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Biosafety Management Practices Among Clinical Laboratory Professionals in Debre Berhan Town Governmental Hospitals, Ethiopia: A Cross-Sectional Study

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ABSTRACT

Background and Aims: Clinical laboratories play a vital role in modern healthcare, where laboratory test results significantly influence medical decisions. However, laboratory professionals are often exposed to hazardous biological materials, underscoring the importance of biosafety management. This study aimed to assess biosafety practices among clinical laboratory professionals in Debre Berhan town, Ethiopia.

Methods: A cross-sectional study involving 81 participants was conducted using a standard questionnaire covering work habits, protective barriers, safety equipment, and biosafety policy perception. Descriptive data was summarized using a table and graph. Logistic regression was employed to determine factors affecting adherence to biosafety protocols. Statistically significant value was identified using p value ≤ 0.05, 95% CI, and OR.

Results: The results revealed high compliance with essential work habits, such as the use of mechanical pipettes 77 (95.1%) and proper handwashing after handling biohazardous material 78 (96.3%) and after removing gloves 80 (98.8%). However, adherence to the use of protective barriers 50 (61.7%), biosafety training 15 (18.5%), and emergency preparedness 28 (34.6%) were notably low. Only 35 (43.2%) of participants received appropriate immunizations, and access to biosafety equipment like biological safety cabinets was limited 15 (18.5%). Experience and training were significant predictors of biosafety compliance, highlighting the need for continuous education and institutional support.

Conclusion: The findings underscore the importance of enhancing training programs, improving access to safety equipment, and ensuring the consistent application of biosafety protocols to protect laboratory personnel from hazardous biological materials and maintain public health.

1 | Introduction

Patient care and public health are dependent on the reliability and quality of clinical laboratory testing, since laboratory tests account for the most frequently ordered diagnostic procedures in all patient encounters [1]. Studies also suggest that in the modern healthcare system, at least 70% of today's medical decisions are influenced by laboratory test results [2, 3]. Patient care and public health require timely and reliable laboratory testing. However, clinical laboratory professionals rarely know

whether patient specimens contain infectious agents, making ensuring biosafety while performing testing procedures challenging. The importance of biosafety in clinical laboratories was highlighted during the 2014 Ebola and COVID-19 outbreaks, where concerns about biosafety resulted in delayed diagnoses and contributed to patient deaths [4].

Biosafety management is a critical component of laboratory operations, particularly in clinical settings where exposure to infectious agents is frequent [5]. Clinical laboratory professionals are at the forefront of diagnostic services, handling potentially hazardous biological materials that can pose significant health risks if not managed properly [4]. Ensuring adherence to biosafety practices is essential for minimizing occupational hazards, protecting laboratory personnel, and preventing the accidental release of pathogens into the community. Despite global guidelines and established protocols [6, 7], gaps in biosafety compliance remain, especially in low-resource settings [8].

In developing countries like Ethiopia, the healthcare system faces numerous challenges, including insufficient infrastructure, limited access to updated safety equipment, and inadequate training in biosafety protocols. These challenges are particularly pronounced in clinical laboratories, where professionals often work in suboptimal conditions, increasing the likelihood of exposure to biological hazards. Studies have highlighted that laboratory workers in developing countries are frequently at risk due to the lack of comprehensive biosafety management systems, limited vaccination coverage, and insufficient personal protective equipment (PPE) [8, 9]. In such environments, the establishment and enforcement of strict biosafety protocols become crucial in ensuring the safety of healthcare workers and maintaining public health.

Biosafety practices encompass a range of activities, including the proper handling, storage, and disposal of infectious materials; adherence to laboratory safety guidelines; the use of PPE; and the implementation of emergency protocols in case of exposure. Additionally, biosafety management involves the continuous assessment and mitigation of risks associated with laboratory work, requiring not only individual compliance but also institutional commitment to provide necessary resources and training [6, 7]. However, the effectiveness of these practices relies heavily on regular training, awareness programs, and the availability of functional safety equipment. In this context, there is a need to assess the current state of biosafety management practices in Ethiopia's clinical laboratories. This study evaluates biosafety management practices in clinical laboratories in Debre Berhan town, Ethiopia. It examines how well laboratory professionals adhere to protocols for handling infectious materials, using protective equipment, and following safety guidelines.

