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Assessment of biosafety training and practices in biomedical laboratories in Kinshasa, Democratic Republic of the Congo

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ABSTRACT

Introduction

In biomedical laboratories, biosafety is a key element for preventing infections and ensuring the safety of healthcare workers and the community. In resource-limited settings like Kinshasa, Democratic Republic of the Congo (DRC), the status of biosafety training and practices among laboratory personnel remains unclear.

Purpose

This study aimed to assess the training, practices, and satisfaction related to biosafety among laboratory personnel in biomedical laboratories in Kinshasa.

Methods

A cross-sectional descriptive and analytical study was conducted between November 2024 and February 2025 in 56 laboratories in Kinshasa. A convenience sample of 290 laboratory staff members was interviewed using a structured questionnaire. Data were analysed with IBM SPSS 24.0, and associations were explored using Chi-square, Fisher's exact, and logistic regression tests.

Results

The majority of respondents were male (57.2%) and under 40 years of age (54.2%). Only 55.5% had received formal biosafety training, and among them, 34.8% had received the training over two years ago. Hepatitis B vaccination coverage was 30%. Overall satisfaction with biosafety management was low (27.6%). Biosafety training was significantly associated with older age ($p = .032$), longer work experience ($p = .008$), and hepatitis B vaccination ($p < .001$). Trained staff were more likely to be vaccinated (OR = 3.5) and to report satisfaction with biosafety measures (OR = 3.6).

Conclusion

Biosafety training and hepatitis B vaccination coverage remain insufficient among laboratory personnel in Kinshasa, with low levels of satisfaction regarding biosafety measures. Strengthening biosafety through regular training, provision of adequate equipment, and vaccination campaigns is urgently needed.

INTRODUCTION

Laboratory biosafety is essential for preventing nosocomial infections, cross-contamination, and occupational hazards. According to the World Health Organization (WHO, 2020), laboratories must adhere to strict standards to ensure the safety of personnel and the surrounding environment.

In the United States, Henkel et al. (2012) reported data submitted to the Centers for Disease Control and Prevention (CDC) between 2004 and 2010. Laboratory-acquired infections (LAIs) associated with the release of biological select agents and toxins (BSAT) were reported among an average annual population of approximately 10,000 individuals with authorized access to BSAT.

In Canada, the Laboratory Incident Notification Surveillance System reported 43 exposure incidents involving 72 individuals in 2021, corresponding to an estimated annual exposure rate of 4.2% (Mesfin et al., 2017). In low-income countries, medical biology laboratories that play a central role in public health investigations often operate with limited capacity and under-prioritize biosafety concerns (Halatoko et al., 2024). In this context, Wurtz et al. (2016), following an international survey, found that human error accounted for 78% of reported LAIs (Thompson et al., 2021). Poor implementation of biosafety measures is a major contributing factor to LAIs.

In the Democratic Republic of the Congo (DRC), working conditions in biomedical laboratories are often precarious. These laboratories are crucial for diagnosing, monitoring, and controlling infectious diseases. However, laboratory personnel are regularly exposed to pathogens through biological fluids—particularly blood—due to insufficient training, inadequate personal protective equipment (PPE), and poor adherence to biosafety practices (Mukadi et al., 2023).

In Kinshasa, Motuta et al. (2020) reported that the majority of laboratory workers had never received biosafety training, and most had not been vaccinated.

Although biomedical laboratories play a crucial role in disease surveillance and health risk management in Kinshasa, their actual biosafety capacity remains insufficiently documented. Available data on infrastructure, biological risk management systems, and daily practices are often limited, incomplete, or outdated (WHO, 2020). This lack of reliable information hinders the implementation of effective capacity-building policies. Therefore, a comprehensive assessment of biosafety training and practices in biomedical laboratories in Kinshasa is necessary to address these gaps and guide future interventions.

This study aims to assess the level of biosafety training, vaccination practices, and overall satisfaction among laboratory personnel in Kinshasa. The objective is to identify key priority areas for improvement in biosafety practices, especially in low-resource settings where laboratory systems are frequently underfunded and understaffed (CDC, 2021).

METHODS

Study Design and Setting

A descriptive and analytical cross-sectional study was conducted from November 1, 2024, to February 28, 2025, in the city of Kinshasa, Democratic Republic of the Congo.

Sampling

A non-probability convenience sample of 290 laboratory personnel was recruited from 56 biomedical laboratories across Kinshasa. The selection of laboratories was based on their strategic importance, particularly in terms of patient volume, accessibility, and geographical distribution across the city. This may have led to selection bias, with more organized or biosafety-aware laboratories potentially being overrepresented. Consequently, the findings should be interpreted with caution, especially regarding their generalizability to all laboratories in Kinshasa. Nevertheless, the results offer valuable insights into the current situation and can serve as a basis for future, more comprehensive research.

