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Biosecurity and One Health Integration: An Extensive Analysis of Methods for Preventing Emerging Infectious Diseases

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ABSTRACT

This review analyzes the combination of biosecurity protocols with the One Health framework in mitigating emerging infectious diseases (EIDs), which pose an increasing global health risk. Emerging infectious diseases (EIDs), frequently zoonotic, present substantial threats to human, animal, and environmental Health, underscoring the necessity for cooperative initiatives between biosecurity and One Health paradigms. This review consolidates available evidence to assess the efficacy of these integrated techniques, highlighting significant trends, problems, and deficiencies in present practices. It emphasizes the alignment of biosecurity measures, including monitoring systems and risk management strategies, with the One Health framework to enhance early detection, prevention, and response to infectious diseases. Despite substantial advancements, notable deficiencies persist, especially in the uniformity of implementation techniques across various locations and sectors. The paper analyzes the constraints of existing methodologies, emphasizing the disunity of initiatives and difficulties in resource distribution, especially in low-income environments. Additionally, it examines the significance of international cooperation and frameworks, such as the Global Health Security Agenda (GHSA), in promoting collaboration among human, animal, and environmental health sectors. In summary, the review offers recommendations for future research, highlighting the necessity for longitudinal studies, enhanced policy frameworks, and the establishment of standardized protocols to strengthen the integration of biosecurity and One Health. These findings provide critical insights for policymakers, researchers, and practitioners, thereby enhancing global health initiatives to prevent and control new infectious diseases.

INTRODUCTION

The global environment of infectious diseases is constantly evolving, and the public health, economic, and social threats posed by emerging infectious diseases (EIDs) have significantly increased in recent years (Cleaveland et al., 2017). The intersectional nature of these threats has made the One Health framework, which emphasizes that the health of people, animals, and the environment is interconnected, more relevant than ever (Dalton et al., 2020) . In contrast, biosecurity deals with preventing, detecting, and responding to biological threats that could cause outbreaks (Hulme, 2020). One Health– Biosecurity integration is a promising preventive strategy against EIDs as it provides an integrated understanding of disease transmission dynamics and encourages collaboration across sectors (Baum et al., 2017). The increased importance of

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zoonotic diseases, responsible for > 60% of all Human Infectious Diseases, reflects the urgent necessity for these integrated approaches. EIDs such as COVID-19, Ebola, and Zika have shown the devastation that these diseases cause to a country and the world economy/uniting them around the need to strengthen biosecurity and approach the control gate using the One Health framework (Raina MacIntyre et al., 2018). This review summarizes the state of the literature on biosecurity and One Health implementation, shedding light on the current state of the application and the significant challenges for the management of emerging infectious diseases (Destoumieux-Garzón et al., 2018).

Although significant strides have been made in zoonotic disease biosecurity and One Health integration, important literature gaps impede optimal application. Integrated approaches are practical in disease surveillance and early detection, as shown in the Global Health Security Agenda (GHSA) and Integrated Disease Surveillance and Response (IDSR) initiatives (Dente et al., 2018). However, important research gaps remain, especially regarding procedures for integrating biosecurity and One Health frameworks across sectors and geographies (Dente et al., 2018). However, despite the many countries that have embraced the One Health initiative, such efforts tend to be fragmented and not consistently implemented, specifically in low-resource settings (Maehira & Spencer, 2019). Additionally, even though some regions have implemented biosecurity measures, including surveillance systems, that have proven effective, their coupling with environmental health and the overall One Health approach remains insufficiently discussed (Dalton et al., 2020). Tackling these gaps is essential for optimizing human, animal, and environmental health system integration and reducing EID risks (Cleaveland et al., 2017). To fill these gaps, this review analyses the literature on integrating biosecurity and One Health, highlighting the implementation barriers and providing suggestions to guide improved future investigation and policy processes (Destoumieux-Garzón et al., 2018).

