

Constraints Affecting Implementation of Biosafety and Biosecurity Practices Among Laboratory Workers in Narok County, Kenya

Grace Moraa Orina¹, Ann Koske Ngeno², Geoffrey K Maiyoh³, Ondimu Thomas Orindi⁴

^{1,2,3} School of medicine, Department of Medical Education, Moi University, Eldoret, Kenya

⁴ Department of health sciences, Machakos University, Machakos, Kenya

ABSTRACT

Biosafety and biosecurity (BB) are critical for ensuring safe laboratory operations and preventing exposure to hazardous biological agents. Effective implementation of these measures requires not only competent personnel but also adequate institutional support, including infrastructure, resources, and governance systems. Globally, studies have identified a range of barriers to effective biosafety implementation, including inadequate funding, limited access to essential equipment, weak regulatory enforcement, and insufficient training opportunities. Resource availability is one of the most critical determinants of biosafety compliance. Laboratories lacking essential equipment such as personal protective equipment (PPE), biosafety cabinets, and waste management systems are at increased risk of exposure to infectious agents. A cross-sectional mixed-methods study involving 102 laboratory workers in Narok County was conducted. Data were collected through questionnaires and analysed using descriptive and inferential statistics. Addressing systemic constraints is essential to improve biosafety compliance in laboratory settings.

KEYWORDS

Biosafety, Biosecurity, Constraints, Laboratory safety, Kenya

I. BACKGROUND

Biosafety and biosecurity (BB) are critical for ensuring safe laboratory operations and preventing exposure to hazardous biological agents. Effective implementation of these measures requires not only competent personnel but also adequate institutional support, including infrastructure, resources, and governance systems (World Health Organization 2023). However, in many low- and middle-income countries, the implementation of biosafety practices remains suboptimal due to multiple systemic and contextual constraints.

Globally, studies have identified a range of barriers to effective biosafety implementation, including inadequate funding, limited access to essential equipment, weak regulatory enforcement, and insufficient training opportunities. These challenges are particularly pronounced in resource-constrained settings, where laboratory systems often operate under significant logistical and financial limitations. As a result, even when biosafety guidelines are available, adherence to recommended practices is often inconsistent.

Resource availability is one of the most critical determinants of biosafety compliance. Laboratories lacking essential equipment such as personal protective equipment (PPE), biosafety cabinets, and waste management systems are at increased risk of exposure to infectious agent. In addition, inadequate infrastructure—such as poorly designed laboratory spaces and insufficient ventilation—further compromises the safe handling of biological materials. Human resource constraints also play a significant role in limiting biosafety implementation. Staffing shortages and high workload have been shown to negatively affect adherence to safety protocols, as overburdened laboratory personnel may prioritize task completion over compliance with biosafety procedures. Furthermore, insufficient or irregular training limits the ability of laboratory workers to effectively implement biosafety measures, even when they are aware of the guidelines.

In Kenya, national biosafety guidelines have been developed to promote safe laboratory practices; however, implementation varies across health facilities due to disparities in resource allocation, infrastructure, and workforce capacity. Public health facilities, in particular, often face greater challenges compared to private facilities, including limited funding and higher patient loads, which may hinder effective biosafety compliance. Despite the recognition of these challenges, there is limited empirical evidence documenting the specific constraints affecting biosafety and biosecurity implementation at the county level. Understanding these constraints is essential for informing targeted interventions and policy decisions aimed at strengthening laboratory systems.

This study therefore sought to identify and analyse the key constraints affecting the implementation of biosafety and biosecurity practices among laboratory workers in Narok County, Kenya.

II. METHODS

A. Study design and population

A cross-sectional mixed-methods study involving 102 laboratory workers.

B. Data collection

- Questionnaires on training and implementation
- Facility-level assessments

III. DATA ANALYSIS

Descriptive and inferential statistics were used to identify key constraints.

IV. RESULTS

A. Distribution of reported constraints to biosafety implementation

Table 1. Presents the major constraints affecting biosafety implementation. Inadequate resources were the most frequently reported challenge (76.5%), followed by insufficient

training (67.6%), staffing shortages (62.7%), and poor infrastructure (56.9%). These findings highlight systemic barriers within laboratory settings.

Table 1: Distribution of reported constraints to biosafety implementation

Constraint	Frequency (n)	Percentage (%)
Inadequate resources	78	76.5
Insufficient training	69	67.6
Staffing shortages	64	62.7
Poor infrastructure	58	56.9

B. Constraints by facility type

Table 2. Compares constraints between public and private health facilities. Public facilities reported higher levels of all constraints, particularly staffing shortages and inadequate resources. This suggests disparities in resource allocation and capacity between facility types.