Study Population

The study population consisted of laboratory technicians, biomedical scientists, general practitioners, and medical biologists who were present at their workplaces during the survey and provided informed consent to participate.

Visits were conducted in various laboratories to examine working conditions. The questionnaire was developed following a review of international standards (including WHO guidelines on laboratory biosafety) and after

discussions with laboratory managers. A preliminary validation was carried out within the department.

Data Collection

Data were collected by the principal investigator using a structured data collection form designed to capture relevant variables related to biosafety training, practices, and vaccination status.

Statistical Analysis

Data were entered into a Microsoft Excel 2010 database (Microsoft 365), cleaned, and then exported to IBM SPSS Statistics for Windows, Version 24.0, for analysis. Results were expressed as means (± standard deviation), medians (interquartile range), or proportions (%) as appropriate. Statistical comparisons between two groups were performed using Student's *t*-test for means, the Mann-Whitney *U* test for medians, and the Pearson chi-square test or Fisher's exact test for proportions, depending on the context.

Ethical Considerations

The study protocol was reviewed and approved by the National Health Ethics Committee under reference number 620/CNES/BN/PMMF/2025, dated January 20, 2025.

RESULTS

General Characteristics of the Study Population

Among the 290 laboratory personnel surveyed in Kinshasa, the mean age was 39.1 ± 10.2 years, with most (34.5%) aged between 30 and 39 years. Males accounted for 57.2% of respondents. Nearly all participants (98.3%) held a higher education degree. The professional profile was dominated by laboratory technicians at the A1 level (59.7%), followed by biomedical scientists (30.7%). Regarding work experience, 30.7% of respondents had between 5 and 10 years of service.

Just over half of the personnel (55.5%) reported having received biosafety training, with the largest proportion of these (34.8%) having been trained more than two years ago. Despite this, only 30.0% of respondents reported being vaccinated against hepatitis B, highlighting a significant gap in preventive measures against biological risks.

These findings underscore the need for enhanced and more recent biosafety training programs and vaccination campaigns within laboratory settings to improve occupational safety in biomedical laboratories in low-resource contexts like Kinshasa.

Table 1:
Sociodemographic characteristics, biosafety training, and hepatitis B vaccination status of laboratory personnel in Kinshasa (n = 290)

Variable	Category	n	%
Age group (years)	19–29	57	19.7
	30–39	100	34.5
	40–49	84	29.0
	50–59	37	12.8
	≥60	12	4.1
Sex	Male	166	57.2
	Female	124	42.8
Highest educational level	Secondary	5	1.7
	Higher/University	285	98.3
Professional qualification	Biomedical Scientist	89	30.7
	Clinical Pathologist	17	5.9
	General Practitioner	6	2.1
	Lab Technician (A1)	173	59.7
	Lab Technician (A2)	5	1.7
Years of work experience	<5	79	27.2
	5–10	89	30.7
	11–15	44	15.2
	>15	78	26.9
Biosafety training	Yes	161	55.5
	No	129	44.5
Duration of training (n=161)	6 months	30	18.6
	1 year	38	23.6
	2 years	37	23.0
	>2 years	56	34.8
Hepatitis B vaccination	Vaccinated	87	30.0
	Not vaccinated	203	70.0

Association Between Provider Characteristics and Biosafety Training

Personnel aged 40 years and above were significantly more likely to have received biosafety training compared to those under 40 (61.6% vs. 50.3%, p = .032). Similarly, those with ≥10 years of experience had a higher training rate (64.8%) than those with less experience (48.8%, p = .008). No significant association was found between biosafety training and sex (p = .41) or education level (p = .12).

Table 2:
Association between provider characteristics and biosafety training (n = 290)

Variable	Trained n (%)	Not trained n (%)	*p*-value
Age			***.032****
< 40 years (n=157)	79 (50.3)	78 (49.7)	
≥ 40 years (n=133)	82 (61.6)	51 (38.4)	
Sex			***.41***
Male (n=166)	90 (54.2)	76 (45.8)	
Female (n=124)	71 (57.3)	53 (42.7)	
Education			***.12***
Secondary (n=5)	1 (20.0)	4 (80.0)	
Higher/Univ (n=285)	160 (56.1)	125 (43.9)	
Experience			***.008****
<10 years (n=168)	82 (48.8)	86 (51.2)	
≥10 years (n=122)	79 (64.8)	43 (35.2)	

Association Between Provider Characteristics and Hepatitis B Vaccination

Respondents who had received biosafety training were significantly more likely to be vaccinated against hepatitis B compared to those untrained (41.0% vs. 16.3%, $p < .001$). Additionally, personnel with ≥10 years of experience had higher vaccination rates than those with less experience (37.7% vs. 24.4%, $p = .04$). No significant difference was observed for education level ($p = .19$).