This review aims to thoroughly synthesize studies in biosecurity and One Health integration and identify significant gaps in literature. This review takes a novel approach by reviewing the theoretical and practical aspects of integrating these strategies and applying integrated strategies in real-world settings (Schwind et al., 2021). This paper addresses the separation between theory and policy, and practices by evaluating how biosecurity and One Health can be integrated to prevent EIDs. The review sheds new light on integrated frameworks' suitability and ability to improve global health security by analyzing case studies from global health efforts (Sumption et al., 2020). The results of this review will yield information that will be highly useful to policymakers, research, and practice and will provide actionable recommendations to enhance global environmental health and health relations of emerging infectious diseases. In addition, this review overcomes the limitations of the previous studies, i.e., no longitudinal evaluations of integrated approaches aside from updating the current evidence base by providing streams for future research that can better inform health strategies and policies (Schwind et al., 2021).

Understanding Biosecurity in the Context of Emerging Infectious Diseases

Biosecurity is the collective name for the practices used to reduce the risk of transmission of harmful biological agents (pathogens and pests) across human, animal, and environmental domains (Al Shehri et al., 2022). It is an essential part of the management and mitigation strategies of emerging infectious disease (EID) diseases that have newly increased or expanded in incidence, frequently due to a new pathogen, mutation, or change in environmental parameters. During EIDs, biosecurity is key to quickly avoiding, detecting, and controlling infectious agents (Mutua & Dione, 2021). Many of these diseases are zoonotic (can be transmitted from animals to humans) and have been a serious threat to public health during the last few decades (familiar names include SARS, Ebola, and the COVID-19 pandemic). Since zoonoses account for more than 70% of new infectious diseases, biosecurity functions as the first level of defense to prevent the emergence and spread of these diseases (Ayala et al., 2020).

Key Principles of Biosecurity

There are several fundamental principles around biosecurity strategies, such as prevention, detection, and response. Prevention, the fundamental concept in biosecurity, helps to minimize the risk of pathogens being introduced into new environments (Filippitzi et al., 2018). These may involve restricting animal movement, prohibiting trade in infected materials, and maintaining appropriate hygiene principles in high-risk environments like farmers' and wildlife habitats (Stewart et al., 2020). Detection involves identifying new or potential threats early through multiple surveillance systems that monitor human, animal, and environmental health (Mutua & Dione, 2021). Early detection means early disease containment before spreading into more significant outbreaks. Response strategies — such as quarantines, slaughter, vaccination, or travel bans — may follow once the disease has been detected. These are actions to restrict transmission and to stop an outbreak from transitioning into a pandemic (Stewart et al., 2020).

Biosecurity in Agriculture and Public Health

Biosecurity practices are primarily aimed at animal diseases that could impact livestock populations or spill over into humans and thus have an agricultural application. Such actions may include increased movement control, enhanced hygienic practices, and

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vaccination programs (Stewart et al., 2020). Biosecurity is also important for preventing and controlling human diseases in public health, for which early warning, reporting, and response systems for infectious disease outbreaks exist (Al Shehri et al., 2022). For instance, in the avian flu outbreak, biosecurity measures consist of poultry confinement, movement restriction, disinfection of infected places and areas, and surveillance of animals and human populations (Stewart et al., 2020).

Global Impact and Examples of Biosecurity Failures

One of the most severe examples of loss due to insufficient biosecurity occurred during the 2001 foot-and-mouth disease outbreak in the UK, where thousands of livestock were culled to control transmission due to poor control of livestock movements (Blacksell et al., 2019). Likewise, SARS in 2003 spread so rapidly along global travel lines that effective biosecurity at international border control systems and within healthcare systems became paramount to limit transnational spread (Walker et al., 2020).

