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Development of a Reliable Information System for Medical Device Inventory in Hospitals: A Systematic Literature Review

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A B S T R A C T

Developing an information system for medical equipment inventory in hospitals not only includes technical aspects but also involves an in-depth understanding of the operational needs of the hospital itself. By utilizing the latest technology, such as the Internet of Things (IoT), and efficient data integration, hospitals can ensure that the information systems developed can adapt to the dynamics of future technological needs and developments. This study aimed to explore the development of a reliable information system for inventory of medical equipment in hospitals. The literature search process was carried out on various databases (PubMed, Web of Sciences, EMBASE, Cochrane Libraries, and Google Scholar) regarding the development of a reliable information system for the inventory of medical devices in hospitals. This study follows the preferred reporting items for systematic reviews and meta-analysis (PRISMA) recommendations. Developing an information system for medical device inventory in hospitals is a crucial step in improving the efficiency, availability, and management of health resources. Developing an information system for medical device inventory in hospitals is not just about recording and monitoring but also providing a holistic solution to improve operational efficiency and patient service.

1. Introduction

Hospitals are complex health institutions where managing medical equipment inventory is a critical element in providing quality health services. The correct and efficient use of medical equipment not only supports optimal diagnosis and treatment but also ensures patient safety and the operational efficiency of the hospital itself. Therefore, the development of an information system that is relied upon to manage the inventory of medical equipment in hospitals is an urgent need. In the era of continuously developing information technology, information systems can be an effective solution for improving medical equipment inventory management. This system not only simplifies the recording and monitoring process but also helps make more precise and real-time decisions. The reliability of information systems is the main key to ensuring the availability of adequate medical equipment, reducing the risk of loss or shortage of inventory and ensuring that each medical device can be used in optimal conditions.[1-3]

Developing an information system for medical equipment inventory in hospitals not only includes technical aspects but also involves an in-depth understanding of the operational needs of the hospital itself. By utilizing the latest technology, such as the Internet of Things (IoT), and efficient data integration, hospitals can ensure that the information systems developed can adapt to the dynamics of future technological needs and developments. It is important to note that the implementation of this information system is not only a step toward operational efficiency

but also an effort to improve health services as a whole. By ensuring the availability of optimal medical equipment, hospitals can provide better care to patients, increase medical staff productivity, and ultimately support the hospital's vision and mission as a provider of superior and sustainable health services.[4-6] This study aimed to explore the development of a reliable information system for inventory of medical equipment in hospitals.

2. Methods

The literature search process was carried out on various databases (PubMed, Web of Sciences, EMBASE, Cochrane Libraries, and Google Scholar) regarding the development of a reliable information system for the inventory of medical devices in hospitals. The search was performed using the terms: (1) "development" OR "system" OR "information" OR "inventory" AND (2) "medical equipment" OR "hospital." The literature is limited to studies and published in English. The literature selection criteria are articles published in the form of original articles, a study about the development of a reliable information system for inventory of medical equipment in hospitals, studies were conducted in a timeframe from 2013-2023, and the main outcome was the development of a reliable information system relied on for inventory of medical equipment in hospitals. Meanwhile, the exclusion criteria were studies that were not related to the development of a reliable information system for the inventory of medical equipment in hospitals and duplication of publications. This study follows the preferred reporting items for systematic reviews and meta-analysis (PRISMA) recommendations.

