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Strengthening Laboratory Biosafety and Biosecurity in BSL Settings: Biorisk Mitigation Strategies for Emerging Viruses in Limited-Resource Environment

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Abstract

The prevalence of emerging viruses has increased in the last twenty years and is expected to rise in the future. Emerging viral diseases are a serious risk to public health globally. Despite increased awareness of safety and containment methods, the risk of Laboratory-acquired infections (LAIs) is increasing steadily as high number of laboratories and scientists are working on emerging viruses for diagnostics and research purposes worldwide. The risk of harm from these viruses can be minimized through the implementation of appropriate bio-risk management policies and practices. Laboratory biosafety is currently a critical global issue in clinical and research labs with the biological harm caused by emerging infectious diseases. Well-trained, knowledgeable, and biohazard-aware laboratory workers, understanding all modes of transmission, and trained on safe laboratory practices and its management are critical parameters in preventing laboratory-acquired infection. The review provides a comprehensive analysis of pathogens that fall beyond standard operating procedures. It particularly highlights the existing gaps and limitations in practical approaches for managing emerging pathogenic viruses within biosafety level 2 (BSL-2) facilities, which are commonly used in low-and middle-income countries (LMICs). The review suggests that effective biorisk mitigation requires strong safety culture. In addition, this review contributes to building new capacity in diagnostic and research laboratories that routinely handle biological samples involving emerging pathogens. The conclusions emphasize the shared responsibility of government and institutional biosafety committees to ensure the consistent application of appropriate techniques, facilities, and training for the safe handling of these evolving threats, particularly in low-resource settings.

Keywords: Biorisk, Emerging viruses, Biosafety, Biosecurity, Infectious disease, Enhanced BSL-2, Laboratory acquired infections

1. Introduction

Laboratory-acquired infections (LAIs) have long been recognized as an occupational hazard in diagnostic and research lab practice. Historical evidence, including documented cases from the twentieth century, highlight thousands of LAIs worldwide, demonstrating the persistent vulnerability of laboratory personnel. This emphasizes the critical role of biosafety and biosecurity system in protecting laboratory workers, public and animal health, and the environment. Emerging infectious diseases (EIDs), defined as newly identified infectious agents or previously known pathogens with rapid increase in incidence or geographic range are increasingly being observed [1–3]. Their emergence is driven by multiple factors, including infectious agents previously underestimated for their disease-causing ability, spread of known pathogens into new regions or host population and the reappearance of infectious agents that were previously under control. In lieu of this, emerging viral infections remain a growing global health concern, due to increase in frequency, geographic spread, and high potential to cause disease outbreaks. These continuous events underline the importance of strengthening laboratory preparedness and maintaining robust biosafety systems across diagnostic and research settings [4–7].

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Although international biosafety guidelines are well established, there remains a clear disconnect between recommended standards and their consistent application in routine laboratory practice, particularly in low-and middle-income countries (LMICs) [2, 4, 7]. Existing literature largely focuses on descriptive accounts of biosafety protocols, with limited discussion on real world implementation barriers, training effectiveness, and adaptation to local laboratory conditions. This limitation has become more significant in the post-COVID-19 period, where diagnostic and research activities involving high alert pathogens have increased, often in settings with limited access to BSL-3 and BSL-4 infrastructure. In such circumstances, enhanced BSL-2 practices, based on structured risk assessment, incorporating strengthened engineering controls, appropriate personal protective equipment, and strict operational procedures are frequently used for selected laboratory processes. However, these measures are not a substitute for higher containment BSL-3 and BSL-4 laboratories but serve as supplementary risk-reduction strategies within existing infrastructure.

Laboratory professionals have observed that main challenge in labs is the huge disconnect between biosafety guidelines and real-world laboratory implementation. While international frameworks are comprehensive, their translation into practice is constrained by resource limitations, institutional capacity, and workforce preparedness. Addressing this gap requires strengthened training, improved infrastructure, and development of a sustained biosafety culture that supports compliance in both routine and outbreak settings [3, 5, 7].

