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Research Article [OPEN ACCESS]

A Barcode-Based Medical Asset Management System with Integrated Monitoring in Hospitals

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ABSTRACT

This study proposes a barcode-based medical asset management system designed to address persistent challenges in hospital asset tracking, integration, and condition monitoring. Using the Design Science Research (DSR) methodology, the system was developed and implemented in Bhayangkara Sartika Asih Hospital, Indonesia. Key features include centralized data entry, QR code generation for unique asset identification, advanced search filters, and a real-time dashboard for visualizing asset conditions and distribution. Black box and usability testing involving 10 users demonstrated a 100% success rate in functional execution and high user acceptance, with 87.5% of respondents expressing satisfaction with the system's usability and effectiveness. This system enhances traceability, reduces redundancy, and supports data-driven decision-making in asset procurement and maintenance. The study also highlights the potential for broader adoption across Indonesian hospitals, with future integration of IoT components recommended to enable automated real-time asset condition updates. The proposed system contributes to the digital transformation of healthcare infrastructure in line with national health priorities.

Keyword: Asset management system, barcode technology, hospital digitalization

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1. INTRODUCTION

Hospitals play a fundamental role in delivering public healthcare services, and their effectiveness is highly dependent on the availability and management of medical equipment. Medical devices are indispensable for diagnosis, treatment, and patient monitoring, thereby making efficient asset management an essential component of hospital operations (Arab-Zozani et al., 2021; Gholamhosseini et al., 2019; Moons et al., 2019; Suakanto et al., 2021, 2024). Effective asset management also aligns with global development goals, particularly Sustainable Development Goal 3 (SDG 3), which seeks to ensure healthy lives and promote well-being for all (Das et al., 2021; SDGs Indonesia, 2024). In Indonesia, the medical device industry has undergone rapid expansion—recording an eightfold growth since the COVID-19 pandemic in 2020 (Indonesia.go.id, 2024). This surge has led hospitals to manage a growing and increasingly complex inventory of medical devices, intensifying the need for robust systems to support asset monitoring and maintenance (Lin et al., 2021).

However, despite the exponential increase in medical equipment, asset management in many Indonesian hospitals remains highly manual and fragmented. Hospitals often rely on spreadsheet-based tracking systems that lack integration, real-time updates, and standardized procedures. This results in several operational issues: difficulty in locating assets during critical procedures, inconsistencies in

inventory records, duplication of data entries, and delays in maintenance planning (Perwitasari et al., 2023; Widyadhari et al., 2024). Moreover, the absence of a centralized monitoring platform increases the risk of equipment loss or mismanagement, ultimately impacting healthcare service quality and operational sustainability (Ashari et al., 2024). These challenges are evident in Bhayangkara Sartika Asih Hospital, Bandung, where asset management is still decentralized and relies heavily on manual input, making it difficult for administrators to perform real-time asset tracking or make data-driven decisions.

Although several studies have attempted to address hospital asset management issues through the development of web-based systems, these efforts exhibit significant limitations. For example, prior research has largely focused on static assets—such as buildings or roads—without addressing the mobility and traceability of frequently relocated medical equipment (Arthana et al., 2024; Li et al., 2024; Zingde & Shroff, 2021). Other initiatives have introduced dashboards for asset management; however, these are typically limited to visualizing distribution data and fail to support real-time condition monitoring of mobile devices (Ashari et al., 2024). To date, there is a lack of comprehensive, dashboard-based systems that integrate real-time tracking, condition assessment, and barcode-based scanning specifically for mobile medical assets—such as infusion pumps, defibrillators, and portable monitors—which are crucial for day-to-day hospital operations.

In response to this gap, the present study aims to develop a barcode-integrated hospital asset management dashboard designed specifically for mobile medical devices. By incorporating barcode technology, the proposed system enables accurate tracking, condition monitoring, and maintenance management of medical equipment within the hospital setting. This system offers real-time data visualization and centralized information access, supporting more effective resource allocation, reducing the risk of asset misplacement, and enhancing operational decision-making. Furthermore, this study contributes to the broader discourse on digital transformation in healthcare by offering a scalable model for smart hospital asset management systems aligned with Indonesia's digital health infrastructure goals.

