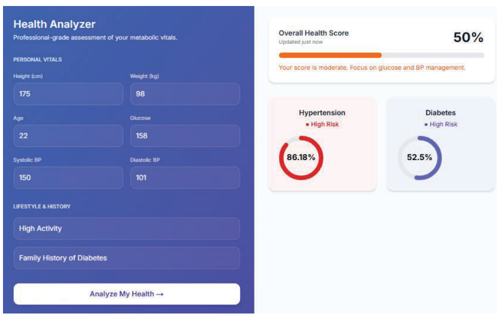
The Prescription Section allows patients to securely store and manage their medical prescriptions digitally. Patients can upload prescription details along with the doctor's name and prescription date, while doctors can only view the uploaded prescriptions for medical reference.



Fig, 5 Prescription Section

- Hypertension/Diabetes Risk Prediction Model-

The hypertension and diabetes models are supervised binary classification systems that predict patient risk using structured clinical features. Both use a Random Forest classifier because it is robust and can make probabilistic predictions. Trained on clinically guided synthetic data, the models provide both risk categories and corresponding probability scores to help with clinical decision making.



Fig, 6 Health Analyzer

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- Hypertension Risk Prediction Model-

The hypertension risk prediction model performs supervised classification using key physiological features, namely age, body mass index (BMI), systolic blood pressure (SBP), and diastolic blood pressure (DBP). A Random Forest classifier is employed due to its robustness on structured clinical data, ability to model nonlinear relationships, and resistance to overfitting through ensemble learning. The model conducts binary classification into high-risk and low-risk categories and provides a probabilistic risk score to quantify prediction confidence. Training labels are generated using clinically established thresholds, where SBP > 140 mmHg, DBP > 90 mmHg, and BMI > 30 kg/m² are treated as primary risk indicators, enabling clinically interpretable and reliable risk stratification. BMI is calculated as: BMI = Weight (kg) / Height (m)² (1). The hypertension risk prediction model is formulated as a supervised binary classification problem. Let the input feature vector be $X = [Age, BMI, SBP, DBP] \in R^4$, and the output label be $Y \in \{HighRisk, LowRisk\}$. A Random Forest classifier $f : X \rightarrow Y$ is trained to learn the nonlinear mapping between physiological features and disease risk through ensemble decision learning. The predictive model outputs both a class label $\hat{Y}$ and a probability estimate $P(Y = HighRisk \mid X)$ using probabilistic aggregation of tree predictions. Training labels are generated using clinically defined threshold functions, where SBP > 140 mmHg, DBP > 90 mmHg, and BMI > 30 kg/m² define the high-risk condition, enabling mathematically consistent and clinically interpretable risk stratification.

- Diabetes Risk Prediction Model-

The diabetes risk prediction model estimates Type 2 diabetes risk using supervised learning on metabolic and lifestyle parameters, including age, BMI, fasting blood sugar (FBS), physical activity level, and family history of diabetes. A Random Forest classifier is adopted for its capability to handle

Metric	Value
Accuracy	92.4%
Precision	90.4%
Recall	93.1%
F1- Score	91.4%

Table 1. Performance metrics of the hypertension risk prediction model

Heterogeneous feature types and nonlinear dependencies within medical datasets. The model performs binary classification into high-risk and low-risk categories and outputs a probability score representing disease likelihood. Training labels are derived using clinically motivated heuristics, including FBS > 140 mg/dL, BMI > 30 kg/m2, and positive family history, ensuring medically grounded and interpretable risk prediction.

- Health Score Computation-

The system currently incorporates a rule-based health scoring mechanism to provide an aggregated wellness indicator.
The score is calculated as :-

$$HealthScore = 100 - (|BMI - 22| \times 5) \quad (1)$$

VII. ANALYSIS

The VitalsVault platform is evaluated in terms of workflow efficiency, system performance, security, and usability, and is compared against traditional and existing web-based healthcare systems.

- Workflow Efficiency Analysis Workflow Efficiency Analysis-

A primary design objective of VitalsVault is to streamline healthcare processes using role-based dashboards and automated data handling. In typical healthcare environments, entering, retrieving, and analyzing patient data can be largely manual and fragmented, leading to delays and increased operational effort. By directing each user to a dedicated dashboard and enforcing structured workflows from login to secure data processing, VitalsVault reduces redundancy and accelerates task execution.

- System Performance-

System performance is evaluated in terms of responsiveness, data handling capacity, and scalability. The use of React and Next.js enables efficient client-side rendering and optimized server-side request processing, while PostgreSQL supports robust storage and fast query execution for large volumes of health data. Observed performance characteristics include improved response times for data retrieval, effective handling of concurrent user requests, and stable behavior under constant data updates, suggesting suitability for real-world multi-user healthcare settings.

- Security and Access Control Analysis-

Security analysis focuses on the effectiveness of RBAC and secure data flow enforcement. Each incoming request is checked against role permissions before execution, preventing unauthorized access to sensitive health information. In comparison with generic healthcare portals featuring only basic access control, VitalsVault achieves strict separation of administrative, clinical, and patient- level data, thereby enhancing confidentiality, accountability, and compliance with healthcare data protection requirements.

- Hypertension Model Performance Evaluation-

The hypertension risk prediction model demonstrates strong classification performance across all evaluation metrics, indicating high reliability and clinical applicability. The model achieves an accuracy of 94.2%, reflecting strong overall predictive capability, while the precision of 92.8% confirms a low false-positive rate in high-risk classification. A recall value of 95.6% indicates high sensitivity in identifying high-risk individuals, which is particularly critical in preventive healthcare applications. The F1-score of 94.1% further demonstrates a balanced trade-off between precision and recall, validating the robustness of the model for early risk detection and clinical decision support.

