Enhancing Global Health through Biosafety and Biosecurity: Integrating One Health Approach

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Abstract

Protecting global health requires more than just medical solutions, it needs a joined-up approach that brings together human, animal, and environmental health. Biosafety and biosecurity play a central role in this effort, helping to prevent accidental or intentional damage from infectious diseases and harmful biological materials. When combined with the One Health approach, they create a powerful framework for identifying and stopping threats early. Many diseases, including SARS, MERS, and COVID-19, have come from animals, making it essential to monitor how people, animals, and ecosystems interact. Safe lab practices, secure handling of pathogens, and responsible sharing of information are key to staying ahead of outbreaks. At the same time, rising antimicrobial resistance is putting lives at risk and needs coordinated action across sectors. Global organizations like the WHO, FAO, and OIE work alongside countries to guide policies and build strong systems. But challenges like unequal resources, limited training, and lack of trust can hold back progress. By investing in communities, encouraging collaboration, and planning for climate-related health risks, the world can build a safer and more prepared future. A more connected, informed, and inclusive response is vital to protecting everyone's health in the face of growing biological threats.

Keywords: One Health, Biosafety, Biosecurity, Zoonotic Diseases, Global Health Security

Cite this Article as: Hussain T, Muhammad J, Ahmad F, Sajjad W, Qaiser H and Qamar MU, 2025. Enhancing global health through biosafety and biosecurity: integrating one health approach. In: Farooqi SH, Kholik K and Zaman MA (eds), One Health Horizons: Integrating Biodiversity, Biosecurity, and Sustainable Practices. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 148-156. https://doi.org/10.47278/book.HH/2025.459

A Publication of Unique Scientific Publishers

Chapter No: 25-020

Received: 16-Jan-2025
Revised: 06-Feb-2025
Accepted: 26-Apr-2025

Introduction

1.1 The Evolution of Biosafety and Biosecurity

Over recent years, models for biosafety and biosecurity have changed to help understand and prevent communicable disease risks and keep pathogens out of the wrong hands (Zhou et al., 2019). In the middle of the twentieth century, expanding studies in microbiology led to the development of biosafety measures. High-containment laboratories were designed in the 1940s and 1950s to order and assess risks. After the 2001 anthrax attacks, biosafety became more important and led to the creation of programs like the BWC and WHO Laboratory Biosafety Manual that encourage countries to cooperate (Gao et al., 2025).

1.2 Defining the One Health Approach

By applying the One Health strategy, professionals from different fields work together to find solutions for health issues, mainly when it comes to zoonoses which make up over 60% of new infectious diseases (Taylor et al., 2001). One Health, set up in the nineteenth century, focused on mixing both human and animal medicine. It was mostly due to SARS and AMR, as well as increased global attention, that the plans for an approach like One Health became a reality in the early 2000s (Gibbs, 2014). Three organizations, FAO, OIE and WHO, have begun using the One Health approach to control health problems at the point where humans, animals and the environment meet.

1.3. Relevance to Global Health Challenges

The importance of biosafety and biosecurity is clear, particularly because diseases such as Ebola, Nipah and COVID-19 are on the rise. Interactions between people and animals, combined with damage to nature and the illegal trade of animals, can lead to more cases of zoonotic spillovers in today's world (Karesh et al., 2012). Besides, AMR makes biosecurity significantly more challenging. Teamwork among healthcare and veterinary professionals helps to decrease the problem of antibiotic misuse (Horvat & Kovačević, 2025). The One Health framework, when paired with suitable biosafety and biosecurity measures, allows countries to get better prepared for pandemics, boost global health security and increase protection from dual-use research issues and biological terrorism (WHO, 2018).

2. Core Principles of Biosafety and Biosecurity

2.1. Biosafety Levels and Containment Strategies

Biosafety refers to the procedures designed to prevent the accidental release of pathogens (microorganisms) into the environment. Biosafety levels (BSL), BSL 1,2,3 and 4 are used to define the required safety equipment, infrastructure, and laboratory procedures, all of which are tailored to the specific hazards associated with identified microorganisms (biological agents) (WHO, 2020b).