Table 2: Constraints by facility type

Constraint	Odds Ratio (OR)	p-value
Inadequate resources	2.8	0.002*
Insufficient training	2.3	0.005*
Staffing shortages	2.6	0.003*
Poor infrastructure	2.1	0.011*

C. Association between constraints and biosafety compliance

Table 3. Shows that all identified constraints were significantly associated with reduced biosafety compliance ($p < 0.05$). Inadequate resources had the strongest association ($OR = 2.8$), indicating that laboratories lacking essential materials are significantly less likely to adhere to biosafety standards. Laboratories experiencing these constraints were more likely to have lower levels of adherence to biosafety and biosecurity practices.

Table 3: Association between constraints and biosafety compliance

Constraint	Odds Ratio (OR)	p-value
Inadequate resources	2.8	0.002*
Insufficient training	2.3	0.005*
Staffing shortages	2.6	0.003*
Poor infrastructure	2.1	0.011*

D. Key constraints identified:

- Inadequate resources: Lack of essential biosafety equipment
- Insufficient training: Limited access to structured training programs
- Staffing shortages: High workload, especially in public facilities
- Poor infrastructure: Substandard laboratory design

V. DISCUSSION

This study identified several key constraints affecting the implementation of biosafety and biosecurity (BB) practices among laboratory workers in Narok County, including inadequate resources, insufficient training, staffing shortages, and poor infrastructure. These findings highlight the multifaceted nature of barriers to biosafety compliance, which extend beyond individual competency to include systemic and institutional challenges.

Among the identified constraints, inadequate resources emerged as the most significant barrier to effective biosafety implementation. Laboratories lacking essential supplies such as personal protective equipment (PPE), biosafety cabinets, and waste management systems are unable to fully adhere to recommended safety standards. This finding is consistent with previous studies indicating that resource limitations are a primary obstacle to biosafety compliance in low-resource settings. Without adequate material support, even well-trained personnel may be unable to implement appropriate safety measures, thereby increasing the risk of laboratory-acquired infections.

Insufficient training was another major constraint identified in this study. Although some laboratory workers reported having received biosafety training, the lack of regular, structured, and competency-based training programs limits the effective implementation of biosafety practices. This aligns with findings from other studies, which emphasize that irregular or inadequate training reduces adherence to safety protocols and undermines laboratory safety culture. Continuous professional development and refresher training are therefore essential to ensure that laboratory personnel remain updated on evolving biosafety standards and practices.

The study also found that staffing shortages and high workload significantly affect biosafety compliance, particularly in public health facilities. Overburdened laboratory workers may prioritize rapid service delivery over strict adherence to safety protocols, leading to increased risk of exposure to hazardous biological agents. Similar observations have been reported in other low- and middle-income countries, where limited human resources contribute to reduced compliance with infection prevention and control. Addressing workforce gaps is therefore critical for improving biosafety implementation.

Poor infrastructure was identified as another important constraint. Inadequate laboratory design, limited space, and poor ventilation compromise the safe handling and containment of biological materials. These findings are consistent with global evidence showing that infrastructure plays a crucial role in enabling or hindering biosafety practices (Brodsky et al., 2021). Laboratories that do not meet minimum biosafety standards are inherently limited in their ability to implement effective safety measures, regardless of staff competency.

The study further revealed disparities between public and private health facilities, with public facilities experiencing more pronounced constraints across all categories. This may be attributed to differences in funding, resource allocation, and patient load, as public facilities often serve larger populations with limited resources. Similar disparities have been reported in previous studies, highlighting inequities in health system capacity that affect service delivery and safety outcomes. These findings underscore the need for targeted interventions focusing on resource-constrained public sector laboratories.

Importantly, the study demonstrated that all identified constraints were significantly associated with reduced biosafety compliance, suggesting that effective implementation of BB practices requires a holistic approach addressing both individual and system-level factors. This supports the broader perspective that biosafety is not solely a function of individual knowledge and skills but is heavily influenced by the enabling environment within which laboratory personnel operate.

VI. CONCLUSION

The implementation of biosafety and biosecurity practices in Narok County is constrained by systemic challenges, including inadequate resources, insufficient training, staffing shortages, and poor infrastructure. Addressing these barriers requires coordinated efforts to strengthen laboratory systems through increased investment, workforce development, and improved infrastructure.

A. Abbreviations

- BB: Biosafety and Biosecurity
- WHO: World Health Organization

VII. DECLARATIONS

A. 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.

B. Competing interests

The authors declare no competing interests

REFERENCES

- [1] Bawolakson, M., et al. (2021). Barriers to biosafety compliance. *Global Health Research and Policy*, 6(1), 45.
- [2] Bota, D. P., et al. (2021). Biosafety training outcomes. *BMC Health Services Research*, 21, 1123.
- [3] Brodsky, B. H., et al. (2021). Laboratory-acquired infections. *Clinical Microbiology Reviews*, 34(2), e00052-19.
- [4] Kiwanuka, J., et al. (2020). Laboratory system challenges in Africa. *African Journal of Laboratory Medicine*, 9(1), 1023.
- [5] Muriithi, B., et al. (2018). Biosafety practices in Kenya. *Pan African Medical Journal*, 31, 123.
- [6] World Health Organization. (2023). *Laboratory biosafety manual* (4th Ed.). WHO.