2. MATERIALS AND METHODS

2.1 Materials

This study aims to develop a hospital asset management dashboard, with Bhayangkara Sartika Asih Hospital in Bandung serving as the case study. Data were collected through direct observation and semi-structured interviews with hospital staff to obtain comprehensive insights into the current asset management practices. The collected data focused on the identification and classification of medical equipment used across various hospital units. These devices were categorized by function, including pediatric medical devices (e.g., curettage and dilation set, premature infant incubator), surgical medical devices (e.g., gynecological examination table, oxygen regulator), and emergency medical devices (e.g., operating table for gynecology). These assets were found to be distributed across 11 different rooms within the hospital.

Based on the identification process, key asset parameters required for inclusion in the dashboard system were determined. These parameters include the asset name, category, physical location, current condition, procurement date, unique asset code, and the presence of a barcode or QR code. In addition to the asset attributes, the study also identified the primary user roles within the hospital's asset management ecosystem: asset management officers, medical personnel, and administrative management. These stakeholders are integral to the successful implementation of the dashboard, ensuring accurate data entry, effective tracking, and informed decision-making. The information obtained in this phase forms the foundation for designing a contextually relevant and functionally complete asset management system tailored to the hospital's operational needs.

2.2 Methods

This study adopts the Design Science Research (DSR) approach, which emphasizes the creation and evaluation of innovative, technology-based solutions to address practical problems in specific organizational contexts (Hevner et al., 2004). DSR is characterized by a structured process that includes six

stages: problem identification, defining solution objectives, design and development, implementation, evaluation, and conclusion. In alignment with this framework, the present study employs DSR to develop a hospital asset management dashboard aimed at enhancing the tracking, monitoring, and maintenance of medical equipment. The application of DSR in healthcare informatics has been shown to be effective in developing contextually relevant solutions (Yousefli et al., 2020). The methodological stages implemented in this study are illustrated in Figure 1.

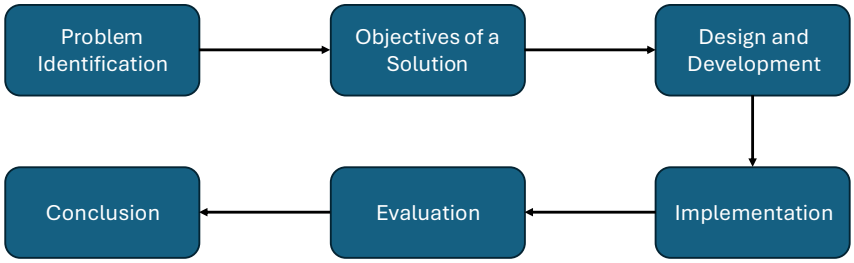

Figure 1. DSR methodology used in the development of the hospital asset management system

The first stage involves identifying key issues in the asset management practices at Bhayangkara Sartika Asih Hospital, including data duplication, inaccurate recording, difficulties in locating assets, and the absence of a centralized information system. A comprehensive literature review was conducted to support theoretical grounding and guide the formulation of solution objectives. The primary goal of the system is to facilitate accurate and efficient asset documentation, enhance traceability, and enable real-time condition monitoring of medical devices. During the design and development phase, functional features were determined based on user needs, including asset input, updates, and dashboard-based visualizations. The system was developed as a web-based application using the Laravel framework. The architectural design is represented using three diagrams: Use Case Diagram (Figure 2), Class Diagram (Figure 3), and Deployment Diagram (Figure 4).

