

Biosafety Practices in Handling Tuberculosis Sputum Samples Among Laboratory Personnel in Public Health Facilities in Sembabule District, Uganda

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ABSTRACT

Tuberculosis (TB) exposes laboratory personnel to occupational infection risks during the collection, processing, and disposal of sputum specimens. This study assessed biosafety practices among laboratory personnel in public health facilities in Sembabule District, Uganda. A descriptive cross-sectional quantitative study was conducted among 60 laboratory personnel selected from public facilities providing TB diagnostic services. Data were collected using a structured self-administered questionnaire and summarized using descriptive statistics. Only 46.7% of respondents fully understood national TB infection prevention and control guidelines, 45.0% had never received structured TB biosafety training, and 43.3% never attended biosafety refresher or continuous professional development sessions. Consistent adherence was also suboptimal: 45.0% always followed recommended sputum-handling protocols and 43.3% always used personal protective equipment (PPE). Frequent biosafety supervision was reported by 33.3%. Infrastructure gaps were substantial: PPE was always available to only 30.0%, fully functional biosafety cabinets were reported by 23.3%, and adequate ventilation by 36.7%. These findings indicate that moderate knowledge is not matched by consistent practice or adequate institutional support. Strengthening continuous training, supportive supervision, PPE supply systems, biosafety cabinet functionality, and laboratory ventilation is necessary to reduce occupational TB exposure in peripheral public health laboratories.

KEYWORDS: tuberculosis; biosafety; sputum; laboratory personnel; personal protective equipment; infection prevention and control; Uganda

1. INTRODUCTION

Tuberculosis (TB) remains a major global public health problem. The World Health Organization reported approximately 10.8 million new TB cases and 1.25 million deaths worldwide in 2023 [1]. Laboratory personnel are a particularly important occupational risk group because they routinely handle sputum specimens that may contain high concentrations of *Mycobacterium tuberculosis*. Procedures such as smear preparation and centrifugation can generate infectious aerosols, making laboratory biosafety an essential component of TB infection prevention and control [2].

The burden of occupational exposure is especially important in high TB-burden and resource-limited settings. Uganda reports a substantial annual TB burden, while health workers have historically shown elevated risks of latent or active TB compared with the general population [1,3]. National and international guidance emphasizes correct use of PPE, safe specimen handling, adequate ventilation, biosafety cabinets where indicated, standard operating procedures, training, and supervision. However, implementation may be inconsistent in peripheral laboratories where resources and infrastructure are constrained [2].

Evidence reviewed in the source study suggests that knowledge and adherence vary considerably across settings. Moderate knowledge has been reported among laboratory personnel in Uganda and Ethiopia, while stronger knowledge in some settings has been associated with structured training and continuous professional development [4-7]. Likewise, adherence appears to improve where supervision and enforcement are stronger [8-11]. Infrastructure limitations, including inconsistent PPE availability, inadequate ventilation, and limited access to functional biosafety cabinets, remain important barriers in resource-limited laboratories [12-15].

District-level evidence from Sembabule was limited despite the role of public health laboratories in TB diagnosis. This study therefore examined biosafety practices in handling TB sputum samples among laboratory personnel in public health facilities in Sembabule District, Uganda. Specifically, it assessed knowledge of recommended biosafety practices, adherence during sputum collection, processing and disposal, and the availability and adequacy of biosafety infrastructure and PPE.

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2. MATERIALS AND METHODS

2.1. Study Design and Setting

A descriptive cross-sectional study using quantitative methods was conducted in public health facilities in Sembabule District, Uganda. The district has a predominantly rural public health system comprising Health Centre IIIs, Health Centre IVs, and a general hospital, with selected facilities providing TB diagnostic services. Data collection was conducted between June and August 2026.

2.2. Study Population and Eligibility

The study population comprised laboratory personnel working in public health facility laboratories who were directly involved in collecting, processing, storing, or disposing of TB sputum samples. Eligible participants included laboratory technologists, laboratory technicians, laboratory assistants, and other personnel involved in TB diagnostic activities. Administrative staff, personnel not involved in TB sputum handling, staff unavailable during data collection, and those who declined informed consent were excluded.

2.3. Sample Size and Sampling

The sample size was determined using the Kish and Leslie formula for cross-sectional studies, assuming a 95% confidence level, an estimated biosafety adherence proportion of 50%, and a margin of error of 0.126, giving a sample size of 60 participants. Public health facilities providing TB diagnostic services were purposively selected, and all eligible laboratory personnel in the selected facilities were invited to participate.