This review aims to provide updated information on integration of established biosafety principles keeping the practical laboratory realities in perspective, implementation challenges, workforce training gaps and safety culture limitations. In addition, it aims to propose adaptable and context sensitive biorisk mitigation strategies for emerging viral threats in limited-resource environments with a focus on providing practical insights that support safe laboratory practices and strengthen biorisk management in the face of ongoing and emerging challenges in infectious diseases.

2. Laboratory-Acquired Emerging Virus Infections

Laboratory-acquired infections (LAIs) are defined as infections resulting from occupational exposure to infectious agents during laboratory work. Exposures to emerging viruses can occur in clinical, diagnostic, and research laboratories during routine procedures such as sample handling, diagnostic testing, and experimental research. Although BSL-4 laboratories are essential for studying highly hazardous pathogens, many laboratories must initially manage risk with available containment resources [2].

The COVID-19 pandemic highlighted ongoing vulnerabilities, as increased SARS-CoV-2 infections among laboratory staff demonstrating that LAI remains a significant concern for occupational health. This risk is clear when working with evolving viruses. Historical and recent cases show the dangers of laboratory-acquired viral infections [2–4] with a need for strong biosafety rules that can be used in laboratories. This includes the careful use of enhanced BSL-2 practices integrated to reduce risk of infections, especially when higher-level BSL-3 and BSL-4 facilities are not available [3, 5, 6].

2.1. Biosafety Measures for Emerging Viruses

Biosafety encompasses the integrated application of safety procedures, practices, risk management, and the proper use of containment facilities. Its primary goal is to protect laboratory personnel, the public and the environment by preventing accidental exposure or release of harmful pathogens. When working with emerging viruses, a multi-layered approach to safety is required, combining engineering controls, administrative policies, and personal protective equipment [1, 2].

2.1.1 Biosafety Levels (BSLs) for Emerging Viruses

Biosafety levels define the minimum containment requirements based on agent risk groups, procedural hazards, and available countermeasures. Most emerging viruses are handled at BSL-2, BSL-3, or BSL-4.

- **BSL-2** is suitable for agents that pose moderate individual risk and low community risk, where exposure is typically through percutaneous injury or mucous membrane contact (e.g., diagnostic work with the dengue virus).
- **BSL-3** is required for indigenous or exotic agents that may cause serious disease via aerosol transmission and for which treatments may be available (e.g., work with cultured SARS-CoV, West Nile virus, or HPAI H5N1).
- **BSL-4** is mandated for dangerous/exotic agents that pose a high risk of life-threatening disease are often transmissible via the aerosol route, and for which no effective treatment or vaccine exists (e.g., Ebola, Nipah virus) [1–6].

The enhanced BSL-2 framework is a critical operational bridge, applying BSL 3-level PPE and work practices within a BSL-2 facility to safely perform initial diagnostic activities for higher-risk agents when immediate BSL-3 access is unavailable [3].

2.2. Risk Assessment for Emerging Viruses

Bio-risk assessment is the process of determining proper biosafety precautions, especially for emerging infectious organisms, to assess the need for a work environment that provides safety for lab professionals working within the laboratory. This process involves identifying potential risks and establishing appropriate biosafety standards for their management. In lieu of this, the level of risk to laboratory workers requires alignment of up-to-date information about biosafety, especially when dealing with new/novel viruses. Clearly, the risk to laboratory personnel is multifaceted, extending from initial sample collection and handling to final disposal. Keeping this in perspective, emerging novel viruses can impact this entire workflow including influencing assay type choices, instrumentation, sample storage and waste management protocols. It is a well-known fact that significant risk exposure occurs in lab personnel during routine but critical tasks such as instrument decontamination, cleansing, and maintenance. Therefore, emerging novel viruses require commitment from the laboratory management to ensure safe sample collection, handling and storage, use of proper assays, instrument cleansing and maintenance as well as safe sample disposal of samples. All these are risk factors that must be taken into consideration and implemented to reduce the risk of exposure to lab personnel and environment. The primary objective of biological risk assessment, especially while working with emerging novel viruses, is the dual prevention of laboratory-acquired infections (LAIs) and inadvertent release of virus into the environment.