Primary containment involves ensuring workplace safety through measures such as proper handling practices and personal protective equipment (PPE). Secondary containment refers to facility design elements, like sealed windows and controlled airflow, that help prevent the spread of hazardous materials within the environment (WHO, 2020a).

2.2. Biosecurity: Protecting Against Misuse of Biological Agents

Biosecurity involves measures taken to stop anyone from deliberately using biological resources and technology in terrorism or gaining unauthorized access to dangerous pathogens. It is based on the principles of securing individuals, physical regions and technology (Koblentz, 2010).

Key Components of Biosecurity include

- **Physical Security**: The storage of pathogens is sealed and only qualified scientists working in specific laboratories can access them.
- **Personnel Security**: To address internal risks, staff undergo reviews, get regular training and obey stringent rules and protocols.
- **Material Accountability**: The organization often audits biological agents to make sure their inventory is managed as it should be.
- **Cybersecurity**: Important information linked to pathogens, discoveries and activities is secured and protected from potential threats (National Academies of Sciences & Medicine, 2018).
- **The Biological Weapons Convention (BWC)**: creates a set of laws that prevents the development and use of biological agents in warfare (UNODA, 2025).

2.3 Risk Assessment and Mitigation

Biosafety and biosecurity are based on the need to assess and control risks. It requires checking for dangers, assessing their impact and highlighting key problems when doing a risk assessment (WHO, 2020b).

Steps in risk assessment include:

1. **Identifying Hazards:** Being able to identify potentially hazardous pathogens and processes in the laboratory.
2. **Characterizing Risks:** Assessing the chances of exposure and the level of danger it might cause.
3. **Evaluating Mitigation Measures:** Using management techniques, engineering and personal protection equipment.

Risk mitigation involves implementing protective strategies to reduce identified risks.

- **Engineering Controls:** Designing the facilities, using biosafety cabinets and relying on HEPA filters.
- **Administrative Controls:** Incident reporting systems, SOPs and staff learning.
- **Personal Protective Equipment (PPE):** Masks, gloves, gowns and respirators fitting to the risk level.

It is imperative to monitor risks continuously, since those linked to both emerging pathogens and technologies keep advancing. For this reason, it is important to regularly modify biosafety and biosecurity processes (Bohua et al., 2023)

3. The One Health Framework in Biosafety and Biosecurity

3.1. Understanding Interconnections: Human, Animal, and Environmental Health

According to the Global Health Integration Framework, since human, animal and environmental health influence each other, attention to animal-borne infections helps address 60% of newly occurring infectious diseases globally (Taylor et al., 2001). More urban areas, deforestation and climate change can encourage the spread of viruses through the interactions between humans and wild animals such as the Nipah and Ebola virus (Daszak et al., 2000). Ensuring the health of planets matters because dirty water, soils and air can result in the spread of illnesses and lead to drug-resistant bacteria. Unnecessary antibiotic treatment of people and use in the environment add to the problem (Zhu et al., 2019).

3.2. Operationalizing One Health in Biosafety and Biosecurity

Incorporating planetary health into biosafety and biosecurity connects environmental, animal, and human health, transforming these interconnections into actionable plans. Key components of this approach include:

• **Integrated Surveillance Systems**: One Health calls for a unified effort to observe, detect and fight any emerging threats involving environmental, animal and human sectors. The WHO, the FAO and the OIE team up using the Global Early Warning System (GLEWS) to track zoonotic illnesses (Hassan et al., 2023)

• **Cross-Sectoral Collaboration**: To help protect the environment, animals and humans, policymakers, ecologists, veterinarians and health professionals should collaborate (Destoumieux-Garzón et al., 2018).

• **Capacity Building**: It is necessary to give veterinary staff special training using the One Health approach, since veterinarians play a major role in identifying diseases that spread between humans and animals (Grace et al., 2012).

