



CENTRALIZE NETWORK OF PATHOLOGY LABS WITH DIGITAL REPORT MANAGEMENT SYSTEM

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ABSTRACT

The Digital pathology integrates laboratory data and imaging to improve accuracy, speed, and accessibility in healthcare systems. This paper presents a "Centralized Network of Pathology Labs with Digital Reports Management System," designed to connect multiple laboratories through a secure, web-based platform. The system enables laboratories to upload test results, generate standardized digital reports, and provide real-time access to authorized users including doctors, specialists, and patients. Traditional pathology practices rely on paper-based records, manual data entry, and isolated operations, causing delays, inconsistencies, and increased risk of errors. The proposed system overcomes these limitations through automation, centralized storage, and efficient data management, enhancing operational performance and diagnostic reliability. Developed using modern technologies such as HTML, CSS, JavaScript, React, Node.js, and MySQL, the system ensures data security through authentication, role-based access control, and encryption. It is scalable for future integration with cloud computing and AI-based diagnostic tools. Overall, the system improves turnaround time, collaboration, remote consultation, and patient care in digital healthcare environments.

1. INTRODUCTION

Pathology laboratories are essential components of the healthcare system, playing a vital role in disease diagnosis and patient care. Traditionally, these laboratories rely on manual processes such as paper-based records, physical report handling, and isolated data storage systems. These methods often lead to inefficiencies including delays in report generation, data inconsistency, difficulty in accessing reports, and increased chances of human

error. With the advancement of information technology, there is a growing demand for digital solutions that can improve efficiency and accessibility in healthcare services. A centralized network system for pathology laboratories can address these issues by connecting multiple labs into a unified digital platform. Such a system enables seamless data sharing, real-time report access, and improved communication between patients, doctors, and laboratory staff. This paper

presents a web-based centralized pathology lab network with digital report management that enhances operational efficiency and provides a reliable and scalable healthcare solution.

2. LITERATURE REVIEW

A. Serrano-Gómez, E., et al. "DigiPatICS: Digital Pathology Transformation of the Catalan Health Institute Network of 8 Hospitals—Planning, Implementation, and Preliminary Results." *Diagnostics*, vol. 12, no. 4, 2022. "

The study by Serrano-Gómez, E., et al. (2022) titled "DigiPatICS: Digital Pathology Transformation of the Catalan Health Institute Network of 8 Hospitals Planning, Implementation, and Preliminary Results" presents a comprehensive approach to the large-scale digital transformation of pathology services across a network of hospitals. The research focuses on the implementation of a unified digital pathology system within the Catalan Health Institute, which includes eight hospitals. The primary objective of this initiative was to modernize traditional pathology workflows by introducing digital technologies and integrating multiple laboratories into a centralized and coordinated network. This research supports the proposed project by proving that a network of pathology labs with digital reporting is feasible and can significantly improve healthcare services.

B. Eccher, A., et al. "Digital Pathology Structure and Deployment in Veneto: Enabling a Regional Network of Pathology Laboratories." *Virchows Archiv*, 2024.

The study by Eccher et al. (2024) focuses on the design and deployment of a digital pathology infrastructure in the Veneto region to establish a regional network of pathology laboratories. The research highlights how traditional pathology systems were transformed into a fully digital environment by integrating advanced technologies such as digital imaging, centralized data storage, and laboratory information systems. The main objective was to connect multiple pathology labs across the region, allowing them to share data, standardize workflows, and improve coordination. The study emphasizes that a well-planned digital infrastructure is essential for achieving seamless integration among different laboratories. Furthermore, the research demonstrates that the implementation of a regional network significantly improves diagnostic efficiency and consistency. By enabling real-time data sharing and collaboration among pathologists, the system enhances decision-making and reduces delays in report generation. The study also points out challenges such as the need for high investment, strong IT infrastructure, and proper training for staff. Despite these challenges, the results show that digital networking of pathology labs is highly beneficial

and practical, supporting the development of integrated lab systems like the proposed project.

C. Araújo, A. L. D., et al. "Fully Digital Pathology Laboratory Routine and Remote Reporting during the COVID-19 Pandemic: Validation for Oral and Maxillofacial Pathology." *Virchows Archiv*, vol. 479, 2021.

The study by Araújo et al. (2021) examines the implementation of a fully digital pathology laboratory during the COVID-19 pandemic, with a focus on oral and maxillofacial pathology. The research highlights how the sudden need for remote healthcare services accelerated the adoption of digital pathology systems. By using digital slides and online reporting tools, pathologists were able to continue their work without being physically present in the laboratory. The study validates the effectiveness of digital systems in maintaining continuity of diagnostic services during emergency situations. In addition, the research confirms that remote reporting using digital pathology systems does not compromise diagnostic accuracy. The results show that digital reports are reliable and comparable to traditional microscopic analysis. The study also emphasizes the importance of proper validation, quality control, and training before implementing such systems. Overall, this research demonstrates that digital pathology is not only useful in normal conditions but also critical in crisis situations, making it highly relevant for systems involving digital report networks.

