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Assessment of Knowledge, Attitudes, and Practices on Safety Principales in Laboratory among Laboratory Technicians and Nurses at Centre Medico-Social Biryogo

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Abstract

Background*: Laboratory workers face significant occupational hazards including biological, chemical, and physical risks. Knowledge, attitudes, and practices (KAP) regarding safety standard operating procedures (SOPs) are essential for minimizing laboratory-acquired infections and workplace injuries. However, limited evidence exists on laboratory safety compliance in Rwandan healthcare facilities.*

Objective: *To assess the knowledge, attitudes, and practices regarding laboratory safety SOPs among laboratory technicians and nurses at Centre Médico-Social Biryogo in Nyarugenge District, Rwanda.*

Methods: *A descriptive cross-sectional study was conducted from 2019 to 2022 among 147 healthcare workers (13 laboratory technicians and 134 nurses) using convenience sampling. Data were collected using a structured, self-administered questionnaire and analyzed using SPSS version 16. Descriptive statistics (frequencies and percentages) were used to summarize findings.*

Results: *The majority of participants were male (57.1%), aged 26–30 years (27.2%), and had advanced diplomas (54.4%). Only 24.5% demonstrated good knowledge of laboratory safety principles. Concerning practices were identified: 54.4% handled waste without gloves, 45.6% used incorrect order of draw for specimen collection, and 23.1% failed to identify patients properly. Knowledge gaps included: 23.8% knew to avoid chemical skin/eye contact, and 21.8% knew emergency exit locations. Only 17.7% had received laboratory safety training in the past 12 months. Major barriers to safety SOP adherence included unavailability of SOPs (41.5%), lack of training (30.6%), and lack of materials (27.9%).*

Conclusion: *Laboratory workers and nurses at Centre Médico-Social Biryogo demonstrated suboptimal knowledge and poor compliance with laboratory safety SOPs. Comprehensive training programs, improved availability of safety equipment and SOPs, and establishment of functional infection prevention and control (IPC) committees are urgently needed to enhance laboratory safety culture and reduce occupational health risks.*

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Introduction

Background

Medical laboratory practices worldwide employ diverse personnel including clinical pathologists, scientists, medical laboratory technologists (MLTs), laboratory assistants, nurses, and administrative staff, representing one of the most heterogeneous segments of the healthcare workforce [1]. Due to the nature of their work, these employees face frequent exposure to various occupational hazards and risks associated with the materials they handle and procedures they perform. Common hazards include biological, chemical, physical, mechanical, and electrical risks, as well as psychological stressors and fire hazards [2].

Laboratory-acquired infections (LAIs) have been documented since the early days of laboratory research. Historical records reveal that inadequate safety practices led to illness and death among laboratory workers. Sulkin and Pike's landmark study identified 1,342 LAIs with 39 deaths among 5,000 laboratory professionals surveyed, with 72% of bacterial infections attributed to Brucella spp., Mycobacterium tuberculosis, Francisella tularensis, and Salmonella typhi [3]. More recently, the Centers for Disease Control and Prevention (CDC) reported 916 potential LARI exposures in 2007, with higher risks observed in inpatient institutions with more than 200 beds [4].

Standard precautions serve as fundamental infection prevention measures in healthcare settings. However, their effective implementation depends critically on healthcare workers' knowledge, attitudes, and practices [5]. Research indicates that healthcare workers' (HCWs) knowledge, attitudes, and practices (KAP) of standard precautions vary considerably based on professional category, length of experience, and training exposure [6]. Longer professional experience, formal training in standard precautions, and high risk perception have been associated with increased compliance among health workers.

Studies from Sub-Saharan Africa reveal significant gaps in laboratory safety knowledge and practice. A Nigerian study of two tertiary hospitals found that only 64.3% of respondents could differentiate between N95 respirators and face masks, and while attitudes toward infection control were generally positive, practice gaps persisted [7]. Research from Cameroon demonstrated that HCWs face high risk of infectious disease exposure and may play key roles in disease transmission, particularly when working with minimal barrier protection [8].