• **Policy and Governance**: Authorities should ensure national and international programs are compatible to promote One Health. Regulations on wildlife trade, antibiotics and preserving the environment can help protect people from infections at the core (Gibbs, 2014).

One Health practices were implemented well in the PREDICT program which succeeded in identifying 1,000 new viruses (Carroll et al., 2018).

4. Emerging and Re-Emerging Infectious Diseases

4.1 Zoonotic Diseases and Spillover Risks

One of the biggest challenges posed by newly emerging infectious diseases is the spread of zoonotic infections, where diseases are transmitted from infected animals to humans worldwide. In fact, over 60% of new infectious diseases that affect humans have zoonotic origins (Taylor et al., 2001). Spillover events occur when pathogens cross species barriers due to increased contact between humans, wildlife, and domestic animals, driven by factors like deforestation, urbanization, agricultural expansion, and wildlife trade (Daszak et al., 2000).

Zoonotic diseases like Ebola, rabies, and avian influenza involve complex spillover dynamics, necessitating a One Health approach that integrates human, animal, and environmental health disciplines to identify and mitigate potential risks (Plowright et al., 2017).

4.2. Case Studies: SARS-CoV, MERS-CoV and COVID-19

SARS-CoV

SARS-CoV, originating from bats, spread to humans in Guangdong, China, via animal markets and intermediate hosts like civet cats (Wang & Eaton, 2007). The outbreak resulted in 8,096 cases and 774 deaths across 29 countries, highlighting the significant role of market practices and the wildlife trade in facilitating zoonotic spillovers (Cherry, 2004).

MERS-CoV

In 2012, the MERS-CoV virus was recognized in Saudi Arabia, making its way from bats to humans through the Arabian camel (Zaki et al., 2012). As a result of this outbreak, it became apparent that better biosafety rules are needed for animals as well as improved surveillance to keep occasional outbreaks in check.

COVID-19

In December 2019, the appearance of the first COVID-19 case in Wuhan, China was most likely caused by an intermediate host and strong connection with bats (P. Zhou et al., 2020). As a result of COVID-19, people realized that greater science, cooperation worldwide and effective biosafety are needed to prevent pandemics that have taken millions of lives and caused millions of cases globally (WHO, 2023).

4.3 Antimicrobial Resistance (AMR): A Biosafety and Biosecurity Threat

Antimicrobial resistance becomes a global risk because bacteria are spreading through contact, agriculture and contaminated water or soil from the misuse and overuse of antibiotics in various fields (Van Boeckel et al., 2015). Carbapenem-resistant Enterobacteriaceae, methicillin-resistant Staphylococcus aureus (MRSA) and Mycobacterium tuberculosis are considered top pathogens that cause AMR (WHO, 2024). WHO reported (2017) that AMR is a massive global concern regarding infectious diseases, as it may cause up to 10 million deaths every year by 2050 if nothing is done (O'Neill, 2016).

Efficient protocols for research and health care are required to prevent antimicrobial-resistant pathogens, maintain ethics and safety by using comprehensive monitoring systems and continue successful programs (Bohua et al., 2023; Ahmed et al., 2024). AMR can be managed by implementing shared surveillance system and spreading stewardship efforts throughout every sector.

5. Laboratory Biosafety and Biosecurity in a One Health Context

5.1. Handling Pathogens with Zoonotic Potential

In laboratories, zoonotic pathogens are detected, identified and managed by using strict and appropriate safety and security measures. To prevent infections by zoonotic pathogens such as Bacillus anthracis, Mycobacterium tuberculosis and emerging viruses like SARS-CoV-2, individuals may be required to use Biosafety Levels ranging from 2 to 4, depending on the virus or bacteria (CDC, 2020).