The One Health Framework: A Holistic Approach to Disease Prevention

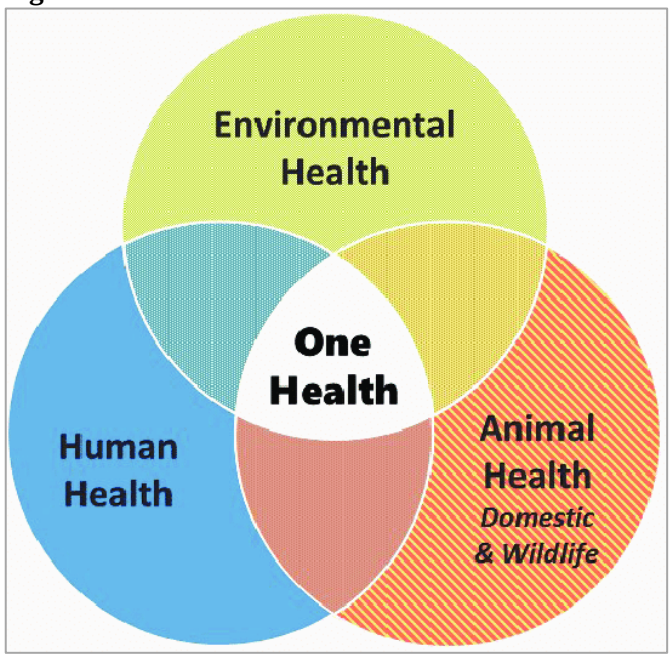
The One Health framework is a One Health approach that integrates human, animal, and environmental Health. This concept originates from the reality that the health status of each sector is interpenetrating and that if the health problem in one area is covered, it can directly or indirectly impact the other Health Systems (Wu et al., 2016). The objective of One Health is to encourage multi-sectoral collaboration comprising various sectors within the health sector, such as the public health sector, veterinary science sector, environmental sector, agriculture sector, etc., for improved combat against emerging infectious diseases (EIDs) and health threats (Asokan & Vanitha, 2017).

The Concept of One Health

One Health is based on many human diseases, especially emerging, zoonotic diseases (i.e., transmissible between animals and humans). About ¾ of new infectious diseases discovered in humans in the past few decades have been zoonotic, often due to environmental changes, human activities, or the increased interaction of humans and wildlife (Wu et al., 2016). The One Health framework's comprehensive approach recognizes the interdependence of human, animal, and environmental Health, and Health offers a powerful strategy for preventing and controlling these diseases as shown in **Figure 1** (Asokan & Vanitha, 2017).

The framework implies that diseases cannot be recognized or managed independently within a single domain. For instance, animal disease outbreaks can be rapidly transmitted from wildlife into livestock and from animals to people—as happened with Ebola, SARS, and COVID-19 (Asokan & Vanitha, 2017). The One Health approach also considers the environment—diseases can continue to spread through environmental forces. For example, environmental degradation triggers increases in disease vectors (mosquitoes) or that all pathogens are carried in ecosystems (Wu et al., 2016).

Figure 1



This diagram illustrates the interconnectedness of human, animal, and environmental health within the One Health framework. It uses a Venn diagram or flowchart to visually represent how these three domains overlap and influence each other. The diagram highlights the importance of collaboration across sectors—public health, veterinary, and environmental health—to address the root causes of emerging infectious diseases and ensure a holistic approach to disease prevention and response (Deem & Brenn-White, 2020).

Historical Development and Application of One Health

The One Health approach is not brand-new, as the links between animal and human disease were highlighted long ago by scientists such as Rudolf Virchow and Sir William Osler in the 19th century. Although the concept has existed for some time, the formalization of One Health gained traction in the 2000s with the resurgence of newly emerging zoonotic diseases such as the H5N1 avian influenza and SARS (Asokan & Vanitha, 2017; Wu et al., 2016).

Further confirmation of the need for a One Health approach in these situations came in 2001 when investigators of the movement of anthrax that year in the United States identified the importance of environmental factors and animal reservoirs of the bacteria in understanding the transmission dynamics of this disease. This incident and the following outbreaks led to subsequent international initiatives to promote collaboration between human Health and the veterinary

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and environmental sectors. For this reason, agencies such as the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organization for Animal Health (OIE) started to promote an integrated cross-sectoral approach to disease prevention and control (Asokan & Vanitha, 2017).

The Need for an Integrated Approach to Zoonotic Diseases

Because of the increasing isolation of potential zoonotic emergencies, an intently studied class of guidance by One Health is zoonotic diseases. Outbreaks of zoonotic diseases, including COVID-19, H1N1 influenza, and the Ebola virus, have revealed the speed with which zoonotic diseases can jump species and borders. These threats can impact human, animal, and environmental Health. Thus, the grated approach is needed for detection, prevention, and management. This requires sharing knowledge, resources, and data across sectors, supported by One Health, to enable better surveillance, assessment of risk, and responses (Asokan & Vanitha, 2017).