In case of viruses, such as those listed in Table 1, the risk assessment should determine essential mitigation strategies that can facilitate management of specific laboratory risks. For example, risk groups must be classified to provide understanding to lab staff on its relative hazard including its pathogenicity and toxin production capability. In addition, risk assessment should be done in a standardized and systematic manner that ensures repeatability of safety guidelines, including specific biosafety level (BSL) requirement, ensuring safe handling of novel viruses every time such samples are received in the lab.

A critical outcome of this assessment in limited-resource contexts is the possible adoption of enhanced BSL-2 protocols, where additional engineering, administrative, and personal protective equipment controls are applied to safely manage specific high-risk procedures for certain pathogens.

Central to this process is the classification of pathogens into risk groups, which describe the relative hazard they pose:

- **Risk Group 1**: The group includes no or low community risk, they are unlikely to cause human/animal disease.
- **Risk Group 2**: This group is associated with moderate individual risk and low community risk. These pathogens can cause human or animal disease but are unlikely to pose a serious hazard to laboratory workers, the community, or the environment. Laboratory exposure may result in infection; however, the risk of spread is limited, and effective preventive or therapeutic measures are often available. Example: Herpes simplex, Influenza virus, Dengue, and Zika virus.
- **Risk Group 3**: This group has high individual risk but low community risk. Such pathogens usually cause serious animal or human diseases and while some may be transmitted between individuals, though the spread is typically limited or controllable. For such groups, effective treatment and preventive measures are available. Example: West Nile, Hantavirus, SARS-CoV.
- **Risk Group 4**: This group includes high individual and community risk and includes pathogens that can cause serious infections in humans and animals and can be transmitted, indirectly or directly, from person to person. No treatment and preventive measures are available. Example: Ebola, Nipah virus [2, 6–9].

2.3. Biorisk Management for Emerging Viruses

Biorisk management is the comprehensive implementation of policies and procedures to mitigate identified risks mentioned above [5–10]. Effective management transforms assessment findings into actionable safety protocols.

A structured, five-step approach provides a framework for the biorisk management process:

1. **Hazard Identification and Initial Risk Analysis**: Begin by identifying the inherent hazards of the specific emerging virus. Analyze key characteristics, including its pathogenicity, infectious dose, routes of transmission, disease severity, and the availability of effective treatments or prophylactic measures.
2. **Procedure-Specific Risk Evaluation**: Identify the risks associated with specific laboratory procedures. The most significant risks often stem from aerosol-generating procedures (e.g., vertexing, pipetting, centrifugation) and handling of concentrated infectious materials.
3. **Selection of Containment and Mitigation Controls**: Based on the cumulative risk assessment, select the appropriate biosafety level (BSL). It is imperative to understand the specific practices, safety equipment, and facility safeguards for the chosen BSL. This step may mandate the application of enhanced BSL-2 protocols, where additional controls (e.g., respirators, sealed centrifuges, rigorous waste handling) are applied to safely conduct specific diagnostic or initial processing work for higher-risk agents.

Table 1: Risk group of viruses and recommended laboratory precautions

Viruses	Risk Group	Recommended Precautions	References
Dengue virus	2	BSL-2; all laboratory procedures	[15]
Zika virus			
HIV	3	BSL-2: Diagnostic work BSL-3: Virus culture	[15, 17] [18, 19]
West Nile virus			
SARS-CoV2			
HPAI, H5N1			
Hantavirus			
Japanese encephalitis virus			
Mpox (Monkeypox)			
MERS-CoV			
Chikungunya virus		BSL-3: all laboratory procedures	
Nipah virus	4	BSL-4; all laboratory procedures	[15, 16]
Ebola virus			
Hendra virus			