2 | Methods

2.1 | Study Design and Study Participants

A cross-sectional study was conducted to assess biosafety management practices among clinical laboratory professionals in Debre Berhan town, Ethiopia. The study was carried out from March 2023 to June 2023, focusing on professionals working in various laboratory settings such as sample collection, clinical chemistry, microbiology, and hematology in Debre Berhan University Hakim Gizaw Hospital and Debre Berhan Comprehensive Specialized Hospital. A total of 81 clinical laboratory personnel and intern medical laboratory science students working in clinical laboratories at the time of data collection were participated.

2.2 | Data Collection Tools

A standard checklist/questionnaire was developed to gather data on sociodemographic characteristics and adherence to biosafety management practices. The checklist/questionnaire includes closed-ended questions covering four key areas: (1) work habits, (2) use of protective barriers and safety equipment, (3) equipment and maintenance, and (4) biosafety policy perception. The questionnaire was prepared based on national [10] and international guidelines [11, 12]. The questionnaire was administered in person to ensure clarity and consistency. Participants were informed about the purpose of the study, and their consent was obtained before participation.

2.3 | Data Analysis

Data was coded manually, and double data entry was done using SPSS version 29 software for descriptive and inferential analyses. Descriptive statistics were used to summarize the demographic data and biosafety practices. Compliance rates for each of the four biosafety categories were calculated and presented as percentages. Statistical associations between compliance rates and factors such as educational level, years of experience, and training were assessed using logistic regression analysis. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated to determine the significant predictors of adherence to biosafety practices. p value ≤ 0.05, 95% CI, and odd ratio (OR) were used to determine a statistically significant value.

2.4 | Operational Definition

- Biosafety training: A structured program of education and practical instruction aimed at equipping medical laboratory personnel with the knowledge, skills, and practices necessary to safely handle, process, and dispose of biological materials and infectious agents and minimizing risks to themselves, their colleagues, and the environment while ensuring compliance with established safety standards and regulations.
- Good biosafety management practice: from biosafety and biosafety management practice questions who answered 55% and above were as a minimum requirement for good biorisk management practice [13].
- Poor biosafety management practice: from biosafety and biosafety management practice questions who answered below 55% is poor biosafety management practice [13].
- Workload: the total volume of tasks or activities performed by laboratory personnel within a specific period,

encompassing all aspects of diagnostic, analytical, and supportive functions necessary to deliver timely and accurate test results.

- Biohazard sign: a visible and standardized warning sign used to indicate the presence of biological hazards in a specific area, equipment, or container.

3 | Results

3.1 | Sociodemographic Characteristics of Study Participants

Most of the participants were male 46 (56.8%) and aged (18–30) 59 (72.8%), with nearly half being intern laboratory students 40 (49.4%; Table 1). A significant majority worked in multiple laboratory areas, including sample collection, clinical chemistry, and microbiology 77 (95.1% each). However, only 15 (18.5%) had received biosafety training and just 4 (4.9%) were enrolled in an exposure prophylaxis program. Vaccination coverage was reported for both HBV 25 (30.9%) and COVID-19 35 (43.2%; Table 1).

Most participants reported compliance with critical biosafety measures such as having waste disposal protocols 61 (75.3%), laboratory safety guidelines 60 (74.1%), and restricted access during experiments 58 (71.6%; Table 2). However, several key areas exhibited lower compliance, with only 35 (43.2%) of professionals receiving appropriate immunizations and just 28 (34.6%) having emergency plans in place for post-exposure control. Notably, the assignment of a biosafety officer 20 (24.7%) and the provision of biosafety training 15 (18.5%) were among the least practiced policies (Table 2).

In a study evaluating biosafety practices related to work habits in clinical laboratories, the data reveals a generally high adherence to essential safety protocols (Table 3). Most participants reported following practices such as not eating, drinking, or applying cosmetics in work areas 65 (80.2%); keeping

TABLE 1 | Distribution of sociodemographic characteristics of clinical laboratory personnel.

Variable	Category	Frequency	Percentage
Sex	Male	46	56.8
	Female	35	43.2
Age	18–30	59	72.8
	31–40	18	22.2
	40–50	2	2.5
	> 50	2	2.5
Education level	Intern laboratory student	40	49.4
	Diploma	5	6.2
	BSc	20	24.7
	MSc	16	19.8
Experience (years)	1–5	49	60.5
	6–10	15	18.5
	11–15	11	13.6
	≥ 16	2	2.5
In which area you are working	Sample collection	77	95.1
	Clinical chemistry	77	95.1
	Hematology and serology	77	95.1
	Blood bank	77	95.1
	Microbiology	77	95.1
	Parasitology and urinalysis	77	95.1
	TB and HIV laboratory	77	95.1
	Pathology	2	2.5
Training on biosafety	Yes	15	18.5
	No	66	81.5
Exposure prophylaxis program	Yes	4	4.9
	No	77	95.1
Vaccination against infectious pathogen	HBV	25	30.9
	COVID-19	35	43.2

TABLE 2 | Biosafety toward policy perception of clinical laboratory personnel.