In Rwanda, increased laboratory accidents and mishaps attributed to lack of occupational safety and health (OSH) awareness represent major contributors to workplace injuries [9]. While previous studies have focused on specific issues such as needle-stick injuries and universal precautions, comprehensive assessments

of knowledge, attitudes, and practices regarding laboratory safety SOPs remain limited, particularly at district-level healthcare facilities.

Statement of the Problem

Medical laboratory technicians and nurses face exposure to numerous pathogenic agents, most notably Mycobacterium tuberculosis, Salmonella typhi, Brucella species, and hepatitis viruses [10]. Additional hazards include toxic chemicals, needle-stick injuries, and various physical and chemical risks. Despite relatively low incident rates among laboratory workers, serious and effective preventive health and safety surveillance systems, along with stringent laboratory practice codes, should be implemented to prevent spread of high-risk pathogens, including HIV, Hepatitis B, and Hepatitis C.

Globally, occupational accidents represent a significant public health burden. The International Labour Organization (ILO) estimates over 2.3 million workplace accidents and work-related fatalities annually, with more than 350,000 resulting from occupational accidents—approximately 1,000 deaths per day [11]. In 2010, over 313 million non-fatal occupational accidents occurred, meaning work-related injuries affect approximately 860,000 people daily worldwide.

In Rwanda, significant knowledge gaps regarding occupational safety and health (OSH) have been identified as major contributors to laboratory accidents [12]. While previous studies have addressed specific issues such as needle-stick injuries, universal precautions, and laboratory-acquired infections, comprehensive research on awareness, knowledge, and practices regarding OSH and hazard management in Rwandan healthcare facilities remains limited.

Centre Médico-Social Biryogo serves a significant population in Nyarugenge District, yet no documented assessment of laboratory safety practices has been conducted at this facility. Understanding current knowledge, attitudes, and practices regarding laboratory safety among staff is essential for developing targeted interventions to reduce occupational health risks and improve patient care quality.

Study Objectives

General Objective

To assess knowledge, attitudes, and practices regarding laboratory safety SOPs among laboratory technicians and nurses at Centre Médico-Social Biryogo in Nyarugenge District, Rwanda.

Specific Objectives

1. To assess knowledge of laboratory safety SOPs among laboratory technicians and nurses.
2. To describe practices regarding waste management and specimen handling.
3. To describe training patterns and perceived barriers to adherence to laboratory safety SOPs.

Significance of the Study

This study's findings will contribute to improving nursing and biomedical educational curricula, clinical practices, and future research directions, ultimately enhancing quality of care and patient outcomes in Rwanda through appropriate laboratory safety management. Results will support development of context-based, evidence-based guidelines for laboratory safety practice.

The study will serve as a reference for academicians and researchers conducting related research and will provide valuable insights for health policymakers regarding the importance of improving hospital facilities and implementing comprehensive safety education programs. Findings will inform context-specific content for nursing and biomedical curricula, particularly clinical learning activities and ongoing professional development (OPD).

Additionally, this research will identify factors associated with suboptimal laboratory safety practices and assist stakeholders in raising awareness about improving hospital facilities and educating healthcare workers on occupational safety and health.

Methodology

Research Design and Approach

This study employed a descriptive cross-sectional design with a quantitative approach. The cross-sectional design was appropriate for assessing knowledge, attitudes, and practices at a single point in time, while the quantitative approach enabled numerical data collection and statistical analysis to explore characteristics and relationships among study variables.

Study Setting and Period

The study was conducted at Centre Médico-Social Biryogo (Nyiranuma), located in Nyarugenge District, Kigali, Rwanda. Data collection occurred between 2019 and 2022. The facility provides primary healthcare services including laboratory diagnostics to the local population.

Study Population

The target population comprised all nurses and laboratory technicians registered and working at Centre Médico-Social Biryogo during the study period. The total target population was 233 healthcare workers.

Sample Size Determination

Sample size was calculated using Yamane's formula (1967) for single population proportions [13]:

$n = N / [1 + N(e^2)]$

Where: n = required sample size, N = total population (233), e = margin of error (0.05)

$n = 233 / [1 + 233(0.05^2)] = 233 / 1.5825 = 147.3 \approx 147$

The calculated minimum sample size was 147 participants, with a 95% confidence level and 5% margin of error. All 147 eligible participants were successfully recruited.

