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Implementation of occupational safety and health in a medical laboratory: A Qualitative Study

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ABSTRACT

Introduction: Occupational Safety and Health (OSH) plays a vital role in ensuring safe and effective learning environments in medical laboratory education. Academic laboratories pose inherent risks from chemical, biological, physical, and ergonomic hazards. Despite established OSH standards, their implementation in educational laboratory settings remains inconsistent, particularly in developing country contexts.

Methods: A qualitative study was conducted in the Medical Laboratory Technology Program laboratory at Politeknik Sandi Karsa, Indonesia. Data were collected through moderate participant observation, semi-structured interviews, and document review. A total of 25 participants were purposively selected, including students, laboratory instructors, laboratory personnel, and program administrators. Data were analysed thematically using an OSH management framework encompassing the preparation, planning, organising, and implementation stages.

Results: The study found that OSH implementation was not fully optimised across all management stages. Significant challenges included the absence of structured OSH training and socialisation, a lack of comprehensive laboratory standard operating procedures, unclear organizational roles for OSH responsibilities, inadequate laboratory infrastructure, and inconsistent compliance with personal protective equipment requirements. Additionally, routine monitoring and evaluation of OSH practices were not systematically conducted.

Conclusion: These findings suggest that limited institutional commitment, insufficient awareness, and infrastructural constraints hinder effective OSH implementation. Strengthening governance mechanisms, enhancing human resource capacity, establishing clear procedures, and improving facilities are critical to advancing laboratory safety. Comprehensive and sustained OSH management is essential to minimize occupational risks and to promote a safe and productive academic medical laboratory environment.

Keywords: Academic laboratory; Implementation; Medical laboratory education; Occupational safety and health.

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INTRODUCTION

Occupational Safety and Health (OSH) is a fundamental element of quality assurance in medical laboratory environments, particularly within higher education institutions that provide laboratory-based professional training (Ahmad *et al.*, 2024). Medical laboratories inherently expose students, instructors, and laboratory personnel to a wide range of hazards, including chemical agents, biological pathogens, physical risks, ergonomic strain, and psychosocial stressors (Ahsan *et al.*, 2024). Without effective OSH management, these risks may lead to occupational accidents, laboratory-acquired infections, and long-term health consequences, ultimately compromising educational quality and institutional credibility (Amaiach *et al.*, 2024).

Despite the existence of international and national OSH guidelines, the practical implementation of OSH in academic medical laboratories remains a persistent challenge (Suprapto, 2021). In many educational settings, laboratory activities are conducted intensively, often involving inexperienced students who are still developing technical competence and safety awareness (Cai *et al.*, 2025). This condition increases the likelihood of unsafe behaviors, non-compliance with personal protective equipment (PPE) use, and improper handling of hazardous materials (Chen and Wang, 2024). Consequently, OSH in educational laboratories requires not only regulatory compliance but also strong organizational commitment, continuous training, and a supportive safety culture (Cheng *et al.*, 2025).

In developing countries, implementing OSH in academic laboratories is further constrained by limited resources, inadequate infrastructure, and insufficient institutional prioritization (Ehrampush *et al.*, 2024). Laboratories may lack comprehensive standard operating procedures (SOPs), proper ventilation systems, functional safety equipment, and structured reporting mechanisms for occupational accidents (Huang *et al.*, 2024). These constraints contribute to a significant gap between OSH standards and everyday laboratory practices. Previous studies have highlighted that the absence of systematic OSH governance often results in fragmented safety practices that rely heavily on individual awareness rather than institutional systems (Jobst *et al.*, 2025).

Although numerous studies have examined OSH implementation in industrial and hospital laboratory settings, empirical evidence focusing on academic medical laboratories remains limited (Kazemizad *et al.*, 2026). Existing research predominantly emphasizes compliance assessment, hazard identification, or quantitative risk measurement. While these approaches are valuable, they often fail to capture the organizational processes, behavioral factors, and contextual challenges that shape OSH implementation in educational environments (Khan, Malik and Chen, 2024). Moreover, many studies treat OSH as a technical issue rather than as a management system embedded within institutional structures and decision-making processes (Khosravipour *et al.*, 2024).