Key safety measures include:

- **Risk-Based Containment:** Organizations should rely on negative pressure rooms and HEPA filters to prevent infections from being transmitted through the air (WHO, 2020b).
- **Personal Protective Equipment (PPE):** Gloves, gowns, masks and eye protection should be used properly whenever working with zoonotic agents.
- **Pathogen Transport Protocols:** Following international guidelines from the International Air Transport Association (IATA) guarantees the safe transport of infectious substances from one location to another (IATA, 2024).

Nipah virus and Rift Valley fever should be handled using advanced testing equipment, alone enclosed laboratories and set protocols for dealing with incidents (Chosewood & Wilson, 2009).

5.2. Collaborative Laboratory Networks across Sectors

Because zoonotic diseases are connected to different fields, collaborating labs in these fields is important. They make it possible to quickly identify pathogens, monitor situations better and collectively answer them.

Key Initiatives

- **The Global Laboratory Alliance**: Linking public health laboratories with veterinary and environmental services to build up the world's ability to diagnose problems (Penthes, 2019).
- **PREDICT Project**: Thanks to this effort, laboratories in wildlife, vet and health sectors were connected, enabling the discovery of more than a thousand viruses that may be transmitted to humans (Carroll et al., 2018).
- **Tripartite Collaboration**: The WHO, the FAO and the OIE cooperate to assist laboratories in low-resource countries (WHO, 2019b).

Collaboration in networks helps with data sharing, ensures live tracking of new viruses and GISAID played a key role during COVID-19 (Shu & McCauley, 2017).

5.3 Training and Capacity Building for Multisectoral Teams

Laboratory biosafety and biosecurity start with training. If capacity is built in various sectors, laboratory staff, veterinarians, epidemiologists and similar professionals can respond properly to zoonotic threats (Khan et al., 2024).

Core Training Areas

- **Biosafety Practices**: Personnel must be trained in the proper handling of zoonotic pathogens, waste disposal, and decontamination procedures.
- **Biosecurity Protocols**: Emphasis on secure storage, access controls, and addressing dual-use research concerns is critical to preventing the misuse of biological agents (WHO, 2020b)
- **Diagnostic Techniques**: Cross-training on diagnostic methods, such as PCR, ELISA, and pathogen genome sequencing, benefits multisectoral teams by enhancing their diagnostic capabilities.

Capacity Building Examples:

- **The Fleming Fund**: Supports low- and middle-income countries in strengthening laboratory infrastructure and workforce capacity to combat antimicrobial resistance (O'Neill, 2016).
- **FAO Laboratory Mapping Tool (LMT)**: Evaluates and improves laboratory capacity for zoonotic disease diagnostics in resource-constrained regions (FAO, 2022).

• **Field Epidemiology Training Programs (FETPs)**: These programs integrate biosafety and One Health principles into training for public health professionals, veterinarians, and laboratorians (CDC, 2020).

Investing in training and infrastructure helps build sustainable laboratory networks that can tackle both current zoonotic threats and emerging pathogens.

6. Governance, Policy and Regulation

6.1. International Frameworks: WHO, OIE, FAO and BWC

Several international organizations and agreements provide foundational frameworks for biosafety and biosecurity:

World Health Organization (WHO)

The WHO plays a central role in guiding biosafety practices, particularly through its *Laboratory Biosafety Manual*, which outlines standards for containment, risk assessment, and emergency response (WHO, 2020b). WHO also coordinates pandemic preparedness through the International Health Regulations (IHR, 2005), which obligate member states to detect and report public health emergencies (WHO, 2008)

World Organization for Animal Health (OIE)

The OIE focuses on veterinary health and zoonotic disease management, issuing standards for animal health practices through its *Terrestrial Animal Health Code*. These standards include biosafety measures for preventing disease spillover from animals to humans (OIE, 2021).

Food and Agriculture Organization (FAO)

The FAO addresses biosafety in food production and agricultural systems. Through programs like the Emergency Prevention System for Animal Health (EMPRES), FAO supports member states in managing transboundary animal diseases (FAO, 2022).