Sampling Procedure

Convenience sampling was employed to select participants based on availability and willingness to participate. Eligible participants were approached during working hours and invited to participate in the study. This approach was deemed appropriate given the study's descriptive nature and resource constraints.

Inclusion criteria: (1) Laboratory technicians or nurses registered and working at Centre Médico-Social Biryogo during the study period; (2) Willingness to provide informed consent; (3) Availability during data collection period.

Exclusion criteria: (1) Healthcare workers on leave or absent during data collection period; (2) Unwillingness to participate or provide informed consent; (3) Administrative staff not involved in direct laboratory or clinical work.

Data Collection Instrument and Procedure

Data were collected using a structured, self-administered questionnaire developed based on literature review and WHO guidelines for laboratory safety. The questionnaire comprised three sections:

- Section A: Demographic characteristics (gender, age, education, experience, marital status, staff category)
- Section B: Knowledge of laboratory safety SOPs (safety rules, guidelines, waste handling, specimen procedures)
- Section C: Training patterns and barriers to safety SOP adherence

The questionnaire was pre-tested among 10 healthcare workers at a similar facility to ensure clarity and comprehensibility. Minor modifications were made based on pre-test feedback. The questionnaire was available in English, the working language at the facility.

Data collection was conducted by trained research assistants who explained the study objectives and obtained written informed consent from participants. Questionnaires were distributed to consenting participants who completed them in private, comfortable locations. Completed questionnaires were collected and checked for completeness before data entry.

Data Analysis

Data were reviewed for completeness, coded, entered into SPSS version 16, cleaned, and analyzed. Descriptive statistics including frequencies, percentages, means, and standard deviations were used to summarize demographic characteristics and study variables. Results were presented in tables and narrative text.

Validity and Reliability

Content validity was ensured through expert review by faculty supervisors and laboratory safety specialists who assessed the relevance and clarity of questionnaire items. The instrument was based on established WHO laboratory safety guidelines and validated tools from similar studies.

Reliability was enhanced through pre-testing, standardization of data collection procedures, and training of research assistants. Clear instructions were provided to participants to ensure consistent interpretation of questions.

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board of Kibogora Polytechnic. Administrative

permission was secured from Centre Médico-Social Biryogo management. All participants provided written informed consent after receiving detailed explanation of the study's purpose, procedures, risks, and benefits.

Participation was voluntary, and participants could withdraw at any time without penalty. Confidentiality and anonymity were maintained by using identification codes instead of names, and storing data securely in password-protected files accessible only to the research team. Data were used solely for research purposes.

Results

Sociodemographic Characteristics of Participants

Table 1 presents the sociodemographic characteristics of the 147 study participants. Males comprised 57.1% (n=84) of participants, while females accounted for 42.9% (n=63). The majority of participants (27.2%, n=40) were aged 26–30 years, followed by those aged 31–35 years (25.2%, n=37). Nearly half (48.3%, n=71) had 2–3 years of work experience, while 28.6% (n=42) had one year of experience.

Regarding educational attainment, 54.4% (n=80) held advanced diplomas (A1 level), 26.5% (n=39) had diplomas (A2 level), and 19.0% (n=28) possessed bachelor's degrees (A0 level). Nurses constituted the majority of participants (91.2%, n=134), while laboratory technicians comprised 8.8% (n=13). In terms of marital status, 44.2% (n=65) were married, 27.9% (n=41) were single, 15.6% (n=23) were divorced, and 12.2% (n=18) were widowed.