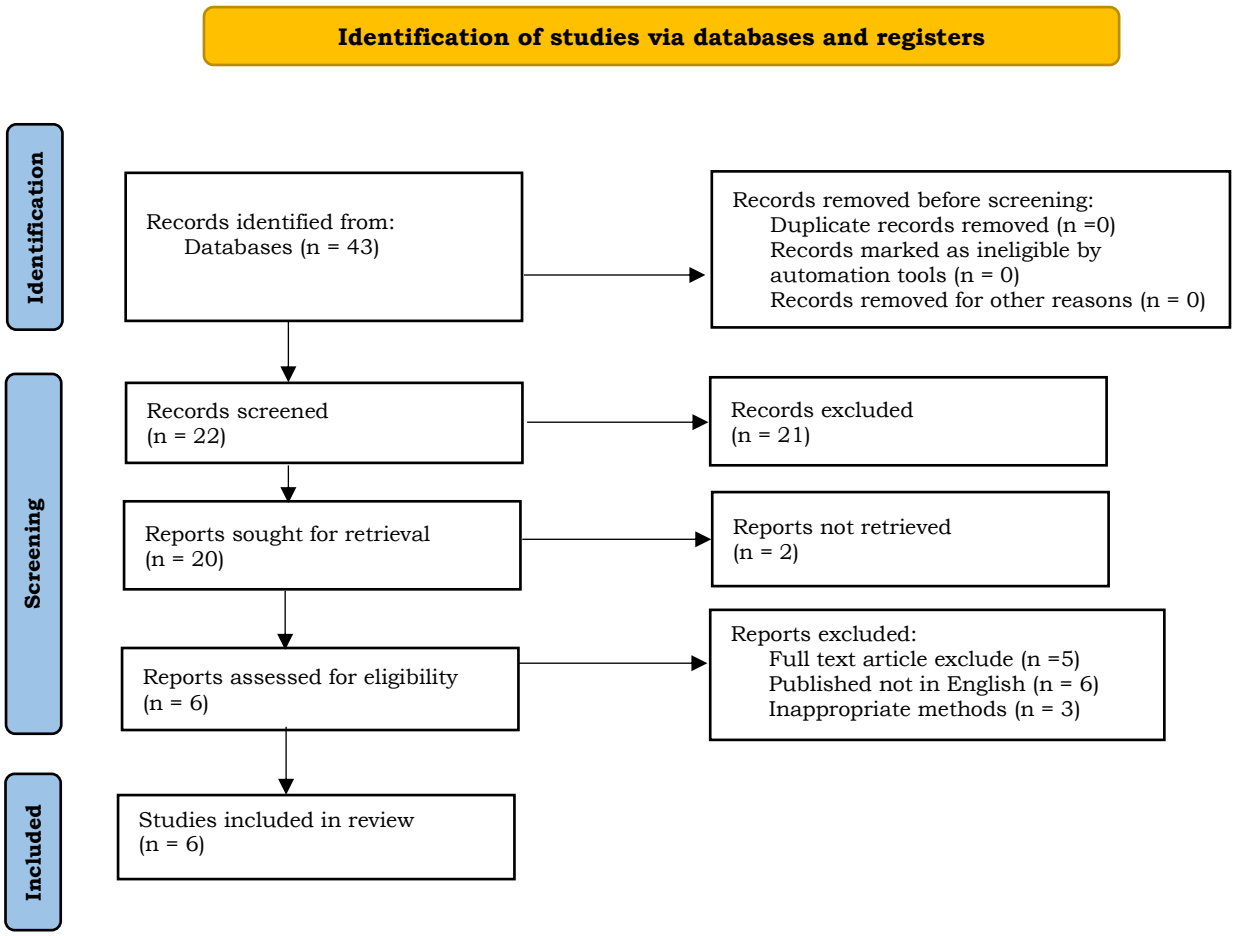

Figure 1. PRISMA flowchart.

3. Results and Discussion

Identify needs and goals

Identification of a hospital's specific needs is a critical step in the development of an information system for medical device inventory. Conduct interviews with related parties at the hospital, such as warehouse staff, nursing staff, medical personnel, and operational managers. Ask about the daily challenges they face in medical device inventory management and listen to their expectations and needs for the new system. Review internal hospital documents, such as inventory reports, expenditure records, and analysis of medical equipment needs. Assess weaknesses and potential improvements of existing inventory management systems. Conduct direct observations of the medical equipment inventory management process in various units or departments in the hospital. Identify manual processes that might be improved with information systems. Conduct surveys or distribute questionnaires to hospital staff to gain a broader view of needs and expectations regarding medical equipment inventory management. Collect quantitative and qualitative data to support needs analysis. Conduct benchmarking with other hospitals that have successfully implemented information systems for medical equipment inventory management. Compare best practices and understand whether there are certain features or strategies that can be adopted. Form a work team consisting of representatives from various departments in the hospital, such as IT, warehouse, nursing, and management. Hold regular meetings to discuss and validate needs. Create a visual mapping of the business processes involved in medical device inventory management. Identify critical points and areas that can be optimized with information systems. Assess the risks associated with medical device inventory management, such as the risk of stock calculation errors or the risk of losing medical devices. Review compliance with applicable health regulations. Hold focus meetings with related parties to deepen specific areas that require special attention. Get in-depth input and solutions from those with direct experience in inventory management.[7-10]