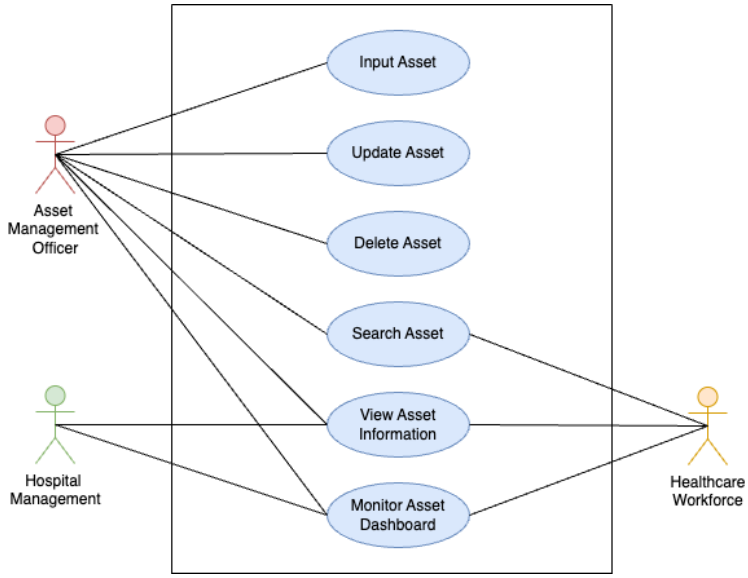

Figure 2. Use case diagram of the hospital asset management system

The Use Case Diagram illustrates interactions among three user roles—Asset Management Officer, Hospital Management, and Healthcare Workforce—who perform functions such as entering, updating, deleting, searching, and viewing assets. The Class Diagram provides the data structure of the system, consisting of classes such as item list, asset details, placement, and dashboard reporting, each defined with relevant attributes and methods to ensure modular system design (Babaalla et al., 2024). Meanwhile, the

Deployment Diagram outlines the system's technical architecture, including user clients (HTML5), a web server using the Laravel MVC framework, an application server that handles asset modules, authentication, and dashboards, and a MySQL database server. This deployment perspective captures the static configuration of the system components and their relationships during runtime (Suriya & Nivetha, 2023).

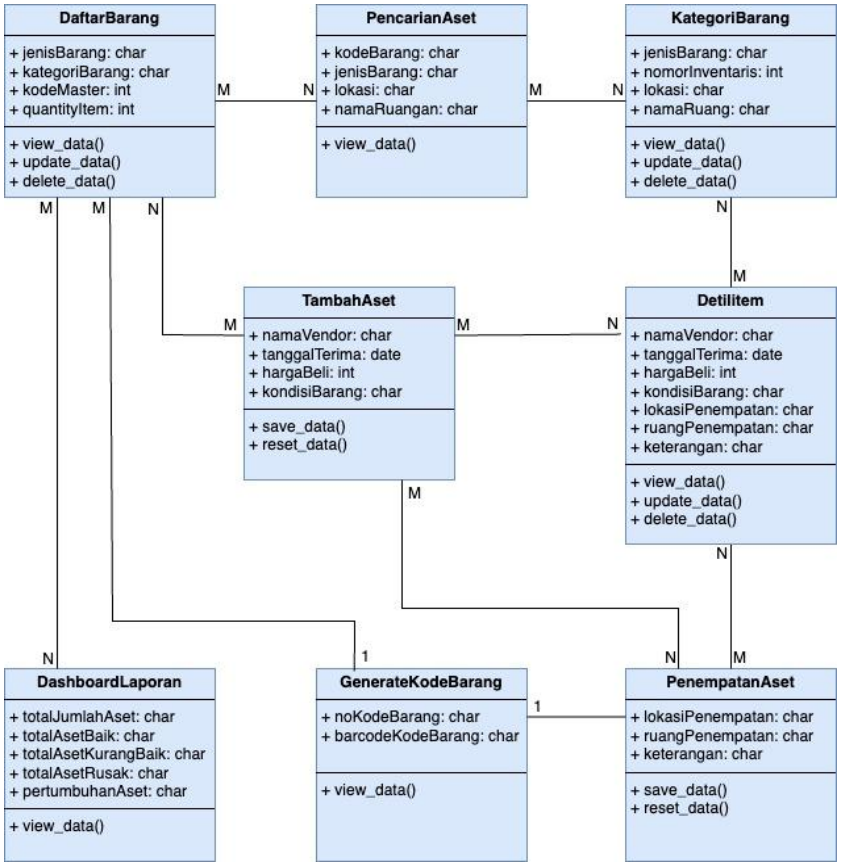

Figure 3. Class diagram representing the structure of the hospital asset management system