One Health program seeks to establish collaborative platforms that bring together talents such as veterinarians, public health professionals, ecologists, and environmental scientists. Such partnerships allow the formulation of broader disease control strategies and the implementation of interventions in multiple sectors. For example, human and animal health monitoring systems can identify emerging diseases promptly, allowing for rapid response activities (Wu et al., 2016).

Case Studies of Successful One Health Initiatives

Many One Health initiatives have successfully dealt with zoonotic diseases considering the pandemic. In Kenya, for instance, the One Health Initiative aims to prevent zoonotic disease outbreaks of Rift Valley Fever or Ebola virus. The program incorporates veterinary care, human public health monitoring, and environmental management to enhance disease surveillance and response capabilities in urban and rural environments (Robertson et al., 2020).

Likewise, the One Health High-Performance Computing (HPC) Initiative is focused on applying big data analytics to find new insights into One Health linkages between human, animal, and environmental health (Wendt et al., 2016). Utilizing data from different sources, including satellite imagery, wildlife tracking, and human health data, the project has aided in more precise predictions of diseases and targeted interventions (Hughes & Anderson, 2020).

Key Methods for Preventing Emerging Infectious Diseases

Various strategies, such as surveillance, risk assessment, early detection, and containment, will be used to thwart emerging infectious diseases (EIDs). They are complicated to prevent and require a One Health balance across human, animal, and environmental health sectors but emerge from standard foundations (Petersen et al., 2018). Preventing diseases is complex and requires acting on the drivers of zoonotic disease emergence, including land use, human behavioral changes, and climate (Liu et al., 2018). Key methods that have been instrumental in preventing and controlling EIDs are as follows.

Surveillance and Monitoring Systems

Disease prevention stands on surveillance. Frequent surveillance of humans, animals and the environmental health status helps health authorities to identify possible threats prior to the occurrence of large outbreaks (Petersen et al., 2018). Most surveillance systems are directed at disease events in the human population, livestock, wildlife and ecosystems. This encompasses passive surveillance where disease reports are submitted by health professionals as they are identified and active surveillance, which involves investigations to search for a latent or newly emerging disease (Hendriksen et al., 2019).

Examples include the Global Early Warning and Response System (GLEWS), a joint platform of WHO, the Food and Agriculture Organization (FAO) and the World Organization for Animal Health (OIE) (Smith et al., 2019). Such a network enables surveillance of emerging animal diseases and their potential to spill over to human populations. Then it allows you to implement measures to prevent too many people from being infected, such as quarantining, travel bans and so on (Chinazzi et al., 2020).

Risk Assessment and Modeling

These emerging infectious diseases are understood, and their threats are managed with us in the context of risk assessment horizons [8]. This information will allow scientists to assess the threat posed by pathogens, environmental changes, and human-associated drivers and create avenues to mitigate disease emergence. This employs qualitative and quantitative methods and uses mathematical modeling to anticipate the spread of diseases and the possible effects of several interventions (Chowell et al., 2016).

Risk assessment models, for instance, can map predictions of the geographical spread of zoonotic disease based on trends in population density, land use, climate change, and animal population dispersal (Chowell et al., 2016). Such models give policy makers and public health leaders critical information about prioritizing areas for intervention and allocating resources (Nii-Trebi, 2017).

Fourth, One Health risk assessments bring together data from human, animal, and environmental health sectors to highlight interactions that drive disease emergence (Smith et al., 2019). These assessments give

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a holistic view regarding disease transmission dynamics by factoring in all three domains, which is necessary for effective prevention (Nii-Trebi, 2017).

Strengthening Animal Health and Veterinary Practices

Since most emerging infectious diseases have zoonotic origins, focusing on animal health interventions is crucial to eliminating the chances of their jumping into the human population. This includes strengthening veterinary surveillance, modifying practices for raising animals, and restricting the movement of animals. In high-risk settings, strengthening veterinary services identifies outbreaks early and prevents further spread (Nii-Trebi, 2017).