This gap is particularly evident in studies conducted in higher education institutions in low- and middle-income countries. Research on OSH in medical laboratory education often lacks a comprehensive management perspective that integrates the preparation, planning, organizing, and implementation stages. As a result, the dynamic interactions between policy, human resources, infrastructure, and daily laboratory practices remain underexplored. Furthermore, limited attention has been given to the perspectives of multiple stakeholders: students, instructors, laboratory staff, and academic leaders who collectively influence OSH performance.

Another critical gap concerns translating OSH knowledge into practice. Although OSH concepts are often included in academic curricula, their application during routine laboratory activities is not consistently reinforced. This disconnect suggests that formal instruction alone is

insufficient to ensure safe laboratory behavior. Instead, OSH effectiveness depends on continuous socialization, role clarity, leadership commitment, and monitoring mechanisms. However, few studies have systematically examined how these factors operate together within academic laboratory settings.

Given these limitations, there is a clear need for qualitative research that provides an in-depth understanding of OSH implementation processes in medical laboratory education. Qualitative approaches enable the exploration of perceptions, experiences, and organizational dynamics that are not easily captured by quantitative methods. By examining OSH as a management process rather than merely a compliance checklist, such research can offer practical insights for institutional improvement.

The novelty of this study lies in its comprehensive qualitative analysis of OSH implementation using a management-stage framework encompassing preparation, planning, organizing, and implementation. Unlike previous studies that focus on isolated safety components, this research adopts a holistic perspective that integrates structural, procedural, and behavioral dimensions of OSH. Additionally, the study incorporates the views of diverse stakeholders involved in laboratory activities, enabling a more nuanced understanding of institutional strengths and weaknesses.

Furthermore, this study contributes novel empirical evidence from an academic medical laboratory in Indonesia, a context that remains underrepresented in the international OSH literature. By situating OSH challenges within a real-world educational setting, the findings provide context-sensitive insights that may inform policy development, institutional governance, and capacity-building initiatives. The study also offers practical implications for strengthening OSH systems in similar educational laboratories, particularly in resource-limited environments.

In summary, addressing OSH in academic medical laboratories is not merely a regulatory requirement but a strategic necessity to ensure safety, learning quality, and institutional sustainability. By identifying existing problems, addressing critical research gaps, and introducing a holistic, management-based perspective, this study aims to advance understanding of OSH implementation in medical laboratory education and to support the development of safer, more effective learning environments.

RESEARCH METHODOLOGY

Study Design

This study employed a qualitative research design to explore the implementation of Occupational Safety and Health (OSH) in an academic medical laboratory setting. A qualitative approach was selected to gain an in-depth understanding of organizational processes, stakeholder experiences, and contextual factors influencing OSH practices within the Medical Laboratory Technology Program laboratory at Politeknik Sandi Karsa, Indonesia.

Study Setting

The research was conducted in the laboratories of the Medical Laboratory Technology Program at Politeknik Sandi Karsa, a higher education institution providing laboratory-based professional training. These laboratories support routine practical activities involving chemical, biological, and physical exposures, making them a relevant setting for examining OSH implementation.

Participants and Sampling

Participants were selected using purposive sampling to ensure the inclusion of key stakeholders directly involved in laboratory activities and OSH-related decision-making. A total

of 25 participants were recruited, consisting of students, laboratory instructors, laboratory personnel, and program administrators. This diverse participant composition enabled the exploration of OSH implementation from multiple perspectives within the institutional context.