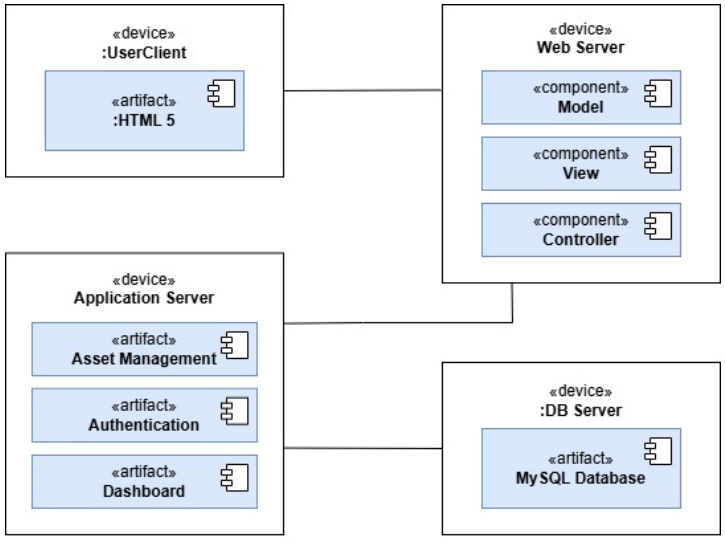

Figure 4. Deployment diagram of the hospital asset management system architecture

Following system development, the implementation phase was conducted within the hospital setting, involving both administrative staff and medical personnel. The evaluation focused on measuring system

functionality in recording and searching assets by category or location, as well as monitoring asset conditions in real time. User feedback was obtained through structured questionnaires to assess usability, data accuracy, and operational efficiency. These findings formed the basis for evaluating system effectiveness and provided insights for future system refinement and scalability.

3. RESULTS AND DISCUSSION

3.1 Implementation

The primary function of the developed system is to manage healthcare asset data and provide a visual dashboard that facilitates users in accessing relevant information about medical assets within the hospital. Several key features have been implemented, including asset master listing, detailed asset information, automated QR code generation, and a real-time asset monitoring dashboard.

1. Asset Master List

   The system includes a categorized master list of medical assets, such as the Curettage and Dilation Set, Gynecological Examining Table, and Operating Table for Gynecology. Each item is assigned a unique master code to prevent duplication and to ensure clear traceability between categories. The quantity column displays the number of available items in each asset group, enabling stakeholders to assess the total inventory per category. This categorization supports structured data management and efficient filtering. The asset master list interface is shown in Figure 5.

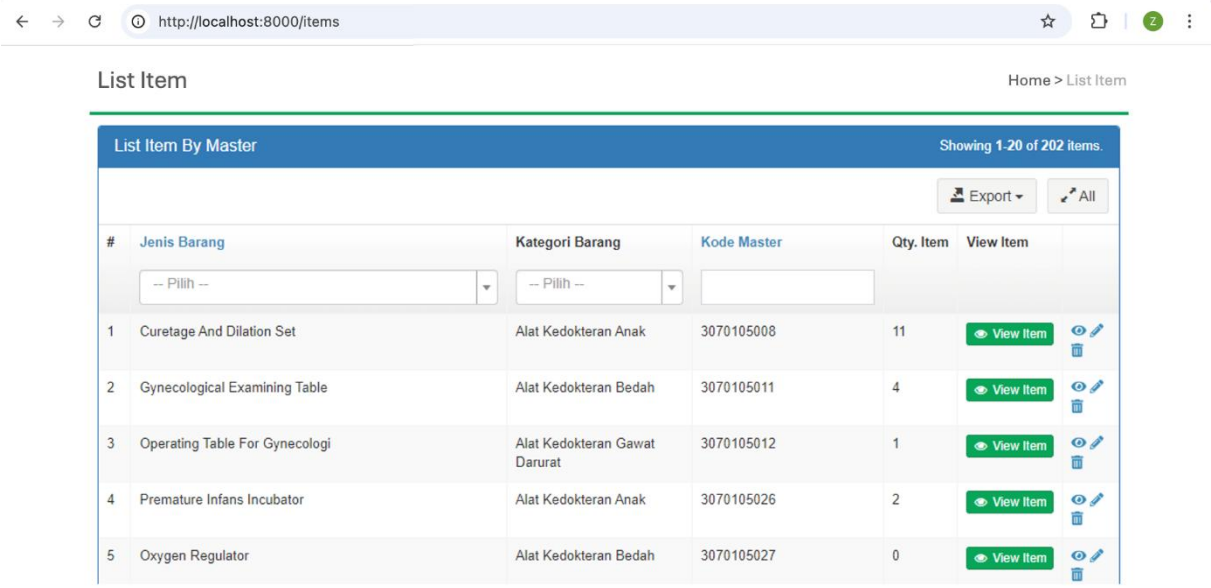

Figure 5. Master list interface of categorized hospital assets with item codes and quantities