2.4. Data Collection

Data were collected using a structured, self-administered questionnaire developed from national TB infection prevention and control guidance and relevant literature. The instrument captured socio-demographic characteristics, knowledge of TB sputum biosafety practices, adherence to recommended procedures, and the availability and adequacy of biosafety infrastructure and PPE. Permission was obtained from relevant authorities before data collection, informed consent was obtained from participants, and completed questionnaires were collected after completion.

2.5. Data Management and Analysis

Completed questionnaires were checked for completeness and coded. Data were entered, cleaned, organized, and analyzed in Microsoft Excel. Descriptive statistics, principally frequencies and percentages, were used to summarize participant characteristics and the main study variables.

2.6. Quality Assurance and Ethical Considerations

The questionnaire was pre-tested in a similar health facility outside the study area and reviewed for clarity, relevance, and consistency. Data entry was cross-checked to minimize errors. The source report states that ethical approval was obtained from a recognized research ethics committee and that permission was obtained from the District Health Office and facility management. Participation was voluntary, written informed consent was obtained, and confidentiality and anonymity were maintained. The specific ethics committee name and approval code were not reported in the source document and should be inserted before journal submission.

3. RESULTS

All 60 targeted participants completed the study, giving a response rate of 100%.

3.1. Participant Characteristics

Table 1. Socio-demographic characteristics of respondents (n = 60).

Variable	Category	n	%
Age (years)	20-29	18	30.0
	30-39	22	36.7
	40-49	12	20.0
	>=50	8	13.3
Sex	Male	36	60.0
	Female	24	40.0
Professional cadre	Laboratory technologists	5	8.3
	Laboratory technicians	12	20.0

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	Laboratory assistants	28	46.7
	Other (TB focal persons)	15	25.0
Experience	<5 years	20	33.3
	5-9 years	18	30.0
	10-14 years	12	20.0
	>=15 years	10	16.7

The largest age group was 30-39 years (36.7%), 60.0% of respondents were male, and laboratory assistants formed the largest professional cadre (46.7%). One-third (33.3%) had less than five years of work experience.

3.2. Knowledge and Training on TB Biosafety

Table 2. Knowledge, training, and continuing professional development related to TB biosafety (n = 60).

Indicator	Response	n	%
Understanding of national TB-IPC guidelines	Fully understand	28	46.7
	Partially understand	20	33.3
	Do not understand	12	20.0
Structured TB biosafety training	More than once	15	25.0
	Once	18	30.0
	Not trained	27	45.0
Familiarity with standard biosafety protocols	Very familiar	26	43.3
	Somewhat familiar	22	36.7
	Not familiar	12	20.0
Refresher/CPD attendance	Regular (at least annually)	14	23.3
	Occasionally (< once/year)	20	33.3
	Never	26	43.3

Fewer than half of participants (46.7%) fully understood the recommended national TB-IPC guidelines. Only 25.0% had received structured TB biosafety training more than once, while 45.0% had never received such training. Similarly, 43.3% reported never attending refresher courses or CPD sessions on biosafety practices.

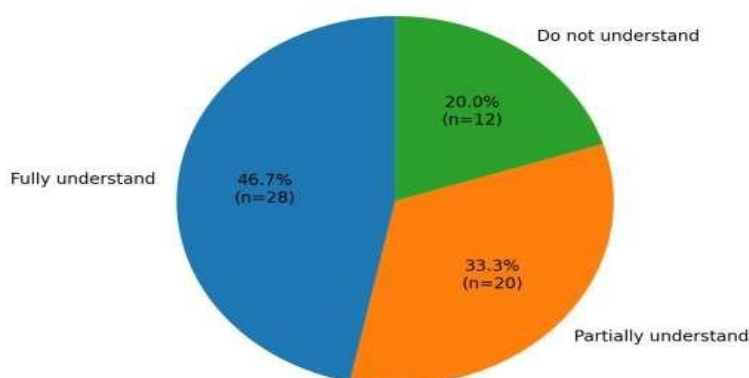


Figure 1. Knowledge and understanding of the recommended national TB-IPC guidelines for handling sputum samples (n = 60).

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Figure 1 shows that 46.7% (28/60) of respondents fully knew and understood the recommended national TB-IPC guidelines, while 33.3% (20/60) had partial knowledge and 20.0% (12/60) had no knowledge. Thus, fewer than half of the laboratory personnel demonstrated full knowledge of the guidelines.