S. no.	Questions	Yes		No	
		Frequency	Percentage	Frequency	Percentage
1.	Laboratory limited/restricted when experiments are in progress	58	71.6	23	28.4
2.	Receive appropriate immunization	35	43.2	46	56.8
3.	Policy/procedure for potential hazards	52	64.2	29	35.8
4.	Waste disposal protocol in place	61	75.3	20	24.7
5.	Safety precautions and procedures	55	67.9	26	32.1
6.	Policies for the safe handling of sharps	50	61.7	31	38.3
7.	Guidelines on laboratory safety	60	74.1	21	25.9
8.	Development and use of manuals, protocols, and SOPs	57	70.4	24	29.6
9.	Willingness to be a biosafety officer to monitor biosafety practices in the laboratory	20	24.7	61	75.3
10.	Provision of biosafety training/orientation	15	18.5	66	81.5
11.	Emergency plans to prevent/control post-exposures	28	34.6	53	65.4

laboratory doors closed during testing 72 (88.9%); and using mechanical pipettes instead of mouth pipetting 77 (95.1%). Additionally, handwashing before leaving the laboratory 75 (92.6%) and after handling biohazardous materials 78 (96.3%) were commonly observed. Despite these positive outcomes, there are areas for improvement. For instance, the implementation of incident/accident report systems was low 50 (61.7%), and routine safety audits were only conducted by 52 (64.2%) of the participants. Furthermore, although practices such as decontaminating used materials outside the laboratory 56 (69.1%) and ensuring proper waste segregation 70 (86.4%) were relatively well-adopted, some practices like decontaminating equipment before maintenance 57 (70.4%) and conducting routine safety audits 52 (64.2%) showed lower adherence rate (Table 3).

The result on protective barrier practices in clinical laboratories indicates a moderate adherence to recommended safety measures (Table 4). Most participants reported using safe protective barriers for splashing or spraying of infectious microorganisms 48 (59.3%) and regularly using PPE for procedures involving infectious aerosols 50 (61.7%). Practices such as using disposable gloves for touching clean surfaces 47 (58.0%) and removing protective clothing before leaving laboratory areas 43 (53.1%) were also reasonably adopted. Additionally, the use of gloves when handling potentially infectious materials 54 (66.7%) and disposing of gloves in biohazard waste containers immediately after use 45 (55.6%) were reported by over half of the participants. However, there is room for improvement in certain areas. For example, only 41 (50.6%) of participants used eye or face protection when other barriers were not available, and adherence to replacing protective garments when contamination is suspected was 46 (56.8%; Table 4).

The result on laboratory safety practices reveals significant variability in adherence to essential protocols (Table 5). Only 15 (18.5%) of the participants reported having ensured access to appropriate biological safety cabinets (BSCs). Around 50 (61.7%) of the participants decontaminated equipment before maintenance and 55 (67.9%) of the participants conducted regular inspections of autoclaves and pressure vessels. A substantial majority of participants reported inspecting centrifuge buckets and rotors 60 (74.1%), discarding cracked and chipped glassware 64 (79.0%), using safe receptacles for broken glass 68 (83.9%), and having readily available sharps disposal containers 70 (86.4%; Table 5).

Overall, the highest compliance was in work habits 1454/1782 (81.6%), followed by equipment maintenance 104/154 (67.5%), the use of protective barriers and safety equipment 423/729 (58.1%), and policy perception 491/891 (55.1%; Figure 1). This highlights that while work habits are well-adopted, improvements are needed in the use of safety equipment and policies.