2. Detailed Asset Information

   Users can access detailed records for each asset item, including inventory numbers, physical location, and room assignment. To facilitate asset retrieval, a filter-based search function allows queries by item type, code, location, or room. This feature significantly improves the speed and accuracy of asset tracking within the hospital. An example of the detailed asset information interface is presented in Figure 6.

3. Asset Code Generation and QR Integration

   Each newly added asset is registered with procurement details such as vendor, acquisition date, and item condition upon arrival. The system automatically generates a unique asset code and a corresponding QR code. These can be printed and affixed to physical items, enabling faster and more accurate asset scanning during audits or maintenance. This reduces confusion caused by visually similar equipment. The interface for asset code generation and QR management is illustrated in Figure 7.

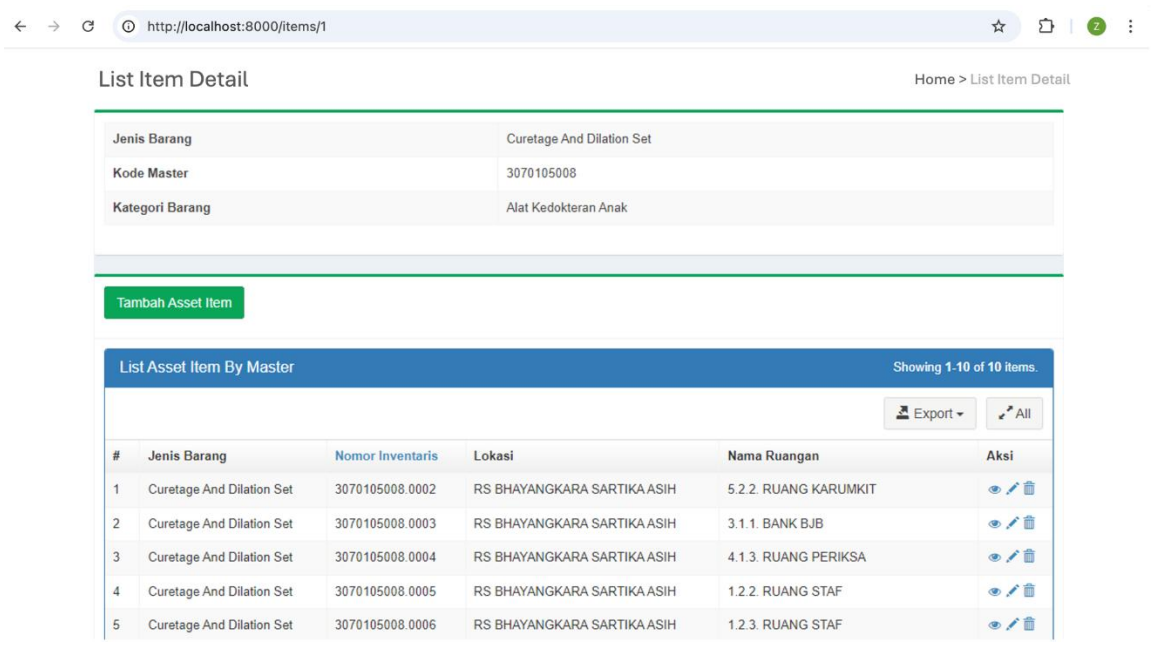

Figure 6. Asset item detail view including search filters and room-level allocation

