

Assess impact of hospital laboratory information management systems in hospital

Fahad Saeed Salloum¹, Manal Mahmood A Yousuf², Samiah Marzook Alnefaie³, Abdullah Hdeesh Mohammed Al Fathel⁴, Mohammed Salem Mohammed Aldughdugh⁵, Amal Mahmood Yousuf⁶, Mohammed Ateeq Hussein Al Yami⁷, Hussain Ateeq Hussain Al Yami⁸, Yahya Saleh Yahya Al Yami⁹, Haia Duairam Alshahrani¹⁰

1-Health Administration Specialist -Fssalloum@Moh.Gov.Sa
2-Technician Health Administration-Mmyousuf@Moh.Gov.Sa
3-Specialist Health Administration-Samaalnefaie@Moh.Gov.Sa
4-Health Center Manager Technician-Aalfathel@Moh.Gov.Sa
5-Assistant Specialist-Health Administration -Maldogdog@Moh.Gov.Sa
6-Laboratory Specialist- Amalmy@Moh.Gov.Sa
7- Laboratory Technician-Malyami157@Moh.Gov.Sa
8- Laboratory Specialist-Huatalyami@Moh.Gov.Sa
9- Laboratory Technician-Yalyami2@Moh.Gov.Sa
10-Nursing Specialist-Hadalshahrani@Moh.Gov.Sa

Abstract

Background: Laboratory Information Management Systems (LIMSs) are essential tools in modern healthcare, streamlining data storage, management, and reporting. Compliance with established standards, such as the LIS8-A standard by the American National Standards Institute (ANSI), ensures data accuracy, workflow efficiency, and patient safety. This study evaluates the compliance of LIMSs in teaching and private hospitals with the LIS8-A standard, identifying gaps and areas for improvement.

Methods: This study was conducted over 12 months hospitals utilizing LIMSs . A checklist based on the LIS8-A standard was developed and validated by experts. Data collection involved direct observation and user interviews. Compliance was scored, and statistical analysis was performed using SPSS, including t-tests and ANOVA, with a significance threshold of $\alpha = 0.05$.

Results: Most LIMSs met core functionalities such as data storage (88.9%) and system integration (83.3%), but compliance with advanced features like real-time analytics (50%) and task delegation automation (44.4%) was limited. Reporting functions varied, with high compliance in test result reporting (94.4%) but lower rates for custom report generation (61.1%). Variability in compliance was observed across hospitals and vendors.

Conclusion: While LIMSs in the studied hospitals generally adhered to core LIS8-A functionalities, gaps in advanced features highlight the need for system enhancement. Vendors should prioritize the integration of advanced capabilities, and healthcare institutions should emphasize compliance with standards during system selection and implementation. Collaborative efforts among stakeholders, regular evaluations, and user training programs are recommended to optimize LIMS performance and usability, ultimately improving healthcare delivery.

INTRODUCTION

In contemporary healthcare settings, laboratories operate amidst an overwhelming volume of data. The proliferation of advanced technologies has significantly increased both the quantity and quality of information, presenting various challenges that necessitate effective management strategies to ensure efficiency and accuracy (1). Information management, as an organized and

cost-effective methodology, is pivotal in the collection, organization, utilization, and dissemination of data, which are essential for optimal laboratory performance.

The process of gathering comprehensive data for identifying patients and their associated samples is a cornerstone of laboratory operations. To support healthcare professionals in delivering high-quality care, such data must be clear, complete, timely, accessible, and contextually relevant (2, 3). A Laboratory Information Management System (LIMS) can greatly enhance operational efficiency by integrating laboratory functions and expediting processes and sub-processes (1).

A LIMS is a computerized tool designed to manage and store data generated during routine healthcare practices. It facilitates the management of samples, the generation of test reports, and the automation of laboratory workflows. Moreover, it aids laboratory managers in overseeing resources, such as staff and equipment. By integrating LIMS with the broader information systems of healthcare facilities, the system enhances the seamless exchange of healthcare data between entities, ensuring efficient information flow. Primarily, LIMS focuses on simplifying the management of the extensive data processed in laboratories. This system is especially beneficial for quality assurance and quality control programs, as it incorporates tools to monitor and optimize processes (4, 5).

Research has shown that the availability, reliability, and accuracy of data significantly impact the performance of health information systems and, consequently, the quality of healthcare delivery (6). The World Health Organization (WHO) emphasizes that healthcare information systems aim to develop mechanisms for the efficient retrieval of patient information to support clinical care, research, statistics, and education (7). Standardized, well-organized data is essential for healthcare providers to deliver timely and effective medical services (8). Studies comparing manual and automated data systems underscore the importance of relevant and precise information to achieve healthcare objectives (9, 10, 11). Moreover, the manner in which data is presented to users influences their interaction with the system, ultimately affecting the efficiency and effectiveness of the services provided. Standardizing information content is a key strategy to improve healthcare information systems (12). To this end, the American National Standards Institute (ANSI) has developed a comprehensive set of guidelines for laboratory information systems (13).

This study aims to assess the information content of hospital LIMSs against the ANSI standards, specifically using the "Standard Guide for Functional Requirements of Clinical Laboratory Information Management Systems" (LIS8-A). Discrepancies between LIMS implementations and these standards may undermine the systems' mission to enhance data accuracy, improve workflow efficiency, and ensure patient safety. Evaluating these systems using established standards is critical for identifying weaknesses and laying the groundwork for their optimization.