Table 1: Sociodemographic Characteristics of Participants (N=147)

Characteristic	Frequency (n)	Percentage (%)
Gender		
Male	84	57.1
Female	63	42.9
Age (years)		
20–25	26	17.7
26–30	40	27.2
31–35	37	25.2
36–40	25	17.0
Over 40	19	12.9
Education Level		
Diploma (A2)	39	26.5
Advanced Diploma (A1)	80	54.4
Bachelor's Degree (A0)	28	19.0
Work Experience		
1 year	42	28.6
2–3 years	71	48.3
4–5 years	25	17.0
Over 5 years	9	6.1
Marital Status		
Single	41	27.9
Married	65	44.2
Divorced	23	15.6
Widowed	18	12.2

Staff Category		
Laboratory Technician	13	8.8
Nurse	134	91.2

Knowledge of Laboratory Safety Standard Operating Procedures

Laboratory Safety Rules Knowledge

Table 2 presents participants' knowledge regarding fundamental laboratory safety rules. Only 24.5% (n=36) demonstrated good overall knowledge of laboratory safety. The most commonly known safety rule was maintaining laboratory tidiness (23.1%, n=34), followed by dressing appropriately (12.9%, n=19) and knowing safety equipment locations (11.6%, n=17). Knowledge about testing skills in laboratory simulations was lowest at 9.5% (n=14).

Table 2: Knowledge of Laboratory Safety Rules (N=147)

Safety Rule	n	%
Dress appropriately	19	12.9
Keep laboratory tidy	34	23.1
Know laboratory safety symbols	36	24.5
Know safety equipment locations	17	11.6
Test skills in laboratory simulation	14	9.5
Handle chemical spills properly	27	18.4
Total	**147**	**100.0**

Knowledge of Safety Guidelines

Table 3 displays participants' knowledge of specific laboratory safety guidelines. Only 23.8% (n=35) knew to avoid skin and eye contact with all chemicals, and 21.8% (n=32) knew emergency exit routes. Knowledge of safety equipment locations (eyewash stations, safety showers, fire extinguishers) was limited to 17.0% (n=25). Fewer participants (15.6%, n=23) understood the importance of minimizing chemical exposures. Knowledge about appropriate laboratory behavior (no horseplay) and assuming unknown chemicals are highly toxic was reported by 12.2% (n=18) and 9.5% (n=14), respectively.

Table 3: Knowledge of Laboratory Safety Guidelines (N=147)

Safety Guideline	n	%
Know safety equipment locations	25	17.0
Know emergency exit routes	32	21.8
Avoid chemical skin/eye contact	35	23.8
Minimize chemical exposures	23	15.6
No horseplay tolerated	18	12.2
Assume unknown chemicals are toxic	14	9.5
Total	**147**	**100.0**

Practices Regarding Waste Management and Specimen Handling

Waste Handling Practices

Table 4 presents participants' waste handling practices. Alarmingly, 54.4% (n=80) reported removing gloves for better manipulation of waste containers—a dangerous practice that increases infection risk. Only 26.5% (n=39) consistently wore appropriate personal protective equipment (PPE) when handling waste. Additionally, 19.0%

(n=28) reported placing paper towels from cleanup in regular trash rather than appropriate biohazard containers.

Table 4: Waste Handling Practices (N=147)

Practice	n	%
Always wear appropriate PPE	39	26.5
Remove gloves for better manipulation	80	54.4
Place paper towels in regular trash	28	19.0
Total	**147**	**100.0**

Specimen Handling Practices

Table 5 displays common errors in specimen handling practices. The most frequent error was incorrect order of draw during blood collection (45.6%, n=67), which can lead to cross-contamination and inaccurate test results. Improper patient identification was reported by 23.1% (n=34), followed by incorrect tube selection (15.0%, n=22). Traumatic draws leading to hemolysis and inadequate mixing or insufficient sample volume were each reported by 9.5% (n=14) and 6.8% (n=10), respectively.

Table 5: Common Specimen Handling Errors (N=147)

Common Error	n	%
Improper patient identification	34	23.1
Incorrect order of draw	67	45.6
Incorrect tube selection	22	15.0
Traumatic draws causing hemolysis	14	9.5
Inadequate mixing/insufficient sample	10	6.8
Total	**147**	**100.0**

Training Patterns and Barriers to Safety SOP Adherence

Table 6 presents training patterns and perceived barriers to laboratory safety SOP adherence. The vast majority of participants (82.3%, n=121) had not received training in laboratory safety SOPs within the past 12 months, with only 17.7% (n=26) reporting recent training.