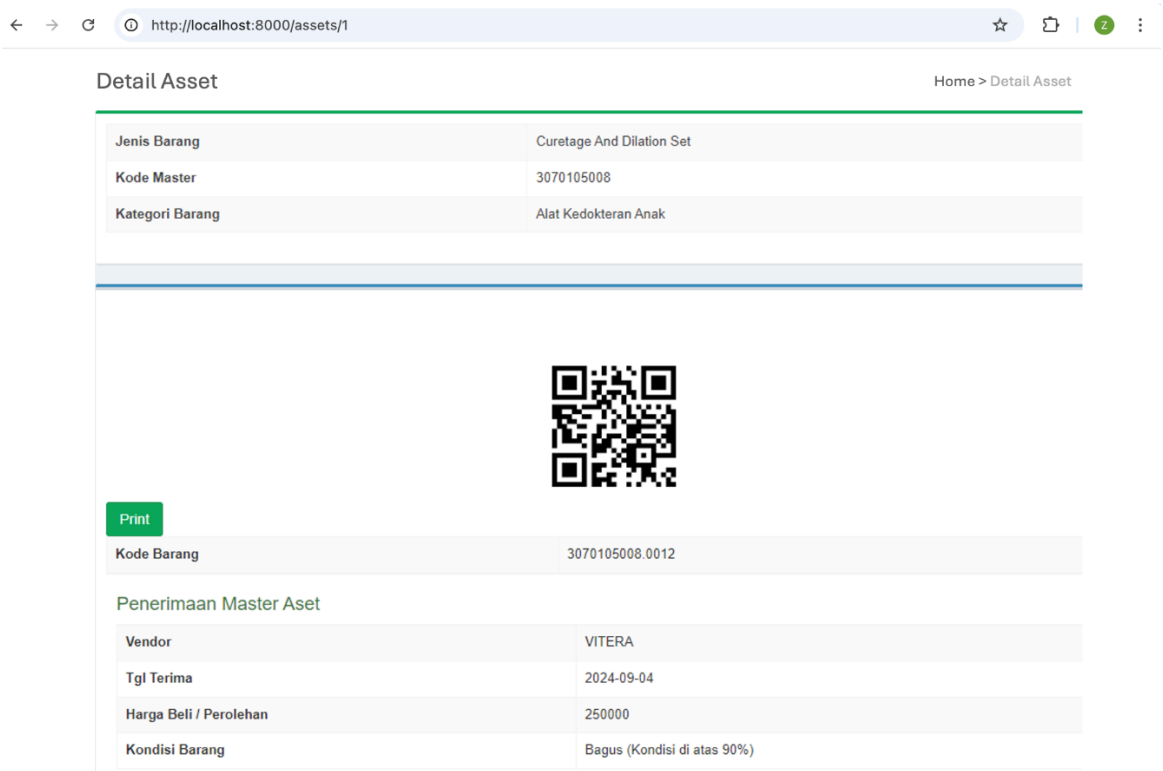

Figure 7. Asset registration interface with QR code and asset condition details

4. Dashboard Visualization

The dashboard feature provides real-time visual summaries of asset status and distribution. Users can view total asset counts, classify them by condition (e.g., good, poor, damaged), and monitor data across asset categories. The dashboard also supports institutional decision-making by offering insights into maintenance scheduling, budget planning, and inventory status. The asset monitoring dashboard is shown in Figure 8.