Business process analysis

An in-depth analysis of the business processes associated with medical device inventory management involves a comprehensive understanding of how medical devices are acquired, stored, reordered, and managed. The analysis begins by determining the need for medical equipment based on requests from various departments in the hospital. Identify clinical and operational factors that influence medical device selection. Users or related departments submit requests for purchasing medical devices to the procurement department. This process includes technical specifications, quantities required, and reasons for selecting a particular medical device. The procurement team evaluates proposals from potential vendors. Vendor selection is based on criteria such as quality, price, after-sales support, and regulatory compliance. After selecting vendors, medical equipment is purchased, and goods are received. Receiving information, including quantity and condition of goods, is recorded in the system. Every medical device received is recorded in an inventory system, including information such as serial number, expiration date, and storage location. The use of barcode or RFID technology can speed up this process. Establish optimal storage methods based on medical device characteristics, such as storage temperature, humidity, or other special requirements. Set storage locations for easy access and organization. Using sensor technology or real-time monitoring to ensure the condition of medical devices remains optimal during storage. Through an information system, hospitals can monitor medical equipment supplies in real-time. This monitoring helps identify when medical devices need to be reordered. Implementation of an automated ordering system based on minimum inventory limits or specific requests. Ensure the availability of medical equipment without excessive human intervention. The procurement team validates orders to ensure compliance with needs and budget availability. The information system tracks the

lifespan of each medical device to avoid use after a specified time limit. Provide notifications if a medical device is approaching its useful life limit. Establish preventive maintenance schedules for medical devices to ensure optimal availability and prevent breakdowns. The system records the repair and replacement history of medical devices. Provides information for performance evaluation and decision-making regarding equipment replacement or upgrades.[11-13]

Technology selection

Choosing the right platform and technology is key to building an information system for medical equipment inventory in hospitals. For inventory management, relational databases such as MySQL, PostgreSQL, or Microsoft SQL Server can be used. NoSQL databases such as MongoDB can also be considered, especially if the inventory data has a flexible structure. Design an adequate database schema to store information such as medical device data, stock status, storage location, and transaction history. Make wise use of indexes to speed up search and update operations. The choice of programming language can depend on the expertise of the development team and system requirements. Languages such as Java, Python, or PHP are generally used for web application development. The choice of web-based technologies such as Node.js or Ruby on Rails can also be considered. Use development frameworks such as Django (Python), Spring (Java), or Laravel (PHP) to speed up development and ensure application security. Leverage frontend technologies such as React, Angular, or Vue.js to create responsive and easy-to-use user interfaces. Choose a hosting service that is reliable and suits your needs, such as AWS, Azure, Google Cloud, or a local-based hosting platform such as Kubernetes. Consider using serverless services to reduce infrastructure complexity. Implement security protocols such as HTTPS for secure communications. Use firewalls and authentication mechanisms to protect access to information systems. Design an architecture that supports high availability and horizontal scalability. Implement caching and load balancing mechanisms to improve system performance. Provide a good API to enable integration with other systems in the hospital, such as patient management systems or electronic medical records (EMR). Use message queues such as RabbitMQ or Apache Kafka to ensure reliable message delivery between modules or systems. Implement appropriate middleware to unify disparate systems, ensuring interoperability between applications and software.[14,15]

System design

Users can submit new orders by filling out an intuitive form. The form should include information such as the name of the medical device, the quantity ordered, and other specific requirements. There is an option to choose which vendor to select based on the evaluation of criteria such as price, quality, and delivery time. Users can see the status of their order, whether it is in process, in delivery, or has been received. Automatic notifications are sent to related parties when order status changes. The system records order history for each medical device, including details such as order date, quantity, vendor, and status. The system connects with automated technology (e.g., barcode or RFID) to monitor stock in real time. When there is a change in stock, the system automatically updates the information in the database. The system sends automatic notifications to users or warehouse staff when medical equipment stock approaches or reaches the specified minimum limit. The system records every stock update, including time, quantity added or reduced, and responsible users. Users can select the type of report they want to create, such as availability, usage, equipment condition reports, or other custom reports. The system supports automatic scheduling of report generation, whether daily, weekly, or monthly reports, to ensure the availability of up-to-date information. Reports are presented in the form of data visualizations that are easy to understand, such as graphs or diagrams, to support decision-making.