HIV: Human Immunodeficiency Virus; SARS-CoV: Severe acute respiratory syndrome coronavirus 2; HPAI: Highly Pathogenic Avian Influenza; HRN1: Hemagglutinin type 5 and Neuraminidase type 1; Mpox: Monkeypox; MERS-CoV: Middle East respiratory syndrome coronavirus

4. **Evaluation of Personnel Competency and Equipment Integrity**: Assess the knowledge, skills, and proficiency of laboratory staff regarding the required safety practices. This assessment should also include regular training updates and drills to ensure that all personnel remain vigilant and prepared for potential exposure incidents. Additionally, routine inspections and maintenance of safety equipment must be conducted to uphold the integrity of the laboratory environment. Concurrently, verify the proper functioning and integrity of all safety equipment, including biosafety cabinets, autoclaves, and personal protective equipment (PPE).
5. **Documentation and Review with a Biosafety Professional**: Formalize the risk assessment and management plan in documentation. This plan should be conducted and periodically reviewed in consultation with a qualified biosafety officer or professional to ensure its adequacy and compliance with current standards [3, 5, 6, 10–14].

2.3.1 Laboratory Design and Engineering Controls

Engineering controls are the first line of defense, consisting of permanent or semi-permanent design features built into the laboratory infrastructure. These controls are intended to minimize exposure without relying solely on human behavior. Key examples include:

- Non-porous, seamless, and easily decontaminated work surfaces.
- Controlled access systems, such as interlocked doors.
- Hands-free sinks and eyewash stations.
- Directional, negative-pressure ventilation systems with HEPA filtration of exhaust air.

For enhanced BSL-2/BSL-3 operations, critical enhancements may include an anteroom for PPE donning and doffing, sealed centrifuge rotors or safety cups, and appropriate local exhaust ventilation or HEPA-filtered containment systems for specific equipment [3–10]

2.3.2 Biosafety Equipment and Personal Protective Equipment (PPE)

Personal protective equipment (PPE) serves as the final barrier between laboratory personnel and biological hazards and must always be selected based on a comprehensive risk assessment, considering the agent, procedure, and exposure risk. According to the World Health Organization Laboratory Biosafety Manual (4th edition), PPE should be tailored to protect the body, hands, eyes, face, and respiratory system, and its selection should be proportional to the level of risk and laboratory containment requirements. Standard requirements include:

- **BSL-2**: Laboratory coat or gown (preferably long-sleeved and cuffed), disposable gloves (task-appropriate), eye protection (safety glasses or goggles) where splashes or aerosols may occur [5, 6].
- **Enhanced BSL-2 / BSL-3**: Solid-front or wrap-around gowns, double gloves, eye and face protection (goggles or face shield), respiratory protection (fit-tested N95 respirator or equivalent) [3, 5, 6].

- **BSL-4**: Fully encapsulated, positive-pressure suit, dedicated air supply system, multiple layers of protective barriers [5, 6].

At BSL-2, PPE is designed to provide protection against moderate-risk agents and routine diagnostic procedures while in BSL-3 settings, respiratory protection becomes essential due to the risk of airborne transmission, and all manipulations are typically conducted within a biological safety cabinet. Enhanced PPE is also applied in BSL-2 laboratories under risk-based approaches when BSL-3 infrastructure is unavailable. On the other hand, BSL-4 level ensures complete isolation of the worker from the environment and is mandatory for handling high-risk pathogens such as hemorrhagic fever viruses [3, 20].

2.3.3 Biosafety Cabinets (BSC)

The BSC is the primary safety device used to control infections, droplets or aerosols produced by many manipulative procedures.

All emerging viruses must be dealt with in biosafety cabinet classes II and III. Usually, HEPA Filter (High-Efficiency Particulate Air filter) is used in biosafety cabinets. BSCs are designed to capture, contain, and exhaust any infectious particles or aerosols that are generated inside the BSCs.