Higher educational levels showed a trend toward better adherence, though not statistically significant (Table 6). Experience of 16 years or more was significantly associated with higher adherence (AOR [95% CI]: 1.75 [1.00–3.10], $p = 0.05$). Regular biosafety training (AOR [95% CI]: 2.10 [1.20–3.75], $p = 0.01$), appropriate biosafety precautions (AOR [95% CI]: 2.30 [1.20–4.40], $p = 0.01$), and the availability of biosafety standard operating procedures (SOPs; AOR [95% CI]: 1.75 [1.00–3.10], $p = 0.05$) were significantly linked to improved biosafety practices. Additionally, posting biohazard signs (AOR [95% CI]: 1.95 [1.05–3.60], $p = 0.03$) and proper engineering controls (AOR [95% CI]: 2.10 [1.15–3.85], $p = 0.02$) were strong predictors of adherence. This underscores the importance of continuous training and infrastructure in promoting safe laboratory practices (Table 6).

4 | Discussion

In this study, nearly half of the participants were intern laboratory students, comprising 49.38% of the total number of participants. Previous research conducted in Uganda [14], Pakistan

TABLE 3 | Biosafety practices related to work habits in clinical laboratories.

S. No.	Questions	Yes		No	
		Frequency	Percentage	Frequency	Percentage
1.	Do not eat, drink, or apply cosmetics in work areas	65	80.2	16	19.8
2.	Biohazard signs posted at laboratory entrance	58	71.6	23	28.4
3.	Keep laboratory doors closed during testing	72	88.9	9	11.1
4.	Incident/accident report system in place	50	61.7	31	38.3
5.	Decontaminate all cultures, stocks, and waste before disposal	67	82.7	14	17.3
6.	Use mechanical/micropipettes to replace mouth pipetting	77	95.1	4	4.9
7.	Seal rotor heads and centrifuge cups while running	64	79.0	17	21.0
8.	Remove broken glassware from the floor mechanically	60	74.1	21	25.9
9.	Use disposable needles for drawing blood specimens and discard them properly	69	85.2	12	14.8
10.	Decontaminate used material outside the laboratory	56	69.1	25	30.9
11.	Wash hands before leaving the laboratory	75	92.6	6	7.4
12.	Decontaminate infectious liquid waste before discharge	62	76.5	19	23.5
13.	Store food outside the work area of the laboratory	73	90.1	8	9.9
14.	Decontaminate equipment before repair/maintenance/removal	57	70.4	24	29.6
15.	Conduct routine safety audits to ensure containment parameters	52	64.2	29	35.8
16.	Proper handling/management of hazardous chemicals using MSDS	66	81.5	15	18.5
17.	Wash hands after handling biohazardous materials	78	96.3	3	3.7
18.	Wash hands after removing gloves	80	98.8	1	1.2
19.	Clean and decontaminate work surfaces at the end of each day	68	83.9	13	16.1
20.	Perform activities carefully to minimize splashes	74	91.4	7	8.6
21.	Use compliant triple packaging for transporting cultures and specimens	61	75.3	20	24.7
22.	Segregate infectious, noninfectious, and sharps waste properly	70	86.4	11	13.6

[15], and China [16, 17] has underscored the significance of hospital laboratory internships. Internships foster a safety-first mindset, teach risk assessment, and ensure regulatory compliance. It also prepare students for emergency response and cultivate accountability in maintaining a safe laboratory environment, which is essential for their future professional careers.

This study evaluated personnel willingness to serve as biosafety officers and found that 20 (24.7%) of the laboratory personnel expressed willingness to serve as biosafety officers, reflecting a moderate interest in assuming this critical role. Biosafety officers are assigned rotationally, typically one or two at a time. While the rotational system promotes shared responsibility, the relatively low willingness suggests a need for capacity building and fostering a stronger culture of biosafety to ensure consistent monitoring and adherence to safety practices [18].

The result indicated significant gaps in biosafety training and exposure prophylaxis among participants, with only 15 (18.5%) having received training and a mere 4 (4.9%) enrolled in an exposure prophylaxis program. This lack of preparedness can lead to increased risks of biological hazards, particularly in handling pathogens such as HBV and COVID-19, as evidenced by the low vaccination rates: 25 (30.9%) for HBV and 35 (43.2%) for COVID-19. The insufficient coverage suggests that many individuals may be vulnerable to infections, which poses a risk not only to themselves but also to public health [5]. To address these issues, it is crucial to implement comprehensive biosafety training programs and increase enrollment in exposure prophylaxis initiatives while promoting vaccination campaigns to enhance overall immunity against infectious diseases.

The high adherence to essential biosafety work habits, such as the consistent use of mechanical pipettes 77 (95.1%) and proper

TABLE 4 | Biosafety practices related to the use of protective barriers and safety equipment in clinical laboratories.