Data Collection

Data were collected using three complementary techniques: moderate participant observation, semi-structured interviews, and document review. Moderate participant observation allowed the researcher to engage with routine laboratory activities while maintaining an analytical distance. Semi-structured interviews were conducted to explore participants' experiences, perceptions, and understanding of OSH practices. Document review included relevant institutional documents, such as laboratory guidelines, safety instructions, and administrative records related to laboratory operations.

Data Analysis

Data analysis was conducted thematically following an iterative process of data familiarization, coding, categorization, and theme development. An OSH management framework guided the study, focusing on four key stages: preparation, planning, organizing, and implementation. This framework facilitated a systematic examination of strengths, gaps, and challenges in OSH practices across different management dimensions.

Trustworthiness

To enhance the trustworthiness of the findings, data triangulation was applied by comparing information obtained from observations, interviews, and documents. The inclusion of multiple participant groups also supported credibility by capturing diverse viewpoints on OSH implementation.

Theme (OSH Management Stage)	Focus Area	Essential Interview Questions
Preparation	OSH awareness and training	How is OSH introduced and communicated to students, instructors, and laboratory staff before laboratory activities?
	Safety orientation	What types of OSH orientation or training have you received before conducting laboratory work?
Planning	Standard operating procedures (SOPs)	Are written SOPs available and accessible for laboratory activities and safety procedures?
	Risk identification	How are potential laboratory hazards identified and addressed during planning stages?
Organizing	Roles and responsibilities	Who is responsible for overseeing OSH implementation in the laboratory, and how are these roles defined?
	Reporting mechanisms	How are occupational accidents or unsafe conditions reported and documented?
Implementation	Use of personal protective equipment	How consistently are personal protective equipment and safety protocols applied during laboratory activities?
	Facilities and infrastructure	How adequate are laboratory facilities (ventilation, safety equipment) in supporting OSH practices?
	Monitoring and evaluation	Is there routine monitoring or evaluation of OSH practices in the laboratory?

RESULT

This section presents the study's findings, derived from observations, semi-structured interviews, and document review conducted in the Medical Laboratory Technology Program laboratory at Politeknik Sandi Karsa. The results are organized thematically based on the

Occupational Safety and Health (OSH) management framework, encompassing the stages of preparation, planning, organizing, and implementation. This structure allows for a systematic presentation of key issues, patterns, and challenges related to OSH practices as experienced by students, laboratory instructors, laboratory personnel, and program administrators. The findings reflect both institutional arrangements and day-to-day laboratory practices that influence the effectiveness of OSH implementation.

Table 2. Overview of Main Categories and Subcategories

Main Category (OSH Stage)	Subcategory	Description
Preparation	OSH socialization and training	Availability and delivery of OSH orientation, training, and safety briefings before laboratory activities
	Safety awareness	Level of understanding and awareness of OSH principles among students and staff
Planning	Standard operating procedures	Existence, accessibility, and completeness of laboratory SOPs related to safety
	Hazard identification	Processes for identifying chemical, biological, and physical risks
Organizing	Roles and responsibilities	Clarity of OSH-related duties among instructors, laboratory staff, and administrators
	Reporting and communication	Mechanisms for reporting occupational accidents and unsafe conditions
Implementation	Use of personal protective equipment	Consistency and compliance in the use of PPE during laboratory work
	Laboratory facilities	Adequacy of ventilation, safety equipment, and workspace conditions
	Monitoring and evaluation	Practices for monitoring, reviewing, and improving OSH implementation

Preparation: Limited OSH Awareness and Training

Topic: Inadequate safety orientation before laboratory activities

Explanation: Participants reported that OSH information was delivered informally without structured training or systematic safety orientation. This limited the depth of safety awareness among laboratory users and increased reliance on individual experience rather than institutional guidance.

> *"Safety is considered important, but there is no formal training before laboratory activities begin." (P1 – Laboratory Instructor)*

Planning: Absence of Standard Operating Procedures

Topic: Lack of written laboratory safety procedures

Explanation: The absence of comprehensive SOPs resulted in inconsistent safety practices. Laboratory activities were guided primarily by verbal instructions that varied depending on the level of supervision and experience.