Reducing the transmission of pathogens In the past, preventive measures, including vaccination programs and the implementation of biosecurity practices, were essential. Vaccines are one of the most effective and cost-efficient tools against rabies, avian influenza, and foot-and-mouth disease in livestock, poultry, and even wildlife! Such measures help ensure animal health and safety while staving off disease in humans (Smith et al., 2019).

Environmental Management and Habitat Preservation

Environments such as driver infectious diseases, especially ones communicated by vectors such as mosquitoes and ticks, are as often as possible subject to the environment. When land for agriculture, logging, or urbanization encroaches on wildlife habitats, ecosystems can be disrupted, and human-wildlife interaction can increase, making the conditions for zoonotic spillover even better (Rohr et al., 2019).

Management of the environmental factors that pose a risk for EIDs is thus key to preventing them. This involves protecting natural ecosystems, promoting sustainable farming practices, and reducing climate change. Moreover, techniques like integrated pest management can lessen the existence of bugs that transmit diseases if breeding sites are handled and pesticides are scant to avoid upsetting natural predators (Rohr et al., 2019) (Nii-Trebi, 2017).

International Collaboration and Information Sharing

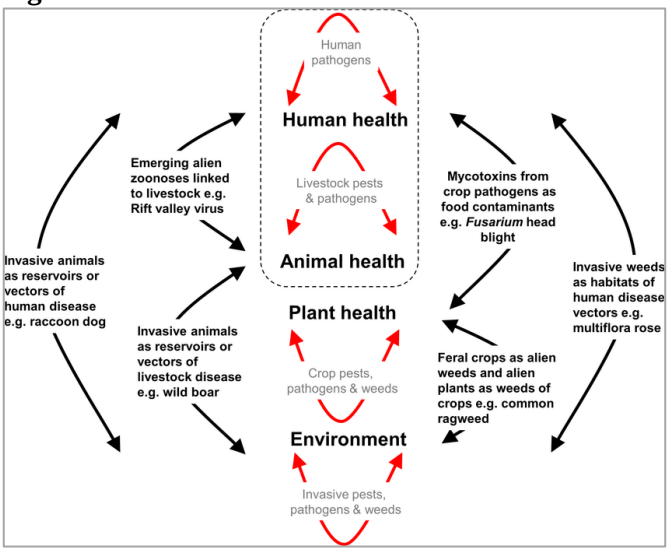
Because emerging infectious diseases have a global dimension, they need to be prevented with international cooperation. Phosphates run off into oceans, causing algae blooms that starve out animal life, and diseases such as SARS, H1N1 influenza, and COVID-19 have shown us how fast a pathogen can cross borders (Nii-Trebi, 2017). Preventing outbreaks effectively requires countries to act in concert by sharing data, resources, and responses (Smith et al., 2019).

International collaboration has advanced through global health institutions such as the WHO, the FAO, and the OIE, which have built systems for quickly sharing information and resources (Smith et al., 2019). The International Health Regulations (IHR) establish legal requirements for countries to notify pertinent infectious disease outbreaks or unusual disease events and to implement measures to prevent the spread of diseases. Owing to these, the genomic information on pathogens can also be shared, leading to the rapid design of vaccines, diagnostics, and treatment strategies (Rohr et al., 2019) (Nii-Trebi, 2017).

Integrating Biosecurity and One Health Approaches

Biosecurity and One Health are linked to preventing and reducing EIDs. Using the same concepts of Human, Animal, and Environmental Health, biosecurity and One Health are two frameworks that share similarities but differ in their scope, with biosecurity being a more narrow focus on the prevention of harmful biological (e.g., infective organisms) agents and One Health being a broader environmental health concept focused on the ecosystem (including plant and soil health as well as animal and human Health) as shown in **Figure 2** (Konda et al., 2020). An integrated approach that drives these two approaches can be a powerful tool to reduce the emergence risk of EIDs, often due to the complex interactions of humans, animals, and the environment (McEwen & Collignon, 2018).

Figure 2



A schematic depiction of the One Biosecurity concept, highlighting the connections between human, animal, plant, and environmental health that emerge from the effects of invasive alien species, including plants, animals, and pathogens. The dashed rectangle illustrates the sectors central to One Health, underscoring the broader scope of One Biosecurity (Hulme, 2020).