The most frequently cited barrier to safety SOP adherence was unavailability and non-adherence to safety SOPs (41.5%, n=61), indicating systemic issues with SOP documentation and accessibility. Lack of training was identified as a barrier by 30.6% (n=45) of participants, while lack of needed materials and consumables was reported by 27.9% (n=41). These findings suggest multiple, interconnected barriers to implementing proper laboratory safety practices.

Table 6: Training Patterns and Barriers to Safety SOP Adherence (N=147)

Variable	n	%
Training in Last 12 Months		
Yes	26	17.7
No	121	82.3
Subtotal	*147*	*100.0*
Barriers to SOP Adherence		
Lack of materials/consumables	41	27.9
Unavailability of SOPs	61	41.5

Lack of training	45	30.6
Total	**147**	**100.0**

Discussion

Knowledge of Laboratory Safety SOPs

This study revealed suboptimal knowledge of laboratory safety SOPs among healthcare workers at Centre Médico-Social Biryogo, with only 24.5% demonstrating good overall knowledge of laboratory safety principles. This finding aligns with Zaveri's (2012) study on laboratory technicians' knowledge of universal work precautions, which found that only 20.8% had heard about universal work precautions terminology [14]. The similarity in findings across different settings suggests widespread gaps in laboratory safety knowledge among healthcare workers in resource-limited settings.

However, our findings indicate lower knowledge levels compared to some other studies. Al-Abhar et al. (2017) reported that 68.4% of laboratory staff in Yemen had adequate knowledge about laboratory safety, substantially higher than our 24.5%. Similarly, Tooba et al. (2021) found that 68.4% of staff had correct knowledge about laboratory safety [15,16]. These discrepancies may reflect differences in training infrastructure, educational requirements, and institutional safety culture between settings.

Specific knowledge gaps identified in our study include limited awareness of chemical safety (only 23.8% knew to avoid skin and eye contact with chemicals) and emergency procedures (21.8% knew emergency exit routes). These gaps are particularly concerning given the potential consequences of chemical exposures and emergency situations. The low proportion (17.0%) knowing safety equipment locations suggests inadequate orientation and ongoing safety education.

The predominance of nurses (91.2%) over laboratory technicians (8.8%) in our sample may partially explain the knowledge gaps, as nurses may receive less specialized training in laboratory safety compared to laboratory technicians. However, given that nurses frequently collect and handle specimens, their knowledge deficits pose significant occupational health risks.

Waste Management and Specimen Handling Practices

Our study identified concerning waste handling practices, with 54.4% of participants reporting that they remove gloves for better manipulation of waste containers. This dangerous practice directly contradicts established safety protocols and significantly increases infection risk. These findings resonate with Tabash et al.'s (2016) study in Gaza, Palestine, which documented poor knowledge and practice scores (50%) before intervention, improving to 75% post-training. This comparison underscores the critical role of training in improving waste management practices [17].

The low rate of consistent PPE use (26.5%) during waste handling aligns with broader literature on PPE compliance challenges in resource-limited settings. Coelho and Díez (2015) emphasized that biological risks and laboratory-acquired infections represent realities that cannot be ignored in health biotechnology settings [18]. The unsafe practices observed in our study create conditions conducive to laboratory-acquired infections and occupational exposures.

Specimen handling errors were also prevalent, with 45.6% using incorrect order of draw and 23.1% failing to properly identify patients. These pre-analytical errors can lead to misdiagnosis, inappropriate treatment, and patient harm. The high frequency of such errors suggests systemic issues with specimen collection training and supervision. Manyele and Mujuni (2010) documented similar challenges in Tanzania, highlighting widespread deficiencies in proper specimen handling practices across East African healthcare facilities [19].

The practice gaps identified in our study likely stem from multiple factors including inadequate initial training, lack of ongoing supervision and mentorship, insufficient availability of SOPs and job aids, and limited access to necessary equipment and supplies. Addressing these multifaceted challenges requires comprehensive, sustained interventions.