Users can export reports to commonly used formats, such as PDF or Excel, to share with interested parties. This system is integrated with the inventory management module to ensure data consistency between orders, stock updates, and other inventory information. The system can be integrated with other systems in the hospital, such as patient management systems or electronic medical records (EMR), to support interoperability. The system implements a strict authorization model to ensure that only authorized users can access, change, or delete order data, stock updates, and reports. Use of strong security protocols, such as data encryption and access control, to protect sensitive information in the system. The system records every user activity, creating an audit log that can be used to track changes or potential security events. With this design, the order management, stock updating, and inventory reporting systems become integrated, efficient, and responsive to hospital needs. Ensuring an intuitive user interface and clear data visualization will help users use the system effectively.[16-18]

Integration with other systems

Integration with patient management systems allows information exchange between inventory management systems and patient data. Patient data, such as health history or certain medical conditions, can influence the need for certain medical devices or influence the selection of medical devices needed. The integration allows the synchronization of patient care data with the inventory of medical devices used during treatment. This helps in monitoring and analyzing medical device usage based on the type of treatment or patient condition. Patient management systems can provide notifications to care staff when certain medical equipment is unavailable or nearing exhaustion, allowing for quick action. Integration with financial systems allows automatic updates to budgets related to the procurement and expenditure of medical device inventory. Ordering and purchasing information can directly affect the status of the available budget. An inventory management system can track the cost of using medical devices for a particular patient. This information can be provided to financial systems for overall maintenance cost tracking. The integration enables the creation of financial reports integrated with inventory data, providing a complete picture of medical device management costs. Data exchanged between inventory management systems and other systems must be protected with a high level of security. Uses strong encryption and authentication protocols to prevent unauthorized access. Implement mechanisms to maintain data consistency between various systems. Use of transaction or data synchronization methods to ensure that information stored in various systems is always current and accurate. Provides an open and easily accessible API to enable integration with other systems. Good API documentation makes it easier for developers from other systems to understand how to interact with the inventory management system. Use middleware or integration hubs to simplify and unify the data exchange process between different systems. Middleware can facilitate data transformation and ensure information alignment. The system can provide notifications to related parties in various departments when significant changes in inventory status occur. Notifications can be customized according to recipient preferences. Implement an activity tracking system (audit log) that records every change and interaction between the inventory management system and other systems. This information can be used for auditing and troubleshooting purposes.[19]

Monitoring and evaluation

System monitoring mechanisms are key to maintaining optimal performance and identifying areas that require improvement or improvement. Use monitoring tools such as Prometheus, Nagios, or Grafana to monitor server health, including CPU usage, memory usage, and storage space. Set threshold limits for notifications to respond quickly to potential issues. Implement a good logging system to document important activities and events in the system. Log analysis can help identify problems or

system errors that require attention. Use third-party services such as UptimeRobot or Pingdom to monitor website or application availability. Immediate notifications if downtime or performance degradation occurs. Measure application response time for each request with tools such as New Relic or Datadog. Identify endpoints or application functions that are slow or frequently experience increased response times. Use analytical tools such as Google Analytics to monitor user behavior and identify the areas of your application that are used most often or cause the most problems. Use tools like Wireshark or PRTG to monitor network traffic and identify potential bottlenecks or connection problems. Provides bandwidth monitoring to understand network usage by systems and applications. Identify unusual or sudden increases in bandwidth usage. Use tools such as MySQL performance schema or Oracle Enterprise Manager to monitor database performance. Identify slow queries or indexes that need to be optimized. Establish capacity monitoring to identify database usage trends and prevent overload. Warning when approaching the maximum capacity limit. Review system security logs to detect suspicious activity or potential attacks. Implement SIEM (security information and event management) tools for advanced security log analysis. Perform regular security scans to identify potential security gaps and system weaknesses. Repair or improve system security based on findings from scans. Monitor the availability of external services or APIs used by the system. Get notified if there is a disruption in third-party services that could affect system performance. Carefully organize notifications so that the IT team or system manager can respond immediately to problems. An effective real-time notification mechanism is key to quickly identifying and resolving issues. Implement automatic escalation to move issues from a lower priority level to a higher priority level if they are not resolved within a certain time. Store historical monitoring data for long-term trend analysis. Compare current performance with previous periods to identify significant changes. Generate regular system performance reports to provide to the management team or stakeholders. This report should include key performance metrics and recommendations for improvement. Implementation of this monitoring mechanism will help manage and improve system performance effectively. By detecting problems before they impact end users or hospital operations, IT teams can make fixes or upgrades quickly, increasing system availability and user satisfaction.[20]

4. Conclusion

Developing an information system for medical device inventory in hospitals is a crucial step in improving the efficiency, availability, and management of health resources. Developing an information system for medical device inventory in hospitals is not just about recording and monitoring but also providing a holistic solution to improve operational efficiency and patient service.

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