Essential Practices for Working in BSC:

- Make sure the BSC sash is exactly at the correct height.
- "Clean to dirty" workflow.
- Enter straight into the cabinet without sweeping your hands.
- The materials should be well placed within the cabinet.
- The disposal bin should be inside the cabinet.
- Make sure that the laminar flow is not disrupted.
- Decontaminate items and glove hands before removal from the cabinet.
- Secure the vacuum line with HEPA filters or traps [2, 11–21].

3. Waste Disposal of Emerging Viruses

Proper decontamination and disposal of waste of emerging viruses are essential to break the chain of infection. All waste generated during the handling of emerging viruses must be treated as potentially infectious and managed according to the level of containment and associated risk.

- **Solid Waste** (e.g., gloves, pipette tips, culture bottles): Must be inactivated by autoclaving (validated cycle) or chemical disinfection before disposal as regular waste.
- **Liquid Waste**: Requires chemical disinfection (e.g., with sodium hypochlorite) in designated "kill tanks" before neutralization and discharge into the sanitary system.
- **Sharps**: Must be placed in puncture-resistant, leak-proof containers and subsequently incinerated or autoclaved.

These types of waste disposal methods are commonly used in BSL-2, enhanced BSL-2/3, and BSL-4 laboratories. In BSL-3 and BSL-4, solid waste is decontaminated using autoclaving or chemical treatment before removal or is directly incinerated. Liquid waste is usually treated in closed systems or special decontamination systems before being safely disposed of [22, 23].

3.1. Samples Spill Management

In the event of a spill involving emerging virus samples, response procedures must follow the laboratory biosafety level. At BSL-2, the area is restricted and cleaned using standard PPE and appropriate disinfectants. At BSL-3, the area must be evacuated and decontamination performed under controlled conditions with enhanced PPE, while at BSL-4, spills are managed only by trained personnel using positive-pressure suits and strict maximum-containment procedures.

Emerging virus samples spill in the lab require proper protocols including:

(1) Take a deep breath, alert others, leave the room, and close the door behind you.

(2) Display the sign for all to see (Spill clean-up in progress).

(3) After 30 minutes, when the aerosols have settled, return to the area to begin clean-up.

(4) Use spill-prevention pad from spill kit.
(5) Put on the appropriate safety equipment (mask, gloves, gowns, safety goggles, footwear, and face shield).
(6) Using forceps and thick gloves pick up any shattered glass and store it in a sharps bag.
(7) Cover the spill with disposable absorbent material.
(8) After the infected material has been absorbed, discard it into a red autoclave bag.
(9) Clean the area as if it were a minor spill.
(10) Notify your supervisors.
(11) Fill out the "Incident Reporting Form" as well as the monthly Safety Indicators to document the spill [2, 24, 25].

Effective spill management is essential to minimize exposure risk and prevent environmental contamination. Procedures must be standardized but adapted according to biosafety level and the nature of the infectious agent.

4. Biosecurity of Emerging Viruses

Emerging viruses can potentially be used as biological weapons or in acts of bioterrorism. One reason they are considered attractive for such misuse is their relatively low cost. Once inside a host, viruses can multiply and spread to other individuals, which can lead to unpredictable outcomes in terms of how many people are affected and how widely the infection spreads geographically.

Biosecurity complements biosafety by preventing unauthorized access, theft, misuse, or intentional release of biological materials. Due to their high risk, emerging viruses are considered potential dual-use research agents of concern. An effective biosecurity plan is tailored to the specific facility and integrates:

- **Physical Security**: Access controls, intrusion detection, detection systems, secure storage solutions.
- **Personnel Security**: Reliability screening and ongoing suitability assessments.
- **Material Control and Accountability**: Inventory tracking of pathogens and toxins.
- **Transportation Security**: Secure packaging and shipping in compliance with all applicable national and international transport regulations.
- **Information Security**: Protection of sensitive research data.

A strong biosecurity plan is essential alongside biosafety when working with emerging viruses to prevent misuse or unauthorized access. Because such research may have dual-use risks, each facility should design tailored biosecurity measures based on its activities, resources, and local context, involving relevant scientific, administrative, and security stakeholders. Risk assessment forms the basis of this system by identifying vulnerabilities and guiding appropriate control strategies [26–31].