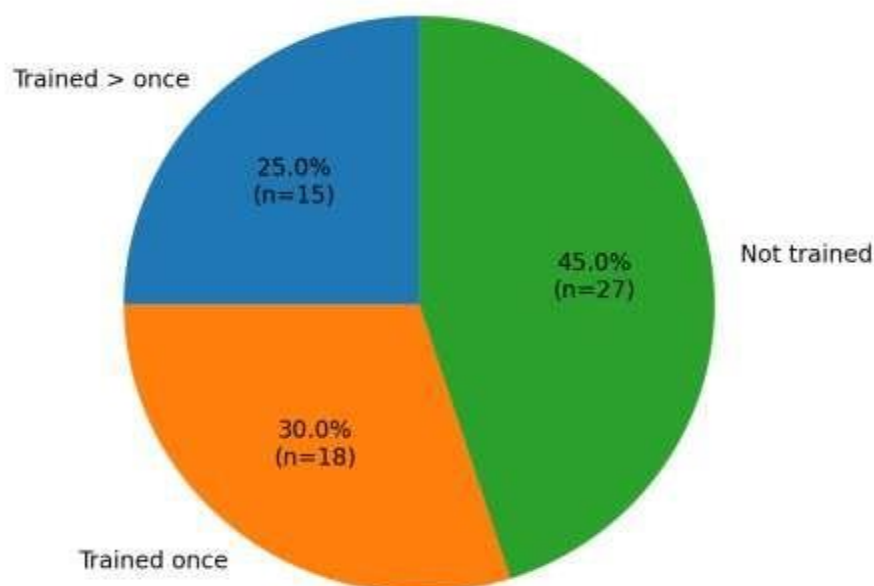


Figure 2. Structured training received on TB biosafety practices, including sputum handling, PPE use, and waste disposal (n = 60).

As shown in Figure 2, 25.0% (15/60) had received structured TB biosafety training more than once and 30.0% (18/60) had been trained once. However, 45.0% (27/60) had never received structured training, indicating an important gap in routine biosafety capacity building.

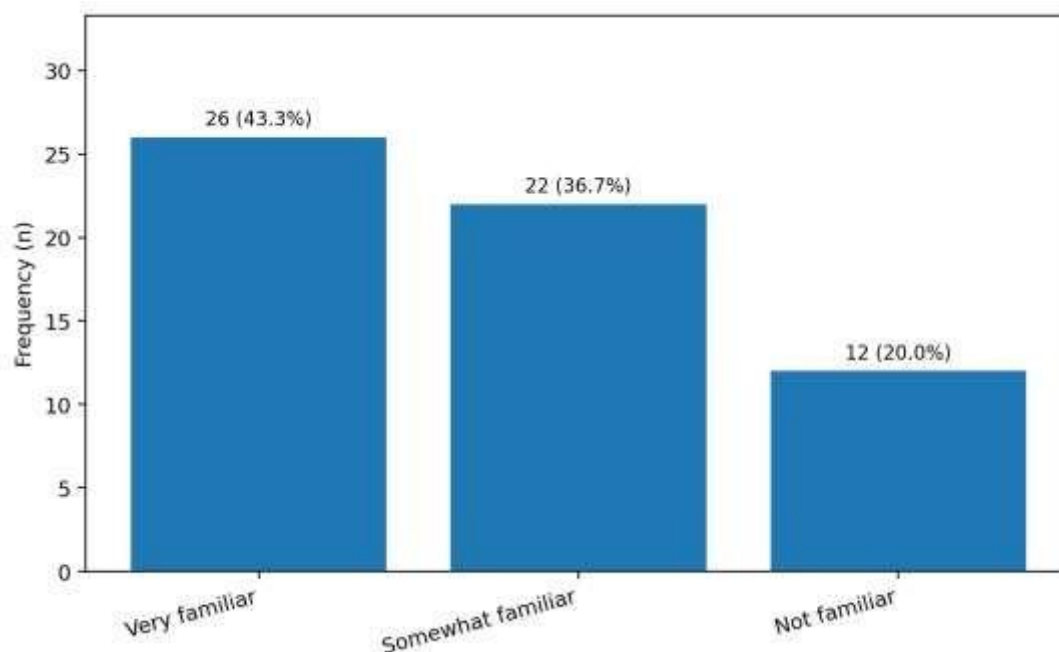


Figure 3. Familiarity with standard biosafety protocols for TB specimen collection, processing, and disposal (n = 60).

Figure 3 indicates that 43.3% (26/60) of respondents were very familiar with standard TB biosafety protocols, 36.7% (22/60) were somewhat familiar, and 20.0% (12/60) were not familiar. The findings demonstrate that complete familiarity with the required procedures was not universal among laboratory personnel.