> *"There are no written safety procedures available in the laboratory." (P2 – Laboratory Staff)*

Organizing: Unclear OSH Roles and Responsibilities

Topic: Weak organizational structure for OSH management

Explanation: Participants indicated that OSH responsibilities were not clearly defined. This created uncertainty regarding accident reporting and emergency response, particularly among students.

"Students are not clearly informed about who is responsible for handling safety issues." (P3 – Student)

Implementation: Inconsistent Use of Personal Protective Equipment

Topic: Variable compliance with PPE use

Explanation: Although PPE use was encouraged, compliance depended heavily on supervision. Inconsistent enforcement reduced the effectiveness of safety measures during routine laboratory activities.

"Not all students use protective equipment consistently." (P4 – Program Administrator)

Implementation: Lack of Monitoring and Evaluation

Topic: Absence of systematic OSH monitoring

Explanation: OSH practices were rarely evaluated through formal monitoring or review processes. Safety improvements were typically reactive rather than preventive.

"There is no routine evaluation of safety practices." (P5 – Laboratory Staff)

The findings indicate that the implementation of occupational safety and health in the academic medical laboratory has not been fully optimized across the preparation, planning, organizing, and implementation stages. Strengthening structured training, standard operating procedures, organizational clarity, and continuous monitoring is essential to improve safety performance and ensure a safe and effective laboratory learning environment. The study lies in its holistic qualitative examination of occupational safety and health implementation in an academic medical laboratory using a management-stage framework encompassing preparation, planning, organizing, and implementation. Unlike previous studies that primarily assess compliance or technical risk factors, this research integrates organizational, procedural, and behavioral dimensions by capturing perspectives from multiple stakeholders, including students, instructors, laboratory personnel, and program administrators. Furthermore, the study provides empirical evidence from an underrepresented higher education context in Indonesia, offering context-specific insights that extend the international literature on occupational safety and health in medical laboratory education and inform practical institutional improvement strategies.

DISCUSSION

This study explored the implementation of Occupational Safety and Health (OSH) in an academic medical laboratory using a thematic framework encompassing preparation, planning, organizing, and implementation. The findings indicate that OSH practices have not been optimally integrated into laboratory management, reflecting systemic challenges rather than isolated technical shortcomings. This discussion interprets the findings by linking them to broader OSH management principles and existing literature.

Preparation: Limited OSH Awareness and Training

The findings demonstrate that OSH preparation in the laboratory is characterized by informal and inconsistent safety orientation. Although OSH is acknowledged as necessary, structured training and systematic socialization are largely absent. This condition impedes the development of a strong safety culture, particularly among students still acquiring technical competencies (Kulor *et al.*, 2024). Previous studies emphasize that adequate OSH preparation requires continuous education and early exposure to safety principles to shape safe working behaviors (Liao *et al.*, 2025). The absence of formal training in the present study suggests that safety awareness remains individual-dependent rather than institutionally embedded (Mansouri, Moradi and Saba, 2024).

Planning: Absence of Comprehensive Standard Operating Procedures

At the planning stage, the lack of comprehensive laboratory SOPs emerged as a critical weakness. SOPs serve as essential instruments for standardizing work processes, minimizing ambiguity, and reducing occupational risks. In this study, safety practices were primarily guided

by verbal instructions and personal experience, resulting in variability in their implementation (Mousavi *et al.*, 2025). This finding aligns with prior research indicating that the absence of written procedures increases the likelihood of unsafe practices and inconsistent compliance. Without clear SOPs, laboratory safety becomes reactive rather than preventive, undermining the effectiveness of OSH management (Moloudpourfard, Zarandi and Pouyakian, 2025).