The Synergy Between Biosecurity and One Health

The introduction, spread, and persistence of pathogens, especially zoonotic pathogens, the viruses that move

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from animals to humans, is a significant target for biosecurity measures. These measures include quarantine measures, sanitation, vaccination, and restriction of movement (van de Burgwal et al., 2017). In contrast, One Health advocates for recognizing the connections between human, animal, and environmental Health and the sectoral collaboration needed to address underlying disease drivers and environmental factors influencing pathogen transmission (Cunningham et al., 2017).

In contrast, One Health focuses on the broad ecological, environmental, and human health drivers influencing disease development. The combination of both methods enables the detection of high-risk areas, the early identification of disease outbreaks, and closer cooperation between various sectors, starting from public Health, veterinary medicine, and environmental science (McEwen & Collignon, 2018).

Practical Applications of Integrated Biosecurity and One Health Approaches

Experience applying integrated biosecurity and One Health approaches conceptually and operationally, particularly in zoonotic disease prevention and control and spillover mitigation—has proved effective in a variety of contexts. For example, Integrated Disease Surveillance and Response (IDSR), which measures human, animal, and ecosystem health in a single system, is widely used in many low—and middle-income countries (McEwen & Collignon, 2018). The system integrates human health surveillance systems, veterinary health programs, and environmental monitoring data to provide early warning mechanisms for possible disease outbreaks (Stratton et al., 2019).

In addition, One Health teams typically include experts from various sectors—public Health, animal health, environmental sciences, and even social sciences all working to assess risk factors, share information, and formulate intervention strategies (McEwen & Collignon, 2018). Such an interdisciplinary collaboration ensures that tying a biosecurity measure is not an isolated action but part of a broader scheme that integrates the ecological and social dynamics that create conditions for disease emergence (Cunningham et al., 2017). Similarly, in the context of the Ebola epidemic in West Africa, the integrative contribution of human and veterinary experts from the WHO and other agencies (supplemented with support from environmental scientists) was pivotal in understanding how wildlife habitats and human-wildlife interactions combined to affect the transmission of the bare worm (i.e., disease) within human populations (van de Burgwal et al., 2017).

Challenges in Integrating Biosecurity and One Health

Although integrating biosecurity and One Health has many clear advantages, there are continuing challenges. A key challenge relates to the fragmented nature of health systems across sectors. Public Health, veterinary Health, and environmental health systems are commonly funded, prioritized, and regulated separately, yet are often inextricably linked. Failure to coordinate can impede information sharing and delay actions, resulting in lost opportunities for prompt intervention (McEwen & Collignon, 2018).

Finally, the capability gap across regions is yet another difficulty. There may be inadequate infrastructure, trained personnel, or funding to implement comprehensive biosecurity measures and One Health programs in resource-limited settings. Even high-income countries with more developed systems may struggle, while low—and middle-income countries experience greater challenges coordinating among sectors and implementing biosecurity activities (Stratton et al., 2019).

In addition, no standardized framework exists to monitor and assess the efficacy of integrated programs, which makes it challenging to improve output. Without explicit indicators of success, one cannot know whether integration serves its purported purpose of preventing and controlling disease (Konda et al., 2020).

Future Directions for Biosecurity and One Health Integration

However, several steps help overcome these challenges and facilitate the integration of biosecurity and One Health. First, national and international governance frameworks need to be strengthened. This entails developing policies requiring the human, animal, and environmental health sectors to coordinate and designate resources to facilitate collaborative work across disciplines (Konda et al., 2020).

Second, developing capacity-building initiatives needs further investment, especially in lower-resource settings. Among these are equipping professionals with knowledge of the One Health approach, enhancing surveillance, and creating molecular early warning systems for emerging diseases (McEwen & Collignon, 2018. More importantly, global initiatives, including the Global Health Security Agenda (GHSA), have the ability to strengthen biosecurity and One Health globally by enhancing international collaboration in responding to health threats that cross borders (Konda et al., 2020).

Finally, it is essential to increase public understanding that human, animal, and ecosystem health is connected, as per One Health. An informed public can be essential in both biosecurity and One Health efforts aimed at community disease prevention (McEwen & Collignon, 2018.