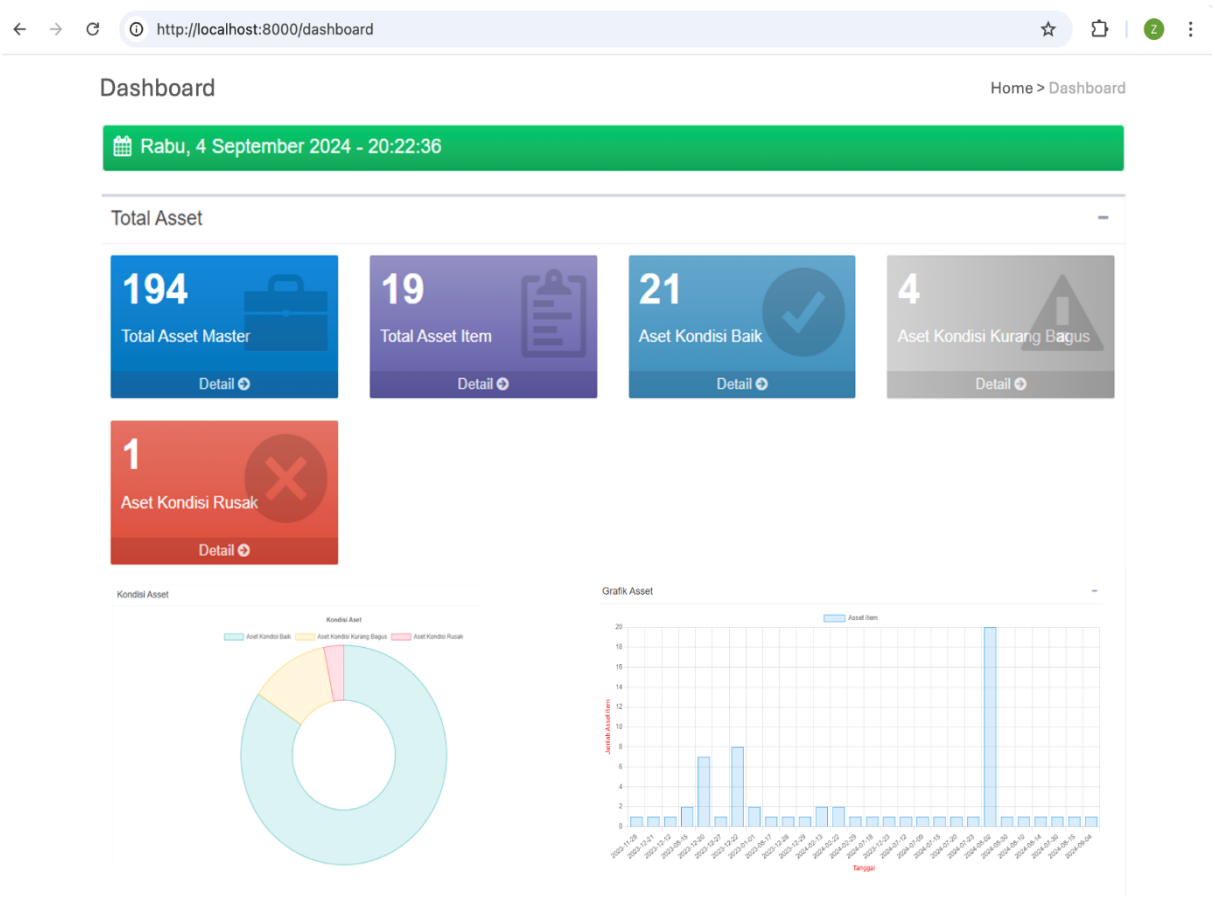

Figure 8. Dashboard view showing asset condition summary, distribution statistics, and trend visualization

Additionally, asset growth trends over time are visualized through graphical reports embedded in the dashboard. These graphs display annual increases or decreases in asset numbers, helping hospital administrators identify periods of high procurement activity or potential gaps in inventory management. This temporal information supports strategic planning for asset replacement or acquisition in subsequent fiscal years.

3.2 System Testing

To evaluate the system's functional performance, black box testing was conducted during the system testing phase. This approach involves executing the software to verify whether it meets the predefined functional requirements without examining its internal code structure (Munthe et al., 2020). In this study, the system was tested by a total of 10 participants, comprising 2 testers from the development team and 8 staff members from Bhayangkara Sartika Asih Hospital. A total of eight test scenarios were prepared, covering both valid and invalid inputs to assess how the system handles various user interactions. The results showed that all functionalities operated as expected, with a 100% success rate across all scenarios. These findings indicate that the system is functionally stable and meets its design objectives. Details of the test scenarios and outcomes are presented in Table 1.

To complement the functional testing, usability testing was also conducted to assess the system's ease of use, intuitiveness, and user acceptance. Usability testing evaluates how effectively users can interact with the system and whether the interface design facilitates a smooth user experience (Roa Romero et al., 2021). In this study, eight hospital staff members participated in usability testing and were asked to respond to several statements related to usability, such as ease of use, confidence in using the system, willingness to reuse it, and perceived system reliability. The results are summarized in Table 2.