Biological Weapons Convention (BWC)

The BWC, enacted in 1975, prohibits the development, production, and stockpiling of biological and toxin weapons. The convention emphasizes biosecurity by promoting measures to prevent the misuse of dual-use research and biological agent (UNODA, 2025).

6.2. National Strategies for Biosafety and Biosecurity

National policies are vital for translating international guidelines into actionable frameworks:

Legislation and Standards

Measures are established based on a country's particular needs in biosafety and biosecurity. For this reason, the United States employs the Federal Select Agent Program (FSAP) which monitors the uses and transfers of dangerous pathogens (CDC, 2020). As for the European Union, it uses the Directive on the Contained Use of Genetically Modified Microorganisms to ensure biosecurity when handling research projects (EUROPEAN-UNION, 2009).

Capacity Building

To improve biosafety, many nations build laboratories and educate their workers on proper procedures, as part of the Global Health Security Agenda's efforts for low- and middle-income countries (NIH, 2025).

Interagency Coordination

A unified approach from agencies such as the health, agriculture and defense ministries is often needed in creating a comprehensive national biosafety and biosecurity strategy for human, animal and environmental health care (WHO, 2022).

6.3 Cross-Border Collaboration and Information Sharing

Biosafety and biosecurity risks often transcend national borders, requiring collaborative solutions:

Global Networks

- **Global Health Security Agenda (GHSA):** The union of over 70 countries supports international efforts for biosafety and biosecurity such as improving surveillance and ensuring the safety of laboratories (NIH, 2025).
- **World Bank Pandemic Fund:** Provides financial support to strengthen health systems in resource-limited countries for managing cross-border health threats (WORLDBANK, 2024).

Data Sharing Platforms

Real-time information sharing is critical for tracking outbreaks and implementing containment measures. Platforms like the Global Early Warning System (GLEWS) facilitate data sharing among WHO, FAO, and OIE to detect and respond to zoonotic diseases (GLEWS, 2013)

Regional Agreements

Regional initiatives, such as the African Union's Africa CDC and the European Centre for Disease Prevention and Control (ECDC), support member states in harmonizing biosafety regulations and improving cross-border surveillance (AfircaCDC, 2023; ECDC, 2025).

Effective biosafety and biosecurity systems require governance, policy, and regulation, integrating international frameworks, national strategies, and cross-border collaboration to address human, animal, and environmental health challenges (Sture et al., 2013).

7. Integration of Surveillance Systems

The integration of surveillance systems, including syndromic and event-based methods, harmonized data across human, veterinary, and environmental health sectors, and real-world case studies, is crucial for global health security (Gardy & Loman, 2018; George et al., 2020).

7.1 Syndromic and Event-Based Surveillance

Syndromic Surveillance

Syndromic surveillance involves the monitoring of syndromes or symptoms in populations to detect outbreaks early. It leverages data from emergency departments, pharmacies, and even social media for the rapid identification of public health threats (Henning, 2004).

For example:

- **Electronic Syndromic Surveillance Systems (ESSENCE):** Used in the United States, ESSENCE collects and analyzes emergency department data to monitor for signs of infectious disease outbreaks (NSSP-CDC, 2024).
- **Veterinary Applications:** Syndromic surveillance is also applied to track zoonotic diseases in livestock, such as foot-and-mouth disease, by monitoring clinical signs (Hoinville et al., 2013).

Event-Based Surveillance (EBS)

EBS involves the collection of information from informal sources, such as news reports, social media, and community observations, to detect unusual health events (WHO, 2020a).

Notable EBS platforms include:

- **ProMED-mail:** A global platform that disseminates reports of emerging disease events based on media and expert inputs (Yu & Madoff, 2004).
- **HealthMap:** Uses algorithms to scan digital media for potential health threats in real time (Freifeld et al., 2008).

7.2. Harmonizing Human, Veterinary, and Environmental Data

One Health Integration

Harmonization of data from human, animal, and environmental health sectors is essential for addressing zoonotic diseases, which account for over 60% of emerging infectious diseases (Taylor et al., 2001).