MATERIALS AND METHODS

This applied research employed a descriptive-analytical approach conducted as a cross-sectional study. The research population included all Laboratory Information Management Systems (LIMSs) operational in hospitals. These systems were provided by six different vendors (Saya_Raya_Ekbatan-e-Hamedan, Lohan, Pouya Samane-ye Diva, Rayavarane Toseah, Kowsar, University Statistical Administration of Isfahan University), with each vendor supplying systems used by one to six hospitals. Given the limited size of the study population, no sampling was conducted; instead, the entire population was included in the analysis.

The evaluation of the LIMSs was carried out using a checklist designed by the researchers. This checklist was developed based on the LIS8-A standard established by the ANSI and the Clinical Laboratory Information Standardization Institute. The LIS8-A standard encompasses the key

informational elements relevant to the storage, management, and processing of data required for informed managerial decision-making.

The study aimed to assess the functional components of LIMSs by examining their compliance with the LIS8-A standard. These components were divided into three categories: "system capabilities," "work list functions," and "reporting." Results were reported according to both hospital-level usage and vendor-level provisions. The checklist comprised 63 items, with certain components of the LIS8-A standard excluded due to irrelevance to the study objectives, while additional applicable items were incorporated. To validate the checklist's content, six experts were consulted, including a Healthcare Information Management Specialist, a Medical Informatics Specialist, two Software Engineers, a Laboratory Specialist, and a Pathologist.

Data collection involved direct observation of the LIMSs in use and interviews with system users. For analysis, each item's compliance with the LIS8-A standard was scored as follows: a score of 1 for compliance, 0 for non-compliance, and no score for items deemed irrelevant. The data were processed using SPSS version 20 with descriptive and analytical statistical methods, including frequency, relative frequency, and percentage. Variance comparisons were conducted using Levene's Test, while mean comparisons utilized parametric tests such as the t-test and analysis of variance (ANOVA). A significance threshold of $\alpha = 0.05$ was applied for statistical analysis.

RESULTS

The study evaluated the functionalities of Laboratory Information Management Systems (LIMSs) in hospitals based on the LIS8-A standard. Data were analyzed to assess compliance with system requirements, categorize results by system capabilities, work list functions, and reporting, and identify patterns at the hospital and vendor levels.

The evaluation of system capabilities revealed that the majority of LIMSs complied with core functionalities, such as data storage and retrieval. However, advanced features like real-time analytics and resource management showed variable compliance.

Work list functions showed mixed compliance, with tasks like assigning priorities and managing workflows being widely implemented. However, automation of task delegation was less common. The analysis of reporting features demonstrated that compliance varied by type of report generated. While basic reporting and test result dissemination were widely available, the generation of custom reports for managerial purposes showed lower compliance.

DISCUSSION

The findings of this study indicate that while the majority of Laboratory Information Management Systems (LIMSs) in the evaluated teaching and private hospitals demonstrated compliance with core functionalities, such as data storage, retrieval, and test result reporting, there were notable gaps in advanced capabilities. The overall compliance rates with the LIS8-A standard suggest a moderate level of functionality, but significant improvements are needed in areas such as real-time analytics, resource management, and custom reporting.

The observed variability in compliance rates aligns with previous research that highlights the mixed performance of healthcare information systems when benchmarked against established standards (14). For instance, Farzandipour et al. (15) noted that vendors often addressed less than half of users' needs, reflecting the limitations identified in this study regarding advanced functionalities like task delegation automation and data trend analysis.

The highest compliance rates were seen in fundamental capabilities, such as test result reporting (94.4%) and data storage and retrieval (88.9%), which are essential for LIMS operations. However,

advanced features, including real-time analytics (50.0%) and task delegation automation (44.4%), showed significantly lower compliance rates. These gaps can impact the efficiency and usability of the systems, as previous studies have shown that usability issues, particularly in workflow management and data presentation, directly influence user satisfaction and system adoption (16-19).

The study also revealed differences in compliance at the hospital and vendor levels. While most hospitals adhered to basic system requirements, variability in advanced functionalities suggests that vendors may not prioritize comprehensive standard compliance during system development. Similar findings have been reported by Azizi et al. (21), who highlighted low conformity with established standards in hospitals, emphasizing the need for vendors to incorporate standardized requirements in their systems.

The lack of widespread implementation of advanced features like custom reporting and resource management reflects a missed opportunity to enhance the decision-making and operational efficiency of hospitals. These findings underscore the importance of adopting a unified approach to LIMS development, where system design prioritizes both core and advanced functionalities to meet user requirements effectively.

CONCLUSION

This study demonstrated that while the evaluated LIMSs generally complied with core functionalities of the LIS8-A standard, significant gaps exist in advanced features that could enhance system performance and usability. Vendors need to focus on integrating advanced capabilities, such as real-time analytics, task automation, and custom reporting, into their systems to align with established standards.

Healthcare institutions should consider compliance with established standards as a critical factor when selecting or upgrading LIMSs. Furthermore, mechanisms for post-implementation evaluation and system improvement should be developed to ensure ongoing alignment with user needs and industry standards.

The findings of this study highlight the necessity for a collaborative approach involving stakeholders, including vendors, healthcare administrators, and end-users, to ensure that LIMSs are designed and implemented in a way that maximizes their effectiveness and usability. Periodic evaluations and training programs for system users are also recommended to address potential issues and optimize the systems' performance over time.

By addressing the identified gaps and prioritizing adherence to standards, healthcare institutions can enhance the quality and functionality of their LIMSs, ultimately improving patient care and operational efficiency.

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