Global Policy and Governance for Emerging Infectious Diseases Prevention

Prevention of emerging infectious diseases (EIDs) is

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contingent on scientific advances, local interventions, and global governance and policy frameworks. Due to the nature of many of the emerging infectious diseases (EIDs), including COVID-19, Zika, and Ebola, effective global policies are necessary to contain the spread of these diseases and organize responses (Wilder-Smith & Osman, 2020). Surveillance, preparedness, resource allocation, cross-border cooperation, the concept of the One Health approach, and biosecurity should be covered under these policies (Kluge et al., 2018).

International Health Regulations (IHR) and Global Cooperation

The International Health Regulations (IHR), the legally binding framework of international cooperation in the prevention and control of global health risks established by the World Health Organization (WHO), has become more relevant since its inception in the 1960s (Elachola et al., 2016). The IHR established obligatory practices for nations to make public health occurrences and EIDs known and enabled government measures to contain or limit these EIDs. The main objective of the IHR is to reduce the spread of disease, and it should be done with the least interference from international traffic and trade (Wilder-Smith & Osman, 2020).

The IHR obligates nations to strengthen surveillance and health systems. This includes setting up the National Focal Points (NFPs) coordination mechanism to provide communication during outbreak situations. It also increases transparency by mandating countries to provide information on public health threats, particularly in high-risk situations, such as when new or re-emerging infectious diseases are spreading (Wilder-Smith & Osman, 2020). For example, the IHR framework was instrumental in galvanizing an international response to control the spread of the virus during the SARS outbreak (Suthar et al., 2017).

While the IHR has had its successes, challenges remain, especially for lower-income countries where the resources to implement requirements are often lacking (Wilder-Smith & Osman, 2020). Moreover, despite the emphasis on information sharing in the IHR, the tools do not bind nations to take preventive measures (e.g., investments in health infrastructure). Therefore, despite the IHR being a useful instrument in their response, they cannot sufficiently meet the challenge of EIDs on their own (Kluge et al., 2018).

The Role of Global Health Organizations

International agencies like WHO, FAO, and OIE are critical in the global governance of emerging infectious diseases to prevent and respond to them as shown in **Figure 3**. These organizations assist in establishing disease prevention, surveillance, and response strategies and offer technical support and resources to countries that require them (Wilder-Smith & Osman, 2020).

An example would be WHO's Global Health Security Agenda (GHSA), an initiative to foster international collaboration to prevent, detect, and respond to infectious disease threats (Elachola et al., 2016). Connecting countries, international organizations, and civil society will strengthen the global ability to prevent and respond to public health emergencies. At the same time, the GHSA highlights aspects of health systems, disease surveillance, and laboratory capacity, particularly in resource-constrained contexts (Wilder-Smith & Osman, 2020).

Plus, these world health organizations set the benchmark for disease management. For example, the WHO spearheads international health standards for vaccines, diagnostics, therapeutics, and public health guidance for the containment and management of diseases (Wilder-Smith & Osman, 2020). EIDs are often of animal or environmental origin and require a multi-sectoral approach to mitigating their emergence and spread to humans. The coordination between WHO, FAO, and OIE facilitates this (Elachola et al., 2016).

Figure 3

The proposed United Nations "One Health" framework emphasizes a collaborative approach to health that integrates human, animal, and environmental sectors. Key organizations involved in this framework include FAO (Food and Agriculture Organization), OIE (World Organization for Animal Health), TDR (WHO Special Programme for Research and Training in Tropical Diseases), UNDP (United Nations Development Programme), UNEP (United Nations Environment Programme), UNFPA (United Nations Population Fund), UNICEF (United Nations Children's Fund), WHO (World Health Organization), and WMO (World Meteorological Organization). This framework aims to promote a holistic understanding of health by fostering

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coordination and cooperation among these diverse entities to address complex health issues at the intersection of human, animal, and environmental health (Mackey et al., 2014).