Training Deficiencies and Systemic Barriers

The finding that 82.3% of participants had not received laboratory safety training within the past 12 months represents a critical gap in ongoing professional development. Regular refresher training is essential for maintaining and updating knowledge, reinforcing proper practices, and adapting to evolving safety standards. The WHO (2018) emphasizes that systematic, ongoing education programs are fundamental to effective infection prevention and control.

The barriers to safety SOP adherence identified by participants—unavailability of SOPs (41.5%), lack of training (30.6%), and lack of materials (27.9%)—point to systemic failures in laboratory safety infrastructure and support systems. These findings align with broader challenges documented in Sub-Saharan African healthcare settings, where resource constraints, infrastructure limitations, and competing priorities often impede implementation of optimal safety practices [20].

The high proportion citing SOP unavailability suggests that either SOPs have not been developed for the facility, are not adequately disseminated, or are not accessible to staff during work. Development, dissemination, and regular updating of comprehensive, facility-specific SOPs should be a priority intervention. Additionally, SOPs must be available in appropriate formats (e.g., laminated job aids, posters, digital resources) and languages to ensure accessibility.

Material shortages (27.9%) create situations where healthcare workers must choose between following safety protocols and completing essential tasks—an untenable position that compromises both worker safety and quality of care. Sustainable solutions require addressing procurement systems, supply chain management, and resource allocation to ensure consistent availability of essential safety equipment and supplies.

Comparison with Regional Studies

Our findings complement and extend existing knowledge about laboratory safety in Sub-Saharan Africa. Ogoina et al. (2015) documented similar challenges in Nigerian tertiary hospitals, emphasizing the crucial role of systematic training programs [21]. Research from Cameroon (Ngum et al., 2021) demonstrated that healthcare workers face substantial occupational health risks, particularly when working with inadequate protective equipment—a situation mirroring our findings.

Studies from other resource-limited settings provide additional context. Raza et al. (2020) identified multiple factors impeding healthcare professionals' ability to safely manage infectious diseases in Pakistan, including inadequate training, resource shortages, and systemic barriers—challenges remarkably similar to those identified in our Rwandan setting [22]. This consistency across diverse geographic contexts suggests that addressing laboratory safety challenges requires strategies that account for common resource constraints and systemic barriers in low- and middle-income countries.

Rwanda's multi-sectoral approach to health emergencies, as documented by Rutayisire et al. (2021), provides a potential framework for addressing laboratory safety systematically. Leveraging similar collaborative approaches involving health facilities, educational institutions, regulatory bodies, and professional associations could enhance laboratory safety culture and compliance across the healthcare system.

Implications for Practice and Policy

Our findings have several important implications for improving laboratory safety in Rwandan healthcare facilities:

1. **Comprehensive training programs:** Develop and implement systematic, competency-based training on laboratory safety SOPs for all healthcare workers involved in specimen collection and handling. Training should include initial orientation, regular refresher courses, and competency assessments.

2. **SOP development and dissemination:** Create facility-specific, comprehensive SOPs covering all aspects of laboratory safety, waste management, and specimen handling. Ensure SOPs are readily accessible to all relevant staff through multiple formats (printed, posted, digital).
3. **Functional IPC committees:** Establish or strengthen infection prevention and control (IPC) committees with clear mandates, adequate resources, and authority to develop, implement, monitor, and enforce safety policies and procedures.
4. **Sustainable resource allocation:** Ensure consistent availability of essential safety equipment, PPE, and supplies through improved procurement, inventory management, and budget allocation.
5. **Supervision and mentorship:** Implement structured supervision systems with regular competency assessments, feedback, and mentorship to reinforce proper practices and identify areas for improvement.
6. **Safety culture development:** Foster organizational safety culture through leadership commitment, staff engagement, recognition of safe practices, and systems for reporting and learning from near-misses and incidents.

Study Limitations

Several limitations should be considered when interpreting these findings. First, the use of convenience sampling may have introduced selection bias, potentially limiting generalizability to other healthcare facilities in Rwanda. However, the sample size (n=147) was adequate for descriptive analysis.