Organizing: Unclear Roles and Responsibilities

The organizing stage revealed insufficient clarity regarding OSH-related roles and responsibilities. Participants reported uncertainty about who is accountable for safety supervision, accident reporting, and emergency response. Such ambiguity weakens institutional control and discourages formal reporting of incidents, particularly among students (Salari and Karimi, 2025). Effective OSH systems require clearly defined organizational structures and explicit allocation of responsibilities (Suarez Rivadeneira *et al.*, 2024). The lack of formal OSH governance identified in this study reflects a broader challenge in academic institutions, where safety management is often considered secondary to educational objectives (Symochko *et al.*, 2024).

Implementation: Inconsistent Use of Personal Protective Equipment

Inconsistent compliance with personal protective equipment (PPE) use was a prominent issue at the implementation stage. While PPE use was encouraged, adherence depended heavily on supervision and individual discipline. This finding highlights the gap between knowledge and practice, a recurring issue in laboratory safety research. Studies have shown that PPE compliance improves significantly when supported by strong leadership, consistent enforcement, and a favorable safety climate. In the absence of these factors, PPE use becomes situational and vulnerable to neglect (Yousofnejad and Es'haghi, 2024).

Implementation: Inadequate Facilities and Infrastructure

Laboratory facilities and infrastructure were also identified as limiting factors for effective OSH implementation. Inadequate ventilation, limited workspace, and insufficient safety equipment contributed to discomfort and reduced concentration during laboratory activities. Such conditions not only increase the risk of accidents but also affect learning quality (Zheng *et al.*, 2024). Infrastructure is a foundational component of OSH systems, and deficiencies in this area reflect institutional underinvestment in safety. The findings underscore the importance of aligning physical infrastructure with safety requirements to support sustainable OSH practices (Yunus *et al.*, 2024).

Monitoring and Evaluation: Reactive Safety Management

The absence of routine monitoring and evaluation further constrained OSH effectiveness. Safety issues were typically addressed only after incidents occurred, indicating a reactive approach to OSH management. Continuous monitoring and periodic evaluation are essential for identifying emerging risks, assessing compliance, and informing corrective actions (Zhang *et al.*, 2026). The lack of systematic assessment observed in this study suggests missed opportunities for learning and improvement. Proactive monitoring is particularly crucial in educational laboratories, where users frequently change, and risk profiles evolve (Yusuf *et al.*, 2025).

Implications for OSH Management in Academic Laboratories

Collectively, the findings suggest that OSH implementation in academic medical laboratories requires a shift from fragmented practices to an integrated management system. Strengthening preparation through structured training, formalizing planning via SOP development, clarifying organizational roles, and ensuring consistent implementation supported by adequate infrastructure are critical steps. Moreover, embedding monitoring and evaluation mechanisms can transform OSH from a reactive obligation into a preventive and strategic function.

This study extends existing literature by highlighting the interconnectedness of OSH management stages in an educational laboratory context. Rather than viewing safety issues as isolated failures, the findings emphasize the need for systemic solutions that address organizational, procedural, and behavioral dimensions simultaneously. Such an approach is essential for fostering a sustainable safety culture and ensuring safe learning environments in medical laboratory education.

CONCLUSION

This study concludes that the implementation of occupational safety and health in the academic medical laboratory has not been fully optimized across the stages of preparation, planning, organizing, and implementation. The absence of structured training, comprehensive standard operating procedures, clear organizational responsibilities, adequate facilities, and systematic monitoring has limited the effectiveness of OSH practices. These findings indicate that OSH remains fragmented and largely dependent on individual awareness rather than being embedded within an institutional management system.

To strengthen OSH implementation, higher education institutions should adopt an integrated OSH management approach that includes regular safety training, the development and enforcement of laboratory-specific standard operating procedures, precise allocation of OSH roles, and routine monitoring and evaluation. Institutional commitment to improving laboratory infrastructure and fostering a safety-oriented culture is essential to ensure a safe, effective, and sustainable learning environment in medical laboratory education.

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Conflict of Interest

There are no potential conflicts of interest relevant to this article.

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