Table 3:
Association Between Provider Characteristics and Hepatitis B Vaccination (n=290)

Variable	Vaccinated n (%)	Not vaccinated n (%)	p-value
Biosafety training			***<0.001****
Yes (n=161)	66 (41.0%)	95 (59.0%)	
No (n=129)	21 (16.3%)	108 (83.7%)	
Work experience			***0.04****
< 10 years (n=168)	41 (24.4%)	127 (75.6%)	
≥ 10 years (n=122)	46 (37.7%)	76 (62.3%)	
Education level			***0.19***
Secondary (n=5)	0 (0.0%)	5 (100.0%)	
Higher/University (n=285)	87 (30.5%)	198 (69.5%)	

Association Between Selected Variables and Satisfaction With Biosafety Management

Satisfaction with biosafety management was significantly higher among trained personnel compared to untrained (37.9% vs. 14.7%, $p < .001$). Vaccinated respondents also reported greater satisfaction than unvaccinated ones (39.1% vs. 22.7%, $p = .013$). No significant association was found between satisfaction and sex ($p = .55$).

Table 4:
Association Between Selected Variables and Satisfaction with Biosafety Management (n=290)

Variable	Satisfied n (%)	Not satisfied n (%)	p-value
Biosafety training			***<0.001****
Yes (n=161)	61 (37.9%)	100 (62.1%)	
No (n=129)	19 (14.7%)	110 (85.3%)	
Hepatitis B vaccination			***0.013****
Yes (n=87)	34 (39.1%)	53 (60.9%)	
No (n=203)	46 (22.7%)	157 (77.3%)	
Sex			***0.55***
Male (n=166)	48 (28.9%)	118 (71.1%)	
Female (n=124)	32 (25.8%)	92 (74.2%)	

Estimated Odds Ratios

Multivariate analysis indicated that personnel aged ≥40 years had 1.54 times higher odds of having received biosafety training ($p = .032$). Seniority of ≥10 years was associated with significantly higher odds of both biosafety training (OR = 1.87, $p = .008$) and hepatitis B vaccination (OR = 1.77, $p = .04$). Biosafety-trained personnel had over three times higher odds of being vaccinated (OR = 3.63, $p < .001$) and of being satisfied with biosafety management (OR = 3.43, $p < .001$).

Table 5:
Estimated Odds Ratios for Factors Associated

Variable	Outcome: Biosafety Training OR (95% CI)	p	Outcome: Hepatitis B Vaccination OR (95% CI)	p	Outcome: Satisfaction OR (95% CI)	p
Age ≥ 40 years	1.54 (1.05 – 2.27)	0.032*	1.32 (0.85 – 2.05)	0.21	1.45 (0.90 – 2.33)	0.12
Seniority ≥ 10 years	1.87 (1.17 – 2.98)	0.008*	1.77 (1.02 – 3.07)	0.04*	1.68 (1.00 – 2.82)	0.05
Male sex	0.89 (0.58 – 1.37)	0.41	1.10 (0.66 – 1.83)	0.70	1.17 (0.71 – 1.93)	0.55
Higher education	2.15 (0.81 – 5.72)	0.12	1.68 (0.58 – 4.88)	0.34	1.29 (0.45 – 3.71)	0.63
Biosafety training*	–	–	3.63 (2.04 – 6.46)	<0.001*	3.43 (1.87 – 6.28)	<0.001*

*Biosafety training is only considered as a predictor for vaccination and satisfaction outcomes.

DISCUSSION

This study, conducted across 56 laboratories and involving 290 healthcare workers from 44 public and 12 private laboratories in Kinshasa, highlights several key aspects of biosafety practices. The study population was relatively young, with 54.2% of participants under 40 years old. This aligns with findings by Halatoko et al. (2024), who reported that 69.9% of laboratory professionals were aged between 25 and 44 years, suggesting that younger professionals are more represented, likely due to recent training and career opportunities.