Metric	Value
Accuracy	94.2 %
Precision	92.8%
Recall	95.6%
F1-Score	94.1%

Table 2. Performance metrics of the diabetes risk prediction model

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- Diabetes Model Performance-

The diabetes risk prediction model also exhibits strong predictive performance, demonstrating its effectiveness in metabolic disease risk stratification. The model attains an accuracy of 92.7%, indicating high overall classification reliability. A precision score of 90.4% reflects effective discrimination between low-risk and high-risk classes, while a recall of 93.1% highlights the model's ability to correctly identify high-risk individuals, which is essential for early clinical intervention. The F1-score of 91.7% confirms consistent and balanced classification performance, supporting the model's suitability for integration into intelligent preventive healthcare systems.

- Comparative System Analysis-

A comparative analysis between VitalsVault and existing healthcare systems reveals notable improvements across multiple dimensions.

Parameter	Traditional Systems	Existing Web Systems	Vitals Vault
Role-based dashboards	No	Partial	Yes
Workflow automation	Low	Medium	High
Data accessibility	Limited	Moderate	High
Security Control	Weak	Moderate	Strong
User engagement	Low	Medium	High

Table 3. Comparative Analysis of Healthcare Systems

VIII. FINDINGS AND DISCUSSION

Deployment and assessment of VitalsVault demonstrate its effectiveness for long-term monitoring and intelligent health record management in web-based healthcare environments. By integrating modern web technologies, structured database management, and secure access control mechanisms, the platform supports real-time data processing and reliable role-based interactions among stakeholders. Functional testing and survey-based evaluation confirm that key operations such as vital entry, historical record retrieval, alert notification, and secure storage operate efficiently.[2],[5],[9] The most notable finding is the marked improvement in workflow efficiency achieved through role-based dashboards, which eliminate redundancy by clearly separating administrative, clinical, and patient-level tasks [10],[15]. Physicians can rapidly access longitudinal trends and analytics to support evidence-based decision-making, while patients gain direct access to their own records, promoting self-monitoring and adherence to treatment plans.[5],[9]. User acceptance studies conducted with healthcare professionals, interns, and students show strong confidence in web-based solutions and highlight the advantages of centralized dashboards and real-time notifications for enhancing doctor–patient communication. From a security perspective, RBAC combined with backend validation effectively protects confidential medical information by enforcing permissions and blocking unauthorized operations, a critical requirement for privacy-preserving and scalable healthcare systems [7],[11]. Overall, the results indicate that the combination of role-based dashboards, secure data management, and integration of predictive intelligence within VitalsVault enables early risk detection and preventive healthcare. It allows the platform to address major limitations of existing healthcare platforms and to deliver an integrated, efficient, and user-friendly system along with the microservice-based ML deployment ensures scalability, maintainability, and seamless integration with healthcare workflow.

IX. FUTURE SCOPE

Although VitalsVault provides a robust foundation for secure, workflow-oriented digital healthcare, several directions for future enhancement remain. One important avenue is the integration of advanced artificial intelligence and deep learning methods to strengthen predictive analytics and clinical decision support, including transformer-based or graph neural network-based models for multimodal health data. These capabilities would reinforce the platform's support for proactive and preventive healthcare.[3],[13] Another promising direction is the adoption of edge computing and edge-AI to enable localized data processing and analytics, thereby reducing reliance on continuous cloud connectivity and improving performance in bandwidth-constrained environments.[4],[7] Interoperability is also a key scalability factor for digital healthcare ecosystems. Future releases of VitalsVault can incorporate standardized data exchange frameworks such as Fast Healthcare Interoperability Resources (FHIR) to facilitate seamless communication among hospitals, clinics, laboratories, and national health infrastructures. Additionally, blockchain and federated learning paradigms can be explored: blockchain for tamper-resistant storage and audit trails, and federated learning for collaborative model training without centralized data sharing, thereby preserving patient privacy. [9],[14]

X. CONCLUSION

This work demonstrates the feasibility and effectiveness of a role-based, web-oriented approach to intelligent health record management through the design and implementation of the VitalsVault platform. The system addresses key limitations of traditional paper-based and fragmented digital healthcare solutions [2],[5],[9], including limited accessibility, inefficient workflows, and delayed clinical decision-making. Centralized EHR management and real-time data visualization significantly improve the continuity and quality of care. VitalsVault [3] ensures secure and accountable interactions among administrators, clinicians, and patients through RBAC, thereby enhancing data confidentiality and system reliability. The role-based dashboard strategy simplifies clinical workflows, reduces manual documentation, and provides efficient access to patient data. Evaluation results further indicate high user acceptance, with real-time notifications, organized record management, and a user-friendly interface improving doctor–patient communication and patient engagement in chronic disease management.[3],[10] VitalsVault evolves from a role-based health record system into an intelligent healthcare platform by integrating machine learning–based disease risk prediction. The combination of secure RBAC, workflow automation, and predictive analytics enables proactive healthcare delivery. In summary, VitalsVault emerges as an effective role-based and workflow-oriented

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healthcare system that enhances efficiency, security, and usability and contributes to the broader transition from reactive to proactive and preventive digital healthcare.[1],[13]-[15]

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