5. Discussion

Laboratory-acquired infections (LAIs) continue to represent a relevant occupational risk in diagnostic and research laboratories despite the availability of well-defined biosafety guidelines. Their continued occurrence highlights a persistent gap between prescribed safety standards and their implementation in routine laboratory practice. This gap is largely influenced by human factors, including inconsistent training, procedural deviations under workload pressure, and variability in institutional safety culture, indicating that biosafety effectiveness depends not only on technical protocols but also on behavioral and organizational compliance.

Risk assessment, although central to biosafety frameworks, is often applied in a static and administrative manner rather than as a continuous, context-driven process. This limitation reduces its sensitivity to evolving laboratory risks, particularly in high-throughput or limited- resource environments where time constraints and workforce shortages restrict thorough evaluation. As a result, risk mitigation strategies may not fully reflect operational realities.

Similarly, biosafety level (BSL) classifications provide a structured containment model, but their practical implementation is uneven across institutions. Infrastructure limitations, insufficient maintenance, and gaps in regulatory oversight can compromise adherence to BSL requirements. These challenges are more pronounced in low-and middle-income countries (LMICs), where financial and human resource constraints often result in partial compliance with established biosafety standards.

Core preventive measures such as personal protective equipment (PPE), waste management, and spill response are well established; however, their effectiveness is dependent on consistent availability, user compliance, and institutional enforcement. In practice, shortages of supplies, improper waste segregation, and delays in spill response continue to be reported, particularly in settings with limited biosafety training and weak monitoring systems. This reinforces the need for sustained operational support beyond guideline dissemination.

Recent infectious disease outbreaks, particularly the COVID-19 pandemic, exposed critical weaknesses in laboratory biosafety systems worldwide. The surge in diagnostic demand placed substantial pressure on laboratory workflows, leading in some instances to procedural compromise. Similar vulnerabilities were observed during previous outbreaks such as Ebola and MERS, underscoring the need for resilient biosafety systems capable of maintaining compliance under emergency conditions.

Emerging viruses can also be misused; therefore, a strong biosecurity system is important. Improving the safe handling of these viruses also helps strengthen surveillance and improve prevention and control measures. Although the number of new viral diseases appears to be increasing, it is still very difficult to predict when future outbreaks will occur or how serious their public health and economic impact will be. Therefore, developing and applying strong laboratory biosafety practices is essential for preparing and responding to future outbreaks of emerging viruses.

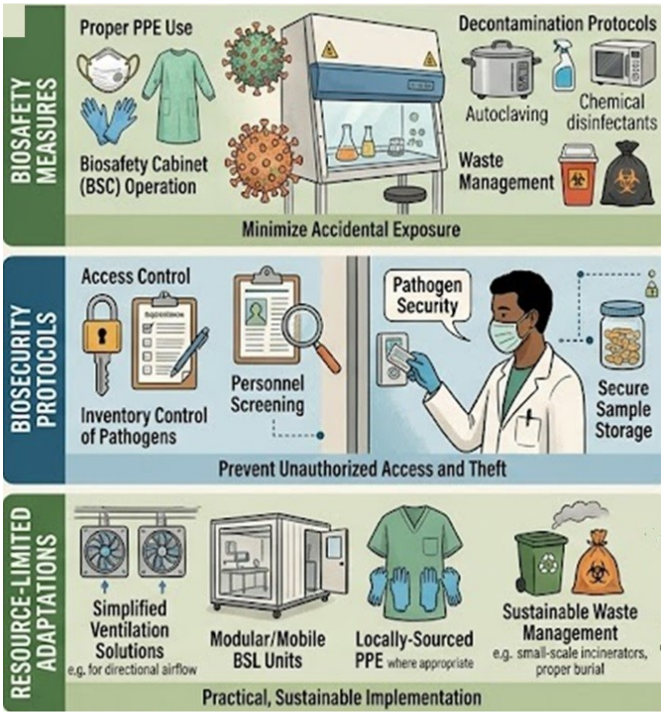

Figure 1: Multidimensional Approach to Biorisk Mitigation for Emerging Viruses. The schematic outlines the integration of "Biosafety Measures", "Biosecurity Protocols", and "Resource-Limited Adaptations". It highlights the workflow from threat identification and risk assessment to the implementation of sustainable strengthening strategies, such as capacity building and modular laboratory infrastructure.

