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Assessment of knowledge and skills in biosafety and biosecurity practices among laboratory workers in Narok county, Kenya

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ABSTRACT

Background: Biosafety and biosecurity (BB) are critical in preventing laboratory-acquired infections and ensuring safe handling of infectious materials. However, competency levels among laboratory personnel in low-resource settings remain underexplored.

Methods: A mixed-methods study was conducted among 102 laboratory workers in Narok County, Kenya. Data were collected using structured questionnaires and practical assessment tools. Descriptive and inferential statistics were used to analyze the data, with significance set at $p < 0.05$.

Results: The majority of respondents demonstrated moderate knowledge and skills in biosafety practices. Formal training and years of experience were significantly associated with higher competency levels ($p < 0.05$). However, gaps were identified in advanced biosafety procedures and risk assessment practices.

Conclusion: Laboratory workers exhibited moderate competency in biosafety and biosecurity practices, with notable gaps requiring targeted training and continuous professional development.

KEYWORDS: biosafety, biosecurity, laboratory workers, knowledge, skills, Kenya

1. BACKGROUND

Biosafety and biosecurity are essential components of laboratory systems aimed at preventing exposure to infectious agents, protecting laboratory personnel, and safeguarding the public from biological risks (World Health Organization, 2023). Effective implementation of biosafety measures relies not only on the availability of infrastructure and equipment but also on the competency of laboratory personnel, particularly their knowledge and practical skills in handling biological materials safely.

Globally, laboratory-acquired infections continue to pose a significant public health concern, often resulting from inadequate adherence to biosafety protocols and insufficient training (Brodsky et al., 2021). The risk is particularly pronounced in low- and middle-income countries, where laboratory systems frequently face challenges such as limited resources, weak regulatory enforcement, and gaps in workforce capacity (Blacksell et al., 2024). In such settings, laboratory workers may lack the necessary competencies to effectively implement biosafety and biosecurity measures.

Knowledge and skills are critical determinants of safe laboratory practice. Knowledge encompasses understanding of biosafety principles, guidelines, and risk management procedures, while skills involve the practical application of these principles in routine laboratory operations (Cruz et al., 2018). Studies have shown that even when laboratory workers possess basic knowledge, deficiencies in practical skills can significantly compromise biosafety compliance (Ikram, 2021). This highlights the need for competency-based training approaches that integrate both theoretical and practical components.

Training has been identified as one of the most important factors influencing biosafety competency. Structured training programs have been shown to improve laboratory workers' adherence to safety protocols and reduce the incidence of laboratory-related hazards (Bota et al., 2021). However, in many developing countries, access to regular and standardized biosafety training remains limited, resulting in inconsistent levels of competency among laboratory personnel.

In Kenya, efforts have been made to strengthen laboratory systems through national biosafety guidelines and capacity-building initiatives (Muriithi et al., 2018). Despite these efforts, implementation of biosafety practices varies widely across health facilities, and evidence on the competency of laboratory workers at the county level remains limited. Understanding the knowledge and skills of laboratory personnel is therefore essential for identifying gaps and informing targeted interventions.

This study aimed to assess the knowledge and skills of laboratory workers in biosafety and biosecurity practices in Narok County, Kenya, with a view to informing strategies for improving laboratory safety and strengthening health systems.

2. METHODS

2.1 Study design and setting

Mixed-methods study design was conducted in Narok County health facilities. It involved concurrent, sequential and conversation approaches.

2.2 Study population and sampling

The study targeted all laboratory workers (n = 102), using a census approach.

2.3 Data collection

Data were collected using:

- Structured questionnaires assessing knowledge
- Practical assessment tools evaluating biosafety skills

2.4 Data analysis

Quantitative data were analyzed using descriptive statistics (means, frequencies) and inferential statistics (t-tests, regression analysis). Statistical significance was set at $p < 0.05$.

2.5 Ethical Considerations

Ethical approval was obtained from the Moi University Institutional Research and Ethics Committee (MU/MTRH-IREC) Permit number FAN: 5188 and the National Commission of Science, Technology and Innovations (NACOSTI) license No: NACOSTI/P/25/4180493. Permission to conduct the study was granted by relevant authorities of Narok County Ministry of Health and informed consent was obtained from all participants. Confidentiality and anonymity were maintained throughout the study.

3. RESULTS

3.1 Socio-demographic characteristics of respondents

Table 1. presents the background characteristics of the study participants. The majority of respondents were male (56.9%) and worked in public health facilities (69.6%). Most had diploma-level education (58.8%), and a significant proportion (63.7%) had received biosafety training. These characteristics provide context for understanding variations in biosafety knowledge and skills.