- **Shared Surveillance Systems:** Tools like the Tripartite Zoonoses Guide, developed by WHO, FAO, and OIE, advocate for standardized surveillance practices across sectors (WHO, 2019a)
- **Data Interoperability:** Using compatible formats and platforms, such as the World Animal Health Information System (WAHIS) and the Global Early Warning System (GLEWS), ensures seamless data sharing across sectors (GLEWS, 2013; WOAH, 2025).

Environmental Monitoring

Using environmental data in surveillance helps identify outbroken diseases affected by the environment. Observing climate data can assist in making predictions about diseases caused by insects carrying the dengue and malaria viruses (Patz et al., 2005).

8. Community engagement and public awareness

To be successful, biosafety and biosecurity approaches must involve the community, create awareness among the public, gain their trust, communicate risks and consider cultural differences, encouraging everybody to unite and follow guidelines (Ampadu-Ameyaw et al., 2021).

8.1. Risk Communication in a One Health Framework

It means providing information on possible dangers to people so that they can better protect themselves. The One Health Frameworks reminds us about the significance of risk communication in dealing with zoonotic and environmental issues (HEALTH, 2020).

Key Principles:

1. **Transparency:** Effective and timely communication builds trust and improves public cooperation during health crisis (Lee & Li, 2021).
2. **Tailored Messaging**: Messages should be audience specific, addressing literacy levels, cultural values, and local concerns (CDC, 2020).

8.2. Building trust and Understanding Among stakeholders:

The Role of Stakeholder Engagement

Building trust among stakeholders include government, health workers, veterinarians, and local communities. It is essential for biosafety and biosecurity. Trust fosters collaboration and compliance with public health initiatives (HEALTH, 2020).

Strategies for Building Trust

1. Inclusivity: Engage all relevant stakeholders in decision making processes to ensure diverse perspective are considered (Ahmad & Islam, 2024).

2. Consistency: Clear, accurate, and consistent messaging from trusted sources mitigates confusion and mistrust (Glik, 2007).

3. Capacity Building: Providing resources and training strengthens local capacity and demonstrate commitment to community wellbeing (WHO, 2020b).

Case Studies

- **H5N1 Avian Influenza:** Multi sector collaboration between governments, poultry, farmers, and public health authorities helped control outbreaks and minimize economic impact (Peiris et al., 2007; Grace et al., 2012; FAO, 2022).
- **Antimicrobial Resistance (AMR):** Stakeholder dialogues facilitated by WHO have enhanced cooperation on surveillance and responsible antibiotic use across sectors (WHO, 2014; Horvat & Kovačević, 2025).

9. Challenges and Future Directions

Biosecurity and biosafety require addressing challenges like unequal resource distribution, global health security, One Health integration, zoonotic outbreaks, AMR crisis, global travel, and global warming, requiring collective efforts from multiple sectors.

9.1. Addressing Resource and Capacity Inequalities

Unequal Distribution of Resources

Many low- and middle-income countries (LMICs) face challenges in biosafety and biosecurity enforcement due to limited resources, including access to laboratory facilities, diagnostic instruments, and skilled staff (Cleaveland et al., 2017)

Capacity Gaps in Surveillance and Response

- **Laboratory Infrastructure:** LMICs face issues in safe handling of high-risk infectious agents due to lack of biosafety level 3 (BSL-3) and BSL-4 facilities (Jeyapragasan, 2024)
- **Workforce Training:** Globally, the lack of specialists in disciplines like epidemiology, bioinformatics, and veterinary medicine limits the potential of health workforce (Alders et al., 2020).

Solutions

- **Technology Transfer:** The advanced technologies, such as biosensors and genome sequencing tools can be employed in LMICs through collaborations with high-income countries (Cleaveland et al., 2017).
- **Funding Mechanisms:** Capacity-building programs can be promoted by providing financial help from international organizations, such as the World Bank and WHO (WORLDBANK, 2024).