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3.3. Adherence to Standard Biosafety Procedures

Table 3. Adherence, PPE use, supervision, and perceived influence of external support (n = 60).

Indicator	Response	n	%
Recommended sputum handling protocols	Always	27	45.0
	Sometimes	21	35.0
	Never	12	20.0
PPE use during TB sputum handling	Always	26	43.3
	Often	18	30.0
	Rarely	10	16.7
	Never	6	10.0
Supervision/auditing	Frequently	20	33.3
	Occasionally	22	36.7
	None	18	30.0
External support improves adherence	Strongly agree	15	25.0
	Agree	20	33.3
	Disagree	17	28.4
	Strongly disagree	8	13.3

Only 45.0% of respondents reported consistently following recommended sputum-handling protocols, and 43.3% always used PPE when handling TB sputum. Frequent supervision or auditing was reported by 33.3%, whereas 30.0% reported no supervision. Overall, 58.3% either agreed or strongly agreed that external support programs influenced adherence to biosafety practices.

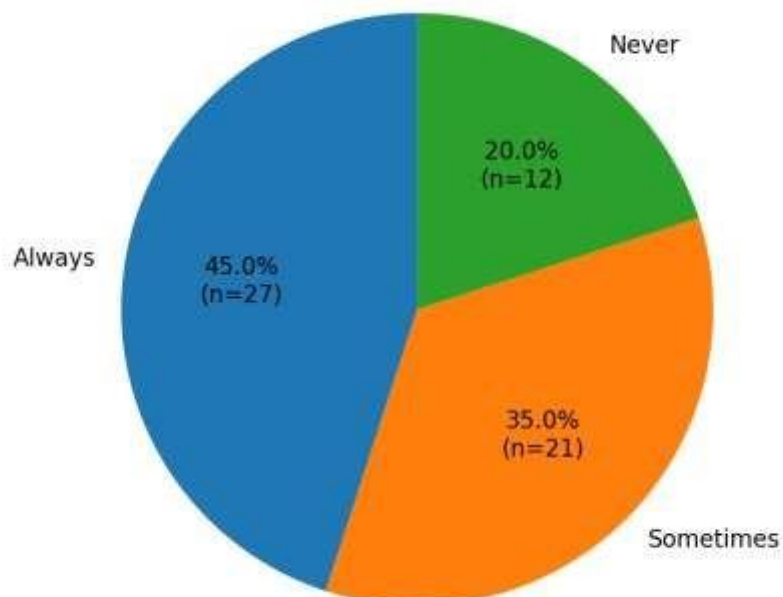


Figure 4. Consistent follow-up of recommended sputum-handling protocols during laboratory procedures (n = 60).

Figure 4 shows that 45.0% (27/60) of respondents always followed recommended sputum-handling protocols, whereas 35.0% (21/60) followed them sometimes and 20.0% (12/60) never followed them. This reflects inconsistent adherence to standard procedures among a substantial proportion of respondents.

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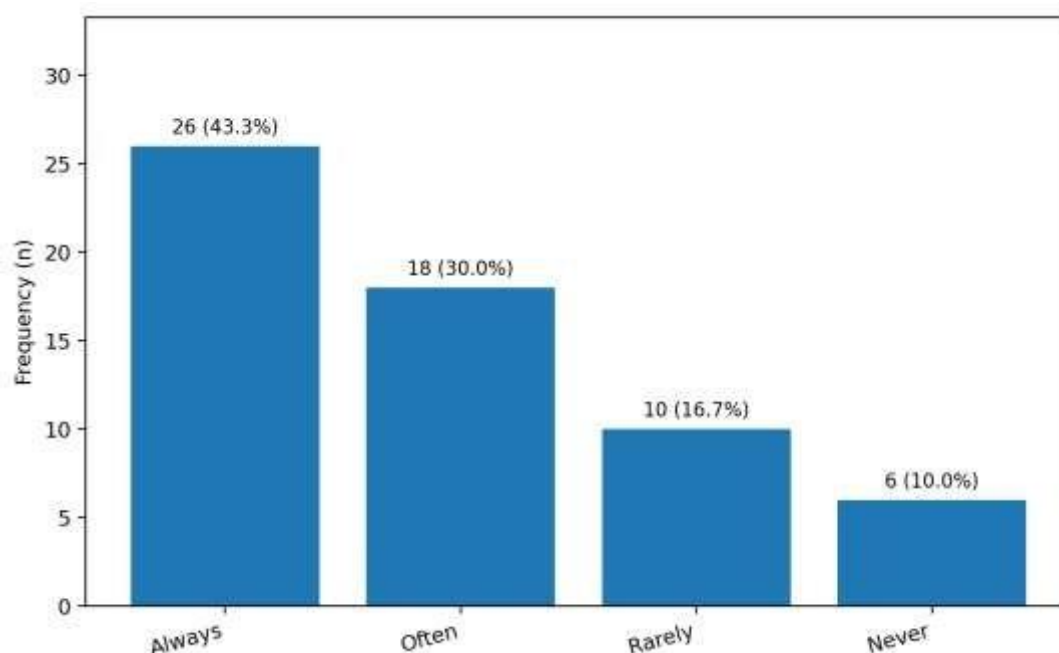