Cross-Border Collaboration and Funding Mechanisms

Emerging infectious diseases are global in scope, but national boundaries complicate effective response and collaboration. Because in many parts of the world, EIDs can spread rapidly across borders through trade, travel, or migration, effective responses frequently require countries to work together (Elachola et al., 2016). Strengthening regional structures and establishing joint regional agreements will be crucial in developing regional preparedness and response plans, such as those set up by the African Union in the Africa Centres for Disease Control and Prevention (Africa CDC) or the Asia Pacific Economic Cooperation (APEC) Health Working Group (Wilder-Smith & Osman, 2020).

Strong funding mechanisms, along with international cooperation, are one of the key components behind the execution of global health strategies (Wilder-Smith & Osman, 2020). The Global Fund to Fight AIDS, Tuberculosis & Malaria and the GAVI Alliance have funded critical resources for disease prevention, particularly in resource-poor settings. Funds used for vaccine distribution, health system strengthening, and emergency response effort (Elachola et al., 2016).

Epidemic outbreaks can grow into pandemics, so rapid response funds are needed in the case of EIDs (Elachola et al., 2016). For example, the World Bank has created the Pandemic Emergency Financing Facility (PEF) to support the early implementation of pandemic preparedness and response by rapidly providing eligible countries with funding. It allows the channeling of rapid resources into countries when an outbreak is seen so the world can beat a disease before it becomes widespread (Wilder-Smith & Osman, 2020).

Addressing Global Inequalities in Health Infrastructure

This disparity in health infrastructure between high-income and low-income countries is a key question for global governance regarding EID prevention. The global health community has increasingly realized that health system inequities can compromise EID prevention and control efforts (Wilder-Smith & Osman, 2020). As a result, in many low-resource settings, health systems do not have adequate funding and capacity to accurately detect, respond to, and contain emerging infectious diseases (Wilder-Smith & Osman, 2020).

Reducing these inequalities in such regions requires global governance, which should necessarily provide capacity building to vulnerable regions. This includes everything from health systems strengthening and surveillance network enhancement to laboratory infrastructure and healthcare worker training (Wilder-Smith & Osman, 2020). Furthermore, global policies must prevent health responses during an outbreak from worsening health inequities by ensuring fair distribution of health interventions (Elachola et al., 2016).

The Role of Data Sharing and Technology in Governance

While previously considered a relatively separate field, the role of data and technology is growing in global health governance agendas. Such platforms, including GISAID for genomic data and ProMED-mail for disease outbreak reporting across countries and organizations, beneficially promote rapid data and information exchange. Data sharing is key in ensuring disease outbreaks are detected quickly, pathogens are traced, and vaccines and treatments are developed quickly (Elachola et al., 2016) .

In addition, global health organizations are now using artificial intelligence (AI) and big data analytics to replace early monitoring and response to emerging diseases. AI-powered predictive models can assist in predicting possible outbreaks and evaluating the effectiveness of preventive measures. These technologies will improve decision-making and preparedness and enable faster responses when applied in concert with international governance frameworks (Wilder-Smith & Osman, 2020).

CONCLUSION

This review discusses the relevance of combining biosecurity with One Health measures to prevent and control EIDs. These frameworks consider the Health and welfare of humans, animals, and the environment, thus making it possible to create a more comprehensive approach to the surveillance, prevention, and control of infectious diseases that cross borders. The review highlights the necessity of international collaboration, reinforced by structures including the International Health Regulations (IHR) and international health organizations like the WHO, FAO, and OIE. These frameworks enable surveillance, data sharing, and coordinated response, which are important components of global health security. Nevertheless, significant deficits exist, such as the absence of standardized protocols to integrate these approaches and inequitable access to resources, especially in low-income countries. Finally, it suggests that longitudinal studies on these combined strategies and approaches may be required to determine how long they remain effective. Further studies should make evidence-based dialogue on insufficient guidelines assess implementation resources, and the effect of climate change on zoonotic diseases. However, considering the rising interconnectedness amongst humans, animals, and the environment, the intersection between biosecurity and One Health is a

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hopeful avenue for handling EIDs. Hence, it promises to strengthen early identification, timely response, and disease transmission etiology. It also highlights the limitations of this review, including publication biases and underrepresentation of regional approaches, but overall reiterates the call for integrated, multisectoral solutions to population health policy. Going forward, further research and international