9.2. Strengthening Global Health Security Networks

Existing Networks and Their Role

Global health security depends on interconnected networks such as:

- **Global Health Security Agenda (GHSA):** Works on the implementation of national programs to observe, counter, and prepare responses against infectious disease outbreaks (NIH, 2025; OSHA, 2025)
- **International Health Regulations (IHR, 2005):** Focuses on giving commands to countries to build fundamental capacities in order to cope with public health emergencies (WHO, 2008).

Challenges in Coordination

Fragmented Approaches: Although, different organizations are working on the maintenance of environmental, animal and human heath but coordination among these networks is still limited (Lee & Brumme, 2013).

Cross-Border Threats: The spread of infectious diseases like Ebola and COVID-19 throughout the world indicates the problems of limiting disease outbreaks within national borders (Gardy & Loman, 2018).

Strategies for Strengthening Networks

1. Cross-Border Threats: The spread of infectious diseases like Ebola and COVID-19 throughout the world indicates the problems of limiting disease outbreaks within national borders (Vaidya et al., 2020) .

2. Data Sharing Platforms: To identify and prevent disease outbreaks effectively, platforms for communicating real-time information among different countries and organizations must be developed (Gardy & Loman, 2018).

3. **Regional Cooperation:** Regional networks, like Africa CDC, strengthen collaboration among member states and provide them specialized assistance in managing disease outbreaks (GLEWS, 2013; WHO, 2018; Penthes, 2019).
4. **Simulated Exercises:** Organizing worldwide simulation campaigns can determine gaps in preparation for disease management, and promote international collaborations (Jit et al., 2021).

9.3. Toward Sustainable One Health Integration

Defining Sustainability in One Health

Sustainable One Health frameworks must manage immediate outbreak action plans by providing long term financial resources for the preparation, education and prevention of diseases (Destoumieux-Garzón et al., 2018).

Key Pillars for Sustainability

1. **Policy Integration:** To successfully employ One Health approaches, coordination of policies and plans among different nations and sectors is considered critical (Cleaveland et al., 2017; OSHA, 2025)
2. **Community Involvement:** Spreading awareness among local communities and urging them to take part in surveillance and action plans promotes long-term community involvement (Leung et al., 2004)
3. **Climate Resilience:** It is also mandatory to utilize guidelines defined by One Health networks regarding the action plans developed to tackle the impact of climate change on zoonotic transmission and vector-borne disorders (Patz et al., 2005; Grace et al., 2012).

Future Directions

- **Multidisciplinary Training:** Preparation of combined curricula focusing on the environmental, animal, and human health programs.
- **Incentivizing Collaboration:** Communication and cooperation can be promoted between primarily isolated institutions by providing financial and policy incentives.
- **Research and Development:** Providing investments for advanced technologies and model building to predict and identify the emergence of infectious diseases before they spread on a larger scale.

Conclusions

Strengthening global health security demands a comprehensive integration of biosafety, biosecurity, and the One Health approach. Managing infectious disease risks, including those from zoonotic sources and antimicrobial resistance, requires collaboration across human, animal, and environmental health sectors. Effective containment strategies, risk assessment, responsible laboratory practices, and secure handling of biological agents form the foundation of preparedness. Real-time surveillance systems, data sharing platforms, and cross-sectoral laboratory networks enhance early detection and coordinated responses to outbreaks. Community engagement, transparent communication, and trust-building among stakeholders are essential to ensuring cooperation and public adherence to health measures. Addressing inequalities in resources and technical capacity, especially in low- and middle-income countries, is critical for equitable protection against global threats. Long-term sustainability depends on investment in training, infrastructure, policy alignment, and climate-resilient health systems. By fostering international cooperation, incentivizing multidisciplinary collaboration, and advancing innovation in diagnostics and disease forecasting, societies can anticipate and respond to biological threats more effectively. A unified, forward-looking strategy is key to building resilient health systems capable of withstanding future pandemics and ensuring safety for all.

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