Table 1. Functional performance results from black box testing of the hospital asset management system

ID	Test Case	Expected Result	Actual Result	Status
A.1	Adding assets with correct asset input	Assets can be added	Asset successfully added	Succes
A.2	Adding assets with incorrect asset input	Assets cannot be added	Asset failed to be added, an error message appears	Succes
A.3	Viewing asset list	Asset list can be displayed	Asset list successfully displayed	Succes
A.4	Searching for assets	Assets can be searched based on selected filters	Asset successfully searched based on the selected filter	Succes
A.5	Viewing asset information details	Asset details can be displayed	Asset details successfully displayed	Succes
A.6	Changing asset information	Asset information can be changed	Asset information successfully changed	Succes
A.7	Deleting assets	Assets can be deleted	Asset successfully deleted	Succes
A.8	Viewing asset dashboard	Asset dashboard can be displayed	Asset dashboard successfully displayed	Succes

Table 2. Usability testing results assessing user perceptions of system efficiency and satisfaction

ID	Questions	STS (%)	TS (%)	N (%)	S (%)	SS (%)
P.1	I think I will use this system again.	—	—	—	50%	50%
P.2	I find this system easy to use.	—	—	12.5%	50%	37.5%
P.3	I feel that I can use this system without assistance from others.	—	—	37.5%	62.5%	—
P.4	I believe the system's features function as expected.	—	—	—	37.5%	62.5%
	Total			**12.5%**	**50%**	**37.5%**

Note: STS = Strongly Disagree, TS = Disagree, N = Neutral, S = Agree, SS = Strongly Agree

Based on the feedback from users at Bhayangkara Sartika Asih Hospital, the system received a highly favorable response. A total of 87.5% of respondents either agreed or strongly agreed that they would reuse the system, found it easy to operate, and believed its features worked as expected. Moreover, all respondents expressed confidence in the system's functionality, and most felt capable of using it without external assistance. However, one participant (12.5%) expressed a neutral opinion on system usability. This feedback highlights both the system's strengths and areas for further improvement, which can inform future iterations aimed at enhancing overall user experience and satisfaction.

3.3 Discussion

This study addresses persistent challenges in hospital health asset management, which have been well documented in prior research. Previous studies have identified several critical issues, including the lack of integration of asset data across hospital departments, data redundancy, and difficulties in obtaining comprehensive information due to the absence of centralized visualization tools (Adha et al., 2023; Widyadhari et al., 2024). To overcome these limitations, the current study developed a centralized data input module supported by an integrated database. Additionally, a unique QR code generation feature was implemented to assign each asset a distinct identification code that can be physically affixed to medical devices. This approach effectively reduces data duplication, improves traceability, and enhances the accuracy of inventory records. Moreover, a search filter function was incorporated to facilitate faster and more precise asset location retrieval. To provide a comprehensive overview, the system also includes a dashboard feature that visualizes real-time asset data. This dashboard serves not only as an informational

tool but also as a decision-support mechanism for hospital administrators, enabling data-driven planning for asset procurement, maintenance, and accreditation processes.

Based on the system implementation and testing results, it can be concluded that the application operates reliably and meets its functional requirements. Functional testing using eight distinct scenarios resulted in a 100% success rate across all system features, indicating that the solution performs as intended. The system is aligned with national health regulations and hospital asset management guidelines, thereby ensuring institutional compliance and operational relevance. A barcode-based identification approach was adopted for its simplicity and cost-effectiveness in the early deployment phase. However, current asset condition assessments still rely on manual observations conducted by staff. Future improvements should consider integrating Internet of Things (IoT) technologies or similar sensor-based systems to automate condition monitoring. This would enable real-time updates of asset conditions in the system, further enhancing the accuracy, reliability, and efficiency of hospital asset management practices.

4. CONCLUSION

The development of a barcode-based hospital asset management system has successfully addressed key issues in asset tracking, data integration, and information access. Through features such as centralized asset entry, unique asset code generation, search filters, and a monitoring dashboard, the system enables faster identification, better organization, and improved control over medical equipment within the hospital. The implementation results showed that all system functionalities ran successfully, supporting the practical use of the application in a real hospital environment.

Given the widespread nature of similar challenges across healthcare institutions, this system has the potential to be adopted in various hospitals with minimal adjustments. Its integration into existing workflows can support structured asset monitoring, improve inventory transparency, and strengthen audit readiness. Future enhancements may include the integration of IoT technologies to enable automated condition detection, thus further improving the system's responsiveness and precision in supporting hospital asset management.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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