6. Conclusion and Perspectives

Laboratory-acquired infections (LAIs) remain an important occupational risk, especially in laboratories that work with emerging viruses. Infection can happen due to accidents, small mistakes during procedures, or unnoticed incidents, showing that risks are always present in diagnostic and research labs. The continuous emergence of new and returning viral pathogens creates ongoing public health challenges, requiring strong laboratory systems. Therefore, fast diagnosis, reliable detection methods, and strict safety and containment practices are essential for infection control.

Biorisk assessment is the foundational process for determining appropriate biosafety precautions and ensuring safe laboratory experimentation with emerging infectious agents. This systematic approach involves the identification of specific hazards and the subsequent determination of acceptable containment standards to mitigate them. For emerging viruses, an accurate risk assessment must be informed by the most current scientific data, as the understanding of their transmissibility, pathogenicity, and stability is often evolving.

This review emphasizes that biosafety and biosecurity are complementary and indispensable frameworks for managing biological risks. Biosafety focuses on preventing unintentional exposure and environmental release of emerging viruses, while biosecurity is a preventive strategy designed to thwart the intentional misuse, theft, or diversion of these viruses. As shown in Figure 1, when handling emerging viruses, a synergistic approach that integrates both a rigorous biosafety program and a tailored biosecurity strategy is essential. The goal extends beyond protecting laboratory workers; it also ensures that these high-consequence pathogens remain secure and out of the hands of malicious actors.

A key insight discussed is the pragmatic role of Biosafety level 2 enhanced (BSL-2+) protocols, which provide a risk-proportionate framework for many laboratories, especially in limited-resource settings. It enables the facilitates handling of certain high-risk pathogens for critical diagnostic work by augmenting standard BSL-2 facilities with enhanced engineering controls, stringent personal protective equipment, and rigorous operational practices. This approach is essential for maintaining frontline diagnostic capabilities during outbreaks when immediate access to high-containment BSL-3 or BSL-4 labs laboratories may be limited or constrained.

Ultimately, safeguarding against laboratory-acquired infections (LAIs) and ensuring the secure management of emerging viruses is a shared responsibility. It requires commitment at all levels: from individual laboratory technicians adhering to protocols, to institutional biosafety committees providing oversight and training, and to national governments establishing and enforcing robust regulatory frameworks. By fostering a pervasive culture of safety, investing in context-appropriate containment strategies, and continuously integrating lessons from past incidents, the global community can strengthen its defenses. This proactive stance is imperative not only to protect those on the frontlines of science but also to safeguard global health security against the evolving threat of emerging viral pathogens.

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Author Contributions

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Ethics Approval and Consent to Participate

Not applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

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AI Declaration

During the preparation of the manuscript, authors used ChatGPT for language editing, clarity, and preparation of graphics. After using the tool, authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

8. Abbreviations

The following abbreviations are used in this manuscript:

BSL: Biosafety Level
BSL-2: Biosafety Level 2
BSL-3: Biosafety Level 3
BSL-4: Biosafety Level 4
BSC: Biosafety Cabinet
COVID-19: Coronavirus Disease 2019
EIDs: Emerging Infectious Diseases
HEPA: High-Efficiency Particulate Air (filter)
LAIs: Laboratory-Acquired Infections
LMICs: Low-and Middle-Income Countries

PPE: Personal Protective Equipment
SARS-CoV: Severe Acute Respiratory Syndrome Coronavirus

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