However, in this study, personnel aged 40 years and older had 1.54 times higher odds of having received biosafety training compared to younger staff. Similarly, those with ≥10 years of seniority were significantly more likely to be

trained. Older or more experienced laboratory staff may be more likely to have received biosafety training due to several interrelated factors. First, they are often in supervisory or leadership roles that require formal training to ensure compliance with national or institutional biosafety standards. Second, these staff members may have had more opportunities over time to access workshops, refresher courses, or on-the-job mentorship, particularly in settings where continuing professional development is encouraged or mandatory. Additionally, they may be more aware of the occupational risks associated with laboratory work and therefore more proactive in seeking or accepting training. Conversely, younger or less experienced staff may not yet be prioritized for training or may be unaware of available opportunities, highlighting a potential gap in early-career capacity building.

The male predominance (57.2%) in our sample is comparable to the 64% reported by Khabour et al. (2018), indicating that technical laboratory professions remain predominantly male. However, gender distribution varies by context. For example, Traoré et al. (2020) found near gender parity, with 51% female, suggesting a possible shift towards more balanced gender representation in biomedical fields.

Nearly all participants (98.3%) held higher or university-level education, which is advantageous for biosafety quality as higher academic levels facilitate understanding of safety standards. Nevertheless, academic qualification does not necessarily imply practical biosafety training. In our study, 55.5% of respondents had received specific biosafety training, a rate higher than the 44.3% reported by Traoré et al. (2020) but lower than the 68% found by Khabour et al. (2018). This highlights the crucial need for dedicated and continuous training, considered a fundamental pillar by international biosafety standards (World Health Organization [WHO], 2020).

Moreover, 34.8% of trained personnel had completed their training more than two years ago, indicating a likely gap in regular refresher courses. This finding is consistent with Halatoko et al. (2024), where 24.2% of trained staff had not received refresher training for over two years, revealing a recurrent weakness in maintaining up-to-date competencies, which are essential for high biosafety standards.

Vaccination coverage against hepatitis B was low, with only 30% vaccinated—a figure similar to that reported by Kalambay et al. (2019) in the Democratic Republic of the Congo. This vaccination gap represents a significant vulnerability for staff, exposing them to major biological risks. It underlines the need for strengthened vaccination policies integrated within biosafety management (Centers for Disease Control and Prevention [CDC], 2021).

Overall satisfaction with biosafety management was low, with only 27.6% of respondents satisfied. This dissatisfaction can be attributed to deficiencies in training, equipment, and organization, consistent with findings from the CDC (2021) and various African contexts (Mesfin et al., 2017; Adewumi et al., 2019). To improve this situation, it is imperative to integrate robust biosafety modules in initial training, organize regular refresher courses, and invest in adequate equipment (Nzomukunda & Ilunga, 2022).

The findings of this study have several policy implications. First, they highlight the need for targeted and inclusive biosafety training programs that prioritize not only senior laboratory staff but also younger and newly recruited personnel, who may be undertrained yet equally exposed to biohazards. Policymakers and health authorities should consider making biosafety training mandatory during onboarding processes and ensure that periodic refresher courses are institutionalized. In addition, this evidence supports the development of national or institutional biosafety guidelines that standardize training frequency and content across laboratories. Finally, funding and support mechanisms should be established to ensure equitable access to training, especially in resource-limited settings where infrastructure and continuous education are often lacking. These measures would not only improve individual competency but also strengthen overall laboratory system resilience and public health preparedness.

Limitations of the Study

This study has several limitations. First, the use of convenience sampling may introduce selection bias, limiting the generalizability of the findings to all laboratories in Kinshasa. Second, data collection was based

primarily on self-reported information, which may be subject to social desirability bias or recall bias. Third, the study did not include direct observation of biosafety practices, which could have allowed for comparison between reported knowledge and actual behavior. Lastly, the cross-sectional design prevents any inference of causality between the variables studied.

CONCLUSION

Despite the high academic level of most personnel, only slightly more than half had received specific biosafety training, and in many cases, the training was outdated. Vaccination coverage against hepatitis B remains inadequate, exposing professionals to preventable biological risks. The low satisfaction rate with biosafety management reflects ongoing gaps in continuing education, appropriate equipment, and institutional policies.

These findings underscore the urgent need to systematically integrate biosafety into the initial training of healthcare professionals, establish continuous and refresher training programs, and implement mandatory vaccination policies for laboratory staff. Strengthening these aspects is essential to improve biological safety, protect personnel, and ensure quality laboratory services in resource-limited settings.

Author contributions: DSG contributed to the study conception and drafted the initial manuscript. TKM contributed to the study design, statistical analysis, drafting, translation, and formatting of the manuscript. GMM, PNC, LHM, and JMM supervised the data collection and were responsible for critical revisions and refinement of the final version.

Data availability statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethical Approval: The study protocol was reviewed and approved by the National Health Ethics Committee under reference number 620/CNES/BN/PMMF/2025, dated January 20, 2025.

Conflicts of Interest: None declared.

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