D. Schwen, L. O., et al. "Digitization of Pathology Labs: A Review of Lessons Learned." *Laboratory Investigation*, 2023.

The research by Schwen et al. (2023) provides a detailed review of the digitization of pathology laboratories and the lessons learned during the implementation process. The study analyses various aspects of digital transformation, including workflow changes, adoption of digital tools, and integration of laboratory information systems. It highlights that digitization significantly improves efficiency by reducing manual work, minimizing errors, and speeding up report generation. The use of digital systems also enhances data organization and allows easy access to patient records. However, the study also discusses several challenges associated with the digitization process. These include high initial costs, the need for advanced infrastructure, data storage requirements, and resistance to change among staff. The research suggests that proper planning, training, and phased implementation are essential for successful adoption. Despite these challenges, the study concludes that the long-term benefits of digital pathology outweigh the difficulties, making it a valuable advancement in healthcare system

The study by Pinto et al. (2023) presents a survey on the real-world implementation of digital pathology systems across Europe and Asia. The research provides insights into how different regions are adopting digital technologies in pathology and the factors influencing their implementation. It highlights that digital pathology systems improve collaboration between.

3. PROPOSED SYSTEM

The proposed system aims to develop a centralized digital platform that connects multiple pathology laboratories into a unified network. This system will replace traditional paper-based and isolated lab operations with an integrated Laboratory Information System (LIS) and digital reporting mechanism.

System Overview

The system will consist of:

- Centralized cloud-based database
- Web/mobile interface for patients, doctors, and lab staff
- Digital report generation and storage
- Secure data sharing across multiple labs

This centralized approach allows multiple labs to operate under a single platform, improving efficiency and coordination.

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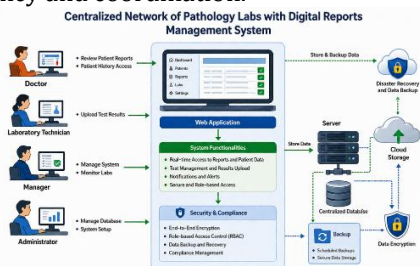


Figure1: Architecture of Centralized Pathology Lab Management System

The above diagram illustrates the architecture of the centralized pathology lab management system. It shows how patients, laboratory technicians, and administrators interact with the web application. All operations are processed through a secure system with authentication mechanisms and a centralized database for efficient data storage and retrieval.

The system follows a three-tier architecture:

A. Presentation Layer (Frontend)

- Developed using HTML, CSS, JavaScript
- Provides user interface for patients and admins

B. Application Layer (Backend)

- Handles business logic
- Processes user requests
- Manages authentication

C. Data Layer (Database)

- Stores user data, lab details, and reports
- Uses MySQL database

Workflow:

- User registers/login
- Searches for nearby pathology labs
- Books appointment
- Lab performs test
- Report uploaded to system
- User downloads report

5. IMPLEMENTATION

A. Frontend Implementation

The frontend of the Centralize Network of Pathology Labs with Digital Report Management System Report System is designed to provide a smooth, interactive, and user-friendly interface for all types of users, including patients, doctors, lab technicians, and administrators. It is developed using modern web technologies such as HTML, CSS, and JavaScript, ensuring that the application is responsive and accessible across different devices like desktops, tablets, and smartphones. The main goal of the frontend is to simplify user interaction and provide easy navigation, even for users with minimal technical knowledge. The frontend communicates with the backend and database using APIs and Firebase services, enabling real-time data updates without reloading the page. Form validation is implemented to ensure that users provide correct and complete information, reducing errors and improving data accuracy. The design follows modern UI/UX principles, with clean layouts, proper color schemes, and intuitive navigation, enhancing the overall user experience. Additionally, responsiveness ensures that the system adapts to different screen sizes, making it widely accessible.

B. Backend Implementation

The backend of the system is responsible for handling all core functionalities, including data

Processing, business logic, authentication, and communication between the frontend and the database. It acts as the backbone of the application, ensuring that all operations are performed efficiently and securely. The backend can be developed using technologies such as Node.js or integrated directly with Firebase services, which provide server less backend capabilities. The backend also manages the flow of data between the frontend and the Firebase database. Whenever a user performs an action, such as booking a test or viewing a report, the request is processed by the backend logic, and the appropriate response is sent back to the frontend. The system also handles sample tracking, where each sample is assigned a unique ID and its status is updated throughout the testing process. The database used in this project is Firebase Real-time Database, which is a cloud-based MySQL database that allows data to be stored and synchronized in real time. This database plays a crucial role in managing all the data related to patients, laboratories, test records, and digital reports. Unlike traditional databases, Firebase stores data in a JSON format, making it flexible and easy to manage. One of the key advantages of Firebase Real-time Database is its ability to provide real-time data synchronization. Whenever any data is updated, such as uploading a report or changing the test status, the changes are instantly reflected across all connected clients. This ensures that users always have access to the most up-to-date information without needing to refresh the application.