Figure 5. Use of personal protective equipment such as gloves, masks, and laboratory coats when handling TB sputum samples (n = 60).

As presented in Figure 5, 43.3% (26/60) always used PPE, 30.0% (18/60) often used it, 16.7% (10/60) rarely used it, and 10.0% (6/60) never used PPE. Although most respondents reported some PPE use, consistent use remained below half of the study population.

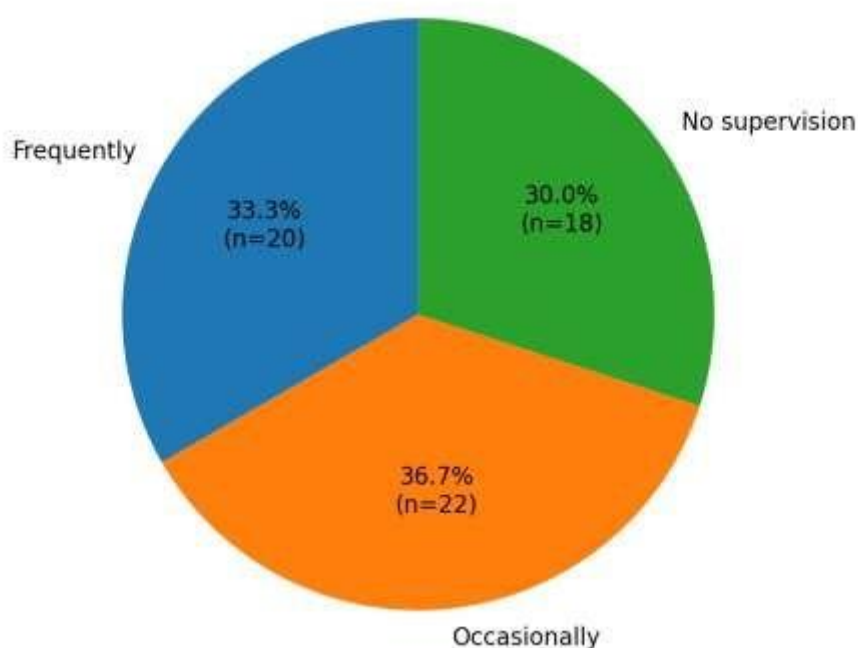


Figure 6. Regular supervision or auditing of biosafety practices by senior staff or institutional committees (n = 60).

Figure 6 demonstrates that 33.3% (20/60) of respondents reported frequent supervision or auditing, 36.7% (22/60) reported occasional supervision, and 30.0% (18/60) reported no supervision. These findings suggest that routine institutional oversight of biosafety practices was limited.

3.4. Biosafety Infrastructure and PPE Availability

Table 4. Availability of PPE, biosafety cabinets, donor support, and ventilation (n = 60).

Indicator	Response	n	%
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PPE availability	Always available	18	30.0
	Sometimes available	24	40.0
	Rarely available	12	20.0
	Not available	6	10.0
Biosafety cabinets	Fully functional	14	23.3
	Available but not functional	10	16.7
	Not available	36	60.0
Donor support for PPE	Regularly	16	26.7
	Occasionally	20	33.3
	No donor support	24	40.0
Ventilation adequacy	Adequate	22	36.7
	Partially adequate	20	33.3
	Inadequate	18	30.0

Only 30.0% of respondents reported that adequate PPE was always available. Functional biosafety cabinets were reported by 23.3%, while

60.0% reported no biosafety cabinet. Forty percent reported no donor

support for PPE supplies. Adequate ventilation was reported by 36.7%, with the remainder describing ventilation as partially adequate or inadequate.