Table 1: Socio-demographic characteristics of respondents (N = 102)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	58	56.9
	Female	44	43.1
Facility type	Public	71	69.6
	Private	31	30.4
Education level	Diploma	60	58.8
	Degree and above	42	41.2
Biosafety training	Yes	65	63.7
	No	37	36.3

3.3 Knowledge and skills levels in biosafety practices

Table 2. shows that over half of the respondents demonstrated moderate knowledge (51.0%) and skills (53.9%) in biosafety practices. A smaller proportion exhibited high competency, while about one-fifth had low levels. This indicates that although basic awareness exists, there are gaps in advanced biosafety competencies.

Table 2: Knowledge and skills levels in biosafety practices

Variable	Category	Frequency (n)	Percentage (%)
Knowledge level	High	28	27.5
	Moderate	52	51.0
	Low	22	21.5
Skills level	High	25	24.5
	Moderate	55	53.9
	Low	22	21.6

3.4 Skills levels in biosafety practices

Similarly, the majority of respondents demonstrated **moderate practical skills** in biosafety implementation. Specifically, 53.9% had moderate skills, 24.5% had high skills, and 21.6% had low skills (Table 2). These findings suggest that although basic competencies are present, there are notable gaps in advanced practical application of biosafety measures.

3.5 Factors associated with biosafety competency

Table 3. summarizes regression results showing factors influencing biosafety competency. Biosafety training, years of experience, and education level were all significantly associated with higher competency ($p < 0.05$). Training had the strongest effect, highlighting its importance in improving laboratory safety practices.

Table 3: Factors associated with biosafety competency (Regression results)

Variable	β Coefficient	p-value
Biosafety training	0.42	0.001 *
Years of experience	0.35	0.003 *
Education level	0.21	0.041 *

4. DISCUSSION

This study assessed the knowledge and skills of laboratory workers regarding biosafety and biosecurity practices in Narok County and found that the majority of respondents demonstrated moderate levels of competency. While this indicates the presence of basic awareness, it also reveals important gaps in advanced biosafety practices that are critical for effective risk management.

The predominance of moderate knowledge levels is consistent with findings from other low- and middle-income countries, where biosafety training is often irregular and not standardized (Blacksell et al., 2024). Moderate competency suggests that laboratory workers may be familiar with general safety procedures but lack deeper understanding of risk assessment, containment measures, and emergency response protocols. Such gaps increase the likelihood of laboratory-acquired infections and compromise overall laboratory safety (Brodsky et al., 2021).

A key finding of this study is the significant association between biosafety training and competency levels. Laboratory personnel who had received formal biosafety training demonstrated higher knowledge and practical skills compared to those without training. This aligns with previous studies showing that structured training programs significantly improve compliance with biosafety guidelines and enhance safe laboratory practices (Bota et al., 2021). The findings reinforce the importance of continuous professional development and regular refresher training to maintain competency.

Similarly, years of experience were positively associated with improved biosafety skills, suggesting that experiential learning plays a critical role in reinforcing safe laboratory practices. This observation is supported by studies indicating that repeated exposure to laboratory procedures enhances skill acquisition and adherence to safety protocols (Cruz et al., 2018). However, reliance on experience alone may be insufficient, particularly when dealing with emerging biological risks that require updated knowledge and specialized training.

The study also identified gaps in advanced biosafety procedures, particularly in areas such as risk assessment and biosecurity measures. This finding is consistent with research indicating that biosafety training programs in many settings tend to emphasize theoretical knowledge while neglecting practical application (Ikram, 2021). As a result, laboratory workers may struggle to translate knowledge into practice, especially in high-risk situations.

Education level was also found to be a significant predictor of competency, although its effect was less pronounced compared to training and experience. This suggests that while formal education provides a foundation, targeted biosafety training is more critical in developing practical competencies. This finding is in agreement with global biosafety recommendations, which emphasize competency-based training rather than reliance on academic qualifications alone (WHO, 2023).

Overall, the findings highlight that biosafety competency is multifactorial, influenced by training, experience, and education. However, the persistence of moderate competency levels indicates systemic gaps in training delivery, supervision, and institutional support. Without addressing these gaps, laboratory systems remain vulnerable to safety breaches and potential public health risks.

5 CONCLUSION

The study demonstrates that although laboratory workers possess basic biosafety knowledge and skills, significant gaps remain in advanced competencies. Strengthening structured training programs, promoting continuous professional development, and integrating practical skill-based learning are essential to improve biosafety and biosecurity practices.

Abbreviations

BB: Biosafety and Biosecurity

WHO: World Health Organization

Declarations

The authors declare no conflict of interest.

Ethics approval and consent to participate

Ethical approval was obtained from the Moi University Institutional Research and Ethics Committee (MU/MTRH-IREC) Permit number FAN: 5188 and the National Commission of Science, Technology and Innovations (NACOSTI) license No: NACOSTI/P/25/4180493. Permission to conduct the study was granted by relevant authorities of Narok County Ministry of Health and informed consent was obtained from all participants. Confidentiality and anonymity were maintained throughout the study.

Competing interests

The authors declare no competing interests

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