7. RESULTS AND DISCUSSION

The implementation of a centralized network of pathology laboratories with a digital report management system successfully demonstrated significant improvements in healthcare service delivery. The system enabled multiple pathology labs to connect through a unified digital platform, allowing seamless data sharing and report generation.

- The system was tested for performance and usability.
- Observations:
 - Reduced report generation time
 - Improved data accuracy
 - Easy access to reports
 - Better coordination between labs
- Comparison

Feature	Traditional System	Proposed System
Report Access	Manual	Online
Data Storage	Paper-based	Digital
Speed	Slow	Fast
Accuracy	Low	High

Workflow of Proposed System:

The workflow diagram illustrates the interaction between different users and the system. It shows

the step-by-step process from user login to report generation and access.

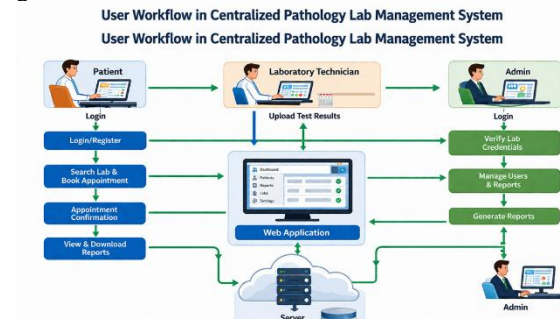


Figure 2: Workflow of Centralized Pathology Lab Management System

The above diagram represents the complete workflow of the system. Patients can register, search for labs, and book appointments. Laboratory technicians upload test results, and administrators verify labs and manage reports. The system ensures smooth data flow and efficient coordination among all users

8. ADVANTAGES

The centralized network of pathology labs with a digital report management system provides efficient and organized data handling by storing all patient records and reports in a single platform. This centralized approach makes it easy to access, manage, and retrieve information quickly while reducing paperwork and minimizing the risk of data loss. Another major advantage is the faster generation and delivery of reports. Digital automation allows laboratories to create reports quickly and share them instantly with patients and doctors, reducing waiting time and improving overall service efficiency. This also helps doctors make timely decisions for better patient care. The system improves accuracy and reliability by minimizing human errors in data entry and report preparation. Standardized digital formats ensure consistency and precision, leading to more dependable diagnostic results. Additionally, remote accessibility enables patients and healthcare professionals to view reports anytime and from anywhere, which is especially beneficial for people in rural or remote areas. It also enhances collaboration among laboratories and doctors, allowing easy sharing of reports and enabling second opinions from specialists. This improves the quality of diagnosis and treatment. Moreover, the system is cost-effective in the long run as it reduces the need for paper, storage, and manual labor, thereby lowering operational expenses.

9. FUTURE SCOPE

The future scope of a centralized network of pathology laboratories with a digital report management system is highly promising and aligned with emerging healthcare technologies

One of the major advancements will be the integration of artificial intelligence, which can assist in analyzing test results and medical images to detect diseases at an early stage with high accuracy. AI-based systems can help pathologists by providing decision support, reducing diagnostic errors, and improving efficiency. The use of cloud computing will allow the system to scale easily, enabling the connection of a large number of laboratories across different regions, thereby creating a nationwide or even global diagnostic network. In the future, telepathology will play a significant role, allowing pathologists to examine samples and reports remotely, which will be especially beneficial for rural and remote areas where access to specialists is limited. The system can also leverage big data analytics to study large volumes of patient data, helping in identifying disease trends, predicting outbreaks, and supporting medical research and public health planning. Integration with hospital management systems and electronic health records will provide a complete digital healthcare ecosystem, ensuring seamless data flow between labs, hospitals, and doctors.

CONCLUSION

The centralized network of pathology labs with a digital report management system represents a significant advancement in healthcare technology. It enhances efficiency, accuracy, and accessibility while reducing manual workload and errors. The system successfully bridges the gap between patients, doctors, and laboratories by enabling real-time data sharing and seamless communication. It ensures better patient care through faster diagnosis and improved collaboration among medical professionals. Although challenges such as cost, training, and data security exist, the long-term benefits outweigh these limitations. With the integration of advanced technologies like AI, cloud computing, and big data analytics, this system has the potential to revolutionize pathology services on a global scale. In conclusion, this project provides a scalable, efficient, and future-ready solution for modern healthcare systems, contributing significantly to digital health transformation.

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