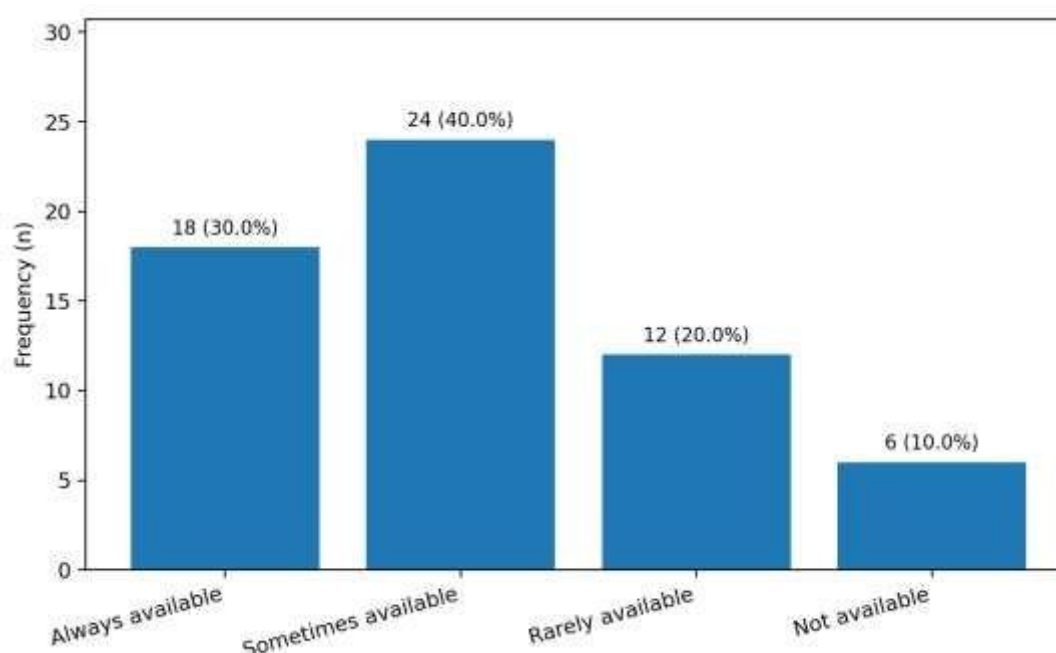


Figure 7. Adequate and consistent availability of PPE in the laboratory (n = 60).

Figure 7 shows that only 30.0% (18/60) reported that adequate PPE was always available. PPE was sometimes available for 40.0% (24/60), rarely available for 20.0% (12/60), and not available for 10.0% (6/60), indicating inconsistent access to essential protective supplies.

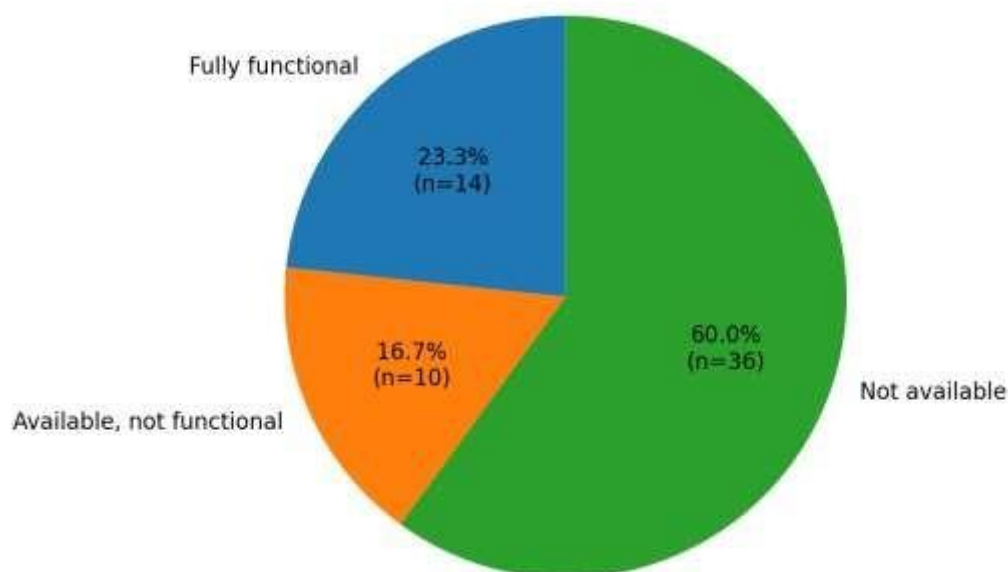


Figure 8. Availability and functionality of biosafety cabinets for handling TB sputum samples (n = 60).