S. No.	Questions	Yes		No	
		Frequency	Percentage	Frequency	Percentage
1.	Use safe protective barriers for splashing/spraying of infectious microorganisms	48	59.3	33	40.7
2.	Regular use of PPE for procedures creating infectious aerosols	50	61.7	31	38.3
3.	Use disposable gloves for touching clean surfaces and avoid wearing them outside the laboratory	47	58.0	34	42.0
4.	Remove protective clothes before leaving non-laboratory areas	43	53.1	38	46.9
5.	Always wear protective coats/gowns in the laboratory	49	60.5	32	39.5
6.	Wear gloves when hands may contact potentially infectious materials	54	66.7	27	33.3
7.	Dispose of gloves in a biohazard waste container immediately after use	45	55.6	36	44.4
8.	Replace protective garments when contamination is suspected	46	56.8	35	43.2
9.	Use eye/face protection if face protection is not provided by other barriers	41	50.6	40	49.4

handwashing protocols 78 (96.3%), demonstrates a commendable level of awareness among laboratory professionals. Hand hygiene is a critical component in infection prevention and control within healthcare settings. The WHO [19] emphasizes that proper handwashing protocols can significantly reduce the transmission of pathogens, thereby decreasing healthcare-associated infections. This adherence is particularly vital for laboratory professionals who are in direct contact with patients' samples. However, the lower compliance with safety audits 52 (64.2%) and the absence of a robust incident reporting system 50 (61.7%) point to gaps in safety oversight. These deficiencies can hinder the timely identification and correction of potential hazards, thus increasing the risk of accidental exposure.

In this study, the moderate adherence to the use of protective barriers and PPE is concerning, particularly in environments where exposure to infectious agents is frequent. Although 54 (66.7%) of the participants reported using gloves when handling infectious materials, only 41 (50.6%) regularly used eye or face protection. A study carried out in Nigeria also revealed significant shortcomings in the knowledge, attitudes, and practices regarding laboratory safety among laboratory personnel, particularly concerning the use of PPE [20]. This low compliance with face and eye protection makes laboratory professionals vulnerable to exposure during high-risk procedures, such as handling aerosols or splashes.

The low compliance of incident reporting systems also poses significant risks to laboratory personnel and public health. These gaps underline the need for immediate policy reforms and institutional support, including regular training, better PPE provision, and the establishment of robust incident reporting mechanisms. Strengthening these areas is essential for aligning Ethiopia's biosafety practices with international standards [10–12] and ensuring a safer working environment for laboratory professionals.

A major finding of this study is the low percentage of professionals receiving biosafety training 15 (18.5%). This is even lower than the 27.8% reported in Greece [21], indicating a persistent issue across various healthcare environments. The lack of training can lead to increased risks of exposure to infectious agents, which can have dire consequences for both healthcare workers and patients [4, 5]. This lack of training and preparedness may contribute to the gaps observed in emergency protocols, with only 27 (34.6%) of professionals reporting the existence of post-exposure emergency plans. In settings where laboratory staff frequently handle potentially infectious materials, regular biosafety training is essential [4, 5]. The strong correlation between training and improved biosafety practices (AOR: 2.10, $p = 0.01$) further underscores the need for continuous educational programs. The study identified that professionals with more years of experience were more likely to adhere to biosafety practices (AOR: 1.75, $p = 0.05$). Similarly, participants with higher educational levels showed better compliance. These findings suggest that both experience and advanced education play crucial roles in enhancing adherence to safety protocols. Encouraging continuous professional development (CPD) and higher education may foster better compliance across all laboratory staff.

The findings also indicate a concerning gap in compliance with immunization requirements among laboratory professionals,

TABLE 5 | Biosafety management practice toward equipment and maintenance.

S. No.	Questions	Yes		No	
		Frequency	Percentage	Frequency	Percentage
1.	Access to appropriate biological safety cabinets (BSCs) and other essential equipment is ensured	15	18.5	66	81.5
2.	Decontaminating equipment before maintenance	50	61.7	31	38.3
3.	Autoclaves and other pressure vessels are regularly inspected	55	67.9	26	32.1
4.	Centrifuge buckets and rotors are regularly inspected	60	74.1	21	25.9
5.	Cracked and chipped glassware is always discarded and not reused	64	79.0	17	21.0
6.	Use safe receptacles for broken glass	68	83.9	13	16.1
7.	Sharps disposal containers are easily available and being used	70	86.4	11	13.6

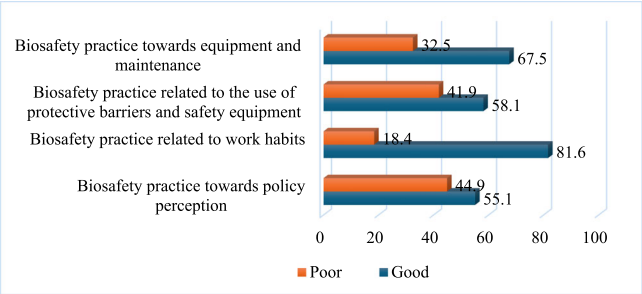

FIGURE 1 | Overall situation of biosafety practices in all four categories.

with only 35 (43.2%) of participants reporting appropriate immunizations. This low rate of compliance poses a significant risk to both individuals and the broader healthcare environment, particularly in settings where laboratory workers are frequently exposed to potentially infectious agents [22]. Immunizations are a critical component of biosafety measures and are emphasized in international guidelines, such as those from the WHO and CDC, to reduce the likelihood of occupational infections [23]. The lack of compliance may reflect barriers such as inadequate awareness, limited access to vaccines, or insufficient institutional policies supporting immunization programs.

Furthermore, the absence of well-defined emergency plans, as reported by participants, underscores a critical vulnerability in the laboratory's biosafety preparedness. Emergency plans are essential for managing incidents such as accidental spills, exposures, or other biohazard events [18, 23]. Without these protocols, laboratories are ill-equipped to respond effectively, increasing the potential for harm to personnel and the wider community. Management must prioritize the development and dissemination of comprehensive emergency plans, including on-site and online training to ensure preparedness [24].

One of the most critical challenges identified in the study was the lack of institutional support for biosafety practices. Only 15 (18.5%) of the participants had access to BSCs, and the assignment of a biosafety officer was rare 20 (24.69%). The availability of biosafety infrastructure, such as BSCs, and the assignment of responsible personnel are essential for mitigating biohazards [25]. Without these resources, even well-trained professionals may find it difficult to implement best practices. Addressing these structural gaps through improved infrastructure and clear biosafety protocols should be a priority for healthcare institutions.

Predictors of compliance with hospital protocols, such as staff training and professional experience, are critical for ensuring adherence to best practices in healthcare. In Ethiopia, integrating these factors into the existing CPD framework can significantly enhance outcomes. Training programs should emphasize practical, scenario-based learning tailored to specific hospital roles, while experience-sharing workshops can facilitate knowledge transfer among staff with varying levels of expertise. Resource allocation, including access to up-to-date guidelines, modern equipment, and periodic competency assessments, should be incorporated into hospital protocols. By embedding continuous education and adequate resource support into CPD initiatives, healthcare facilities can foster a culture of compliance, enhance service quality, and ultimately improve patient outcomes.

In general, the human factor in biosafety is always the weakest one. Humans just do not apply to rules. That is why it is important that management provides sufficient safety equipment (BSC, ventilation, rooms, and security barriers/doors) to enable biosafety. Often, it is the case that people who are interviewed do not tell the truth while filling in questionnaires, but they say what they know would be the optimal situation. So, it can be considered that the “real world” behavior of the employees is lesser adhering to the rules.

4.1 | Study Limitation

One limitation of this study is the relatively small sample size of 81 participants, which may not adequately represent the broader population of clinical laboratory professionals in Ethiopia. Additionally, the study's geographic scope is confined to Debre Berhan town, potentially reducing its applicability to

TABLE 6 | Factors affecting biosafety management practice of laboratory personnel.

Variable		Percentage	COR (95% CI)	*p* value	AOR (95% CI)	*p* value
Sex	Male	56.8	1		1	
	Female	43.2	0.75 (0.45–1.24)	0.29	0.82 (0.48–1.39)	0.45
Education Level	Intern student	49.4	1		1	
	Diploma	6.2	1.10 (0.65–1.84)	0.72	1.05 (0.60–1.85)	0.86
	BSc	24.7	1.25 (0.78–2.01)	0.37	1.30 (0.80–2.10)	0.42
	MSc	19.8	1.50 (0.88–2.54)	0.13	1.40 (0.80–2.45)	0.22
Experience (years)	1–5	60.5	1		1	
	6–10	18.5	1.35 (0.78–2.33)	0.28	1.30 (0.72–2.35)	0.34
	11–15	13.6	1.60 (0.92–2.78)	0.09	1.50 (0.85–2.65)	0.16
	≥ 16	2.5	1.85 (1.05–3.26)	0.03[a]	1.75 (1.00–3.10)	0.05[a]
Workload	Yes	60.6	1		1	
	No	39.4	1.20 (0.75–1.92)	0.44	1.10 (0.65–1.85)	0.64
Regular biosafety training	Yes	18.5	1		1	
	No	81.5	2.25 (1.30–3.90)	0.003[a]	2.10 (1.20–3.75)	0.01[a]
Appropriate biosafety precaution	Yes	80.0	1		1	
	No	20.0	2.50 (1.40–4.45)	0.002[a]	2.30 (1.20–4.40)	0.01[a]
Availability SOP for biosafety practice	Yes	75.6	1		1	
	No	24.4	1.85 (1.05–3.26)	0.03[a]	1.75 (1.00–3.10)	0.05[a]
Availability of a written procedure for each test	Yes	32.7	1		1	
	No	67.3	1.65 (0.95–2.90)	0.07	1.55 (0.85–2.80)	0.14
Post biohazard sign	Yes	67.9	1		1	
	No	32.1	2.10 (1.20–3.65)	0.01[a]	1.95 (1.05–3.60)	0.03[a]
Management aspect	Good	55.1	1		1	
	Poor	44.9	1.45 (0.85–2.50)	0.17	1.35 (0.75–2.45)	0.30
Engineering aspect	Good	54.6	1			
	Poor	45.4	2.30 (1.25–4.25)	0.007[a]	2.10 (1.15–3.85)	0.02[a]

[a]Statistically significant value.

other regions with differing healthcare infrastructure and biosafety practices. There is a possibility of bias, as participants might overreport adherence to safety protocols due to social desirability. Furthermore, the study lacks qualitative insights that could provide a deeper understanding of the challenges faced in adhering to biosafety practices. Finally, the study does not assess the long-term sustainability of improved biosafety practices following training or interventions, leaving questions about how compliance might change over time.

5 | Conclusion

This study highlights both strengths and challenges in laboratory professional's biosafety practices compared to national and global standards. While adherence to essential work habits aligns well with WHO and CDC guidelines, significant gaps remain in training access, emergency preparedness, and biosafety equipment availability. These deficiencies emphasize the urgent need for targeted interventions, such as enhanced training programs, improved infrastructure, and regular safety audits, to elevate biosafety practices to international norms. Despite strong compliance with basic work habits, critical areas like protective barrier use, policy enforcement, and emergency readiness require substantial improvement. Sustained institutional commitment and resource allocation are essential to safeguard laboratory personnel and mitigate biohazard risks effectively.

Recommendations

We recommend conducting future studies focusing on specific laboratory areas (sample collection, clinical chemistry, hematology and serology, microbiology, parasitology and urinalysis, TB and HIV laboratory, blood bank, and pathology) to identify targeted strengths and improvement needs for impactful interventions.

Author Contributions

Mahlet Tewodros Tadesse: conceptualization, investigation, writing–original draft, formal analysis, data curation, methodology. **Libse Lemma Ayalke:** conceptualization, writing–original draft, investigation, formal analysis, data curation, methodology. **Beza Fitiwi Tedla:** conceptualization, writing–original draft, investigation, formal analysis, data curation, methodology. **Fikrite Adefris Weldemeskel:** conceptualization, investigation, writing–original draft, formal analysis, data curation, methodology. **Ahmed Seid Yirdaw:** conceptualization, investigation, writing–original draft, formal analysis, data curation, methodology. **Tsegahun Asfaw Abebe:** funding acquisition, writing–review and editing, methodology, validation, supervision, resources.

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The authors have nothing to report.

Ethics Statement

Ethical approval was obtained from the Institutional Review Board of Debre Berhan University, Health Sciences Campus, and all participants provided written informed consent. Confidentiality of participant data was maintained throughout the study [Protocol number: IRB-090]. Permission was obtained from the hospital administration, and informed consent was secured from participants, ensuring their right to withdraw. Privacy and confidentiality were maintained, with all data kept anonymous.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The authors confirm that the data supporting the findings of this study are available within the article.

Transparency Statement

The lead author Tsegahun Asfaw Abebe affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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