Second, reliance on self-reported data may have resulted in social desirability bias, with participants potentially overreporting compliant behaviors and underreporting unsafe practices. Direct observation or objective assessment methods might have yielded different results. However, the high rates of reported unsafe practices suggest that social desirability bias was not overwhelming.

Third, the cross-sectional design provides a snapshot of knowledge, attitudes, and practices at a single point in time, precluding assessment of temporal changes or causal relationships. Longitudinal studies would better capture the impact of interventions and changing practices over time.

Fourth, the study was conducted at a single facility, which may limit generalizability to other healthcare settings with different resources, staffing patterns, and organizational cultures. Multi-site studies would provide more comprehensive insights into laboratory safety challenges across Rwanda's healthcare system.

Finally, the questionnaire, while based on established guidelines and validated instruments, was not formally validated in the Rwandan context. Future research should include formal validation of assessment tools and consideration of cultural and contextual factors influencing laboratory safety practices.

Conclusion and Recommendations

Conclusion

This study identified significant gaps in knowledge, attitudes, and practices regarding laboratory safety SOPs among healthcare workers at Centre Médico-Social Biryogo. Only 24.5% of participants demonstrated good knowledge of laboratory safety principles, and concerning unsafe practices were widespread, including inadequate PPE use (54.4% handled waste without gloves), poor specimen handling techniques (45.6% used incorrect order of draw), and inadequate patient identification (23.1%).

The vast majority (82.3%) had not received laboratory safety training within the past year, and major barriers to safety SOP adherence included unavailability of SOPs (41.5%), lack of training (30.6%), and shortage of materials (27.9%). These findings indicate urgent need for comprehensive interventions to improve laboratory safety knowledge, practices, and organizational support systems.

Addressing these deficiencies requires multi-level interventions including systematic training programs, development and dissemination of SOPs, establishment of functional IPC committees, sustainable resource allocation, enhanced supervision and mentorship, and cultivation of strong safety culture. Implementation of such interventions will reduce occupational health risks, improve quality of laboratory services, and

ultimately enhance patient care and outcomes.

Recommendations

For Centre Médico-Social Biryogo and Healthcare Facility Management:

- Implement comprehensive, competency-based training programs on laboratory safety SOPs for all relevant staff, with initial orientation and mandatory annual refresher courses.
- Develop facility-specific SOPs covering all aspects of laboratory safety, waste management, and specimen handling, ensuring they are accessible to all staff in appropriate formats.
- Establish or strengthen functional IPC committees with clear mandates, adequate resources, and authority to develop, implement, monitor, and enforce safety policies.
- Ensure consistent availability of essential safety equipment, PPE, and supplies through improved procurement and inventory management systems.
- Implement regular supervision, competency assessments, and mentorship programs to reinforce proper practices and provide ongoing support to staff.

For Rwanda Ministry of Health and National Health Authorities:

- Develop national standards and guidelines for laboratory safety, with clear competency requirements for all healthcare workers involved in specimen collection and handling.
- Establish systematic training programs and certification requirements for laboratory safety, integrated into pre-service education and continuing professional development.
- Strengthen regulatory oversight and accreditation systems to ensure healthcare facilities meet minimum safety standards and maintain compliance.
- Allocate adequate resources for laboratory safety infrastructure, equipment, and supplies across the healthcare system, particularly at district-level facilities.

For Educational Institutions:

- Strengthen laboratory safety content in nursing and biomedical sciences curricula, with emphasis on practical competency development.
- Develop partnerships with healthcare facilities to provide students with supervised clinical experience in proper laboratory safety practices.

For Future Research:

- Conduct multi-site studies to assess laboratory safety KAP across different healthcare facility types and regions in Rwanda.
- Evaluate the effectiveness of training interventions on improving laboratory safety knowledge, attitudes, and practices using rigorous study designs.
- Investigate the relationship between safety compliance, laboratory-acquired infections, and occupational injuries to strengthen the evidence base for safety interventions.
- Explore organizational and cultural factors that facilitate or hinder development of strong laboratory safety culture in Rwandan healthcare settings.

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