As shown in Figure 8, only 23.3% (14/60) reported having fully functional biosafety cabinets, while 16.7% (10/60) reported non-functional cabinets. The majority, 60.0% (36/60), reported that no biosafety cabinet was available, demonstrating a major infrastructure gap for safe TB specimen handling.

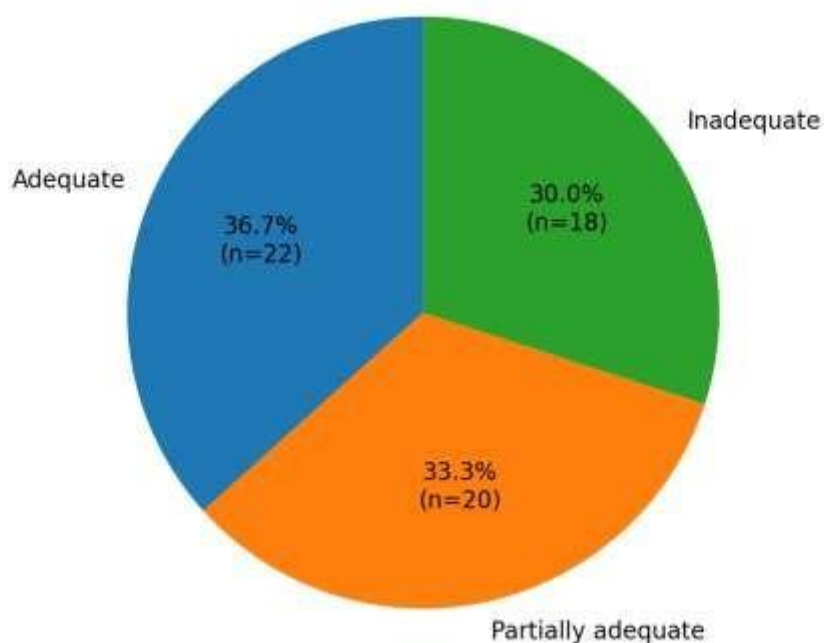


Figure 9. Availability and adequacy of ventilation systems to reduce airborne transmission risks during sputum handling (n = 60).

Figure 9 indicates that 36.7% (22/60) reported adequate ventilation, 33.3% (20/60) reported partially adequate ventilation, and 30.0% (18/60) reported inadequate ventilation. Therefore, almost two-thirds of respondents worked in laboratories where ventilation was either only partially adequate or inadequate.

4. DISCUSSION

This study identified interconnected gaps in knowledge, adherence, supervision, and laboratory infrastructure. Although 46.7% of respondents fully understood national TB-IPC guidelines, substantial proportions had only partial or no understanding. The level of

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full understanding was lower than figures cited in the source report from Uganda (55%) and Ethiopia (52%) [4,5]. The limited exposure to structured training is a plausible programmatic concern: 45.0% had never received structured TB biosafety training and 43.3% never attended refresher or CPD sessions. The source literature similarly associated stronger knowledge with structured training and continuing professional development [6,7].

Knowledge did not translate consistently into practice. Only 45.0% always followed recommended sputum-handling procedures and 43.3% always used PPE. These findings are broadly consistent with the low-to-moderate adherence described in Uganda, Ethiopia, Ghana, and South Africa [8-10,16]. Settings with stronger enforcement and supervision have reported better adherence [11]. In Sembabule, only one-third reported frequent supervision and almost one-third reported none, suggesting that institutional monitoring is an important area for improvement.

The infrastructure findings were particularly concerning. PPE was always available to only 30.0% of respondents, consistent with broader reports of PPE shortages in Ugandan and other resource-limited laboratories [12,17]. In addition, 60.0% reported that biosafety cabinets were unavailable and only 23.3% reported fully functional cabinets. The source report compared this unfavorably with findings from Nigeria and South Africa [13,14]. Ventilation was adequate for only 36.7%, reinforcing the need for engineering controls alongside administrative measures and PPE [15].

External support was perceived to influence adherence by 58.3% of respondents, yet 40.0% reported no donor support for PPE. This mixed pattern indicates that donor-supported programs may strengthen biosafety where present, but reliance on external support alone is unlikely to provide sustainable protection. District and national systems therefore need dependable local procurement, maintenance, supervision, and training mechanisms.

The study has limitations. Its cross-sectional design provides a snapshot and cannot establish causal relationships. The use of self-administered questionnaires may introduce recall or social desirability bias, and the sample was limited to 60 personnel in public health facilities in one district, restricting generalizability. Nevertheless, the study provides useful district-level evidence on occupational biosafety gaps among personnel directly involved in TB sputum handling.

5. CONCLUSION

Biosafety practices for handling TB sputum samples in public health facilities in Sembabule District were suboptimal across knowledge, adherence, and infrastructure domains. Fewer than half of respondents fully understood national TB-IPC guidelines, consistently followed sputum-handling procedures, or always used PPE. Training and refresher participation were limited, supervision was inconsistent, and important infrastructure gaps included unreliable PPE supplies, limited access to functional biosafety cabinets, and inadequate or partially adequate ventilation. Improving occupational protection requires an integrated approach combining continuous training, supportive supervision and audits, reliable PPE supply systems, functional engineering controls, and sustainable resource allocation.

6. RECOMMENDATIONS

The Ministry of Health and District Health Office should strengthen district-level dissemination of TB-IPC guidance, provide annual biosafety refresher training and CPD, and implement standardized supportive supervision with routine laboratory audits. Public financing and supplychain systems should prioritize uninterrupted PPE availability and the maintenance or provision of appropriate biosafety cabinets and ventilation systems. Partnerships with TB programs and external funders may complement these efforts, but sustainable local procurement and maintenance mechanisms should remain central.

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Institutional Review Board Statement: The source report states that ethical approval was obtained from a recognized research ethics committee before commencement of the study, with additional permission from the District Health Office and facility management. The committee name and approval code were not provided and should be inserted before submission.

Informed Consent Statement: Written informed consent was obtained from all participants involved in the study.

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Abbreviations: BSC, biosafety cabinet; CPD, continuous professional development; DHO, District Health Office; IPC, infection prevention and control; MTB, Mycobacterium tuberculosis; PPE, personal protective equipment; TB, tuberculosis; TB-IPC, tuberculosis infection prevention and control.

REFERENCES

- 1) World Health Organization. Global Tuberculosis Report 2024. WHO: Geneva, Switzerland, 2024.
- 2) World Health Organization. Laboratory Biosafety Manual, 4th ed.; WHO: Geneva, Switzerland, 2020.
- 3) Buregyeya, E.; Kasasa, S.; Mitchell, E.M.H. Tuberculosis infection control knowledge and attitudes among health workers in Uganda: A cross-sectional study. *BMC Infect. Dis.* 2016, 16, 416.
- 4) . Aturinde, J. Knowledge of TB biosafety practices among Ugandan laboratory personnel. *Uganda Med. J.* 2025, 22, 14-22.
- 5) Tiruneh, G. Knowledge of TB biosafety practices in Ethiopia. *Ethiop. J. Health Dev.* 2023, 37, 55-63.
- 6) Mosha, D. Knowledge of TB biosafety practices in Tanzania. *Tanzania J. Health Sci.* 2020, 18, 22-30.
- 7) Mukamana, A. Knowledge of biosafety practices among Rwandan laboratory staff. *Rwanda Med. J.* 2022, 14, 88-95.
- 8) Wangari, M. Adherence to TB biosafety practices in Uganda. *Uganda Public Health Bull.* 2024, 20, 22-30.
- 9) Gebremariam, A. Adherence to TB biosafety practices in Ethiopia. *Ethiop. J. Public Health* 2021, 15, 101-109.
- 10) Mensah, K. Biosafety adherence among Ghanaian laboratory staff. *Ghana Med. J.* 2017, 51, 99-106.
- 11) Patel, R. Adherence to TB biosafety practices in India. *Indian J. Med. Microbiol.* 2020, 38, 55-62.
- 12) Kato, P. PPE adequacy in Ugandan laboratories. *Uganda J. Med. Pract.* 2025, 18, 44-52.
- 13) Olawale, O. Biosafety infrastructure in Nigerian public health laboratories. *Niger. J. Health Sci.* 2018, 14, 99-107.
- 14) Nkosi, Z. Availability of biosafety cabinets in South African laboratories. *S. Afr. Med. J.* 2019, 109, 321-328.
- 15) Habimana, J. Ventilation adequacy in Rwandan laboratories. *Rwanda Health J.* 2022, 10, 77-84.
- 16) Moyo, T. Adherence to PPE use among South African laboratory staff. *S. Afr. J. Infect. Dis.* 2019, 34, 144-152.
- 17) Bekele, H. PPE availability in Ethiopian public health laboratories. *Ethiop. J. Health Sci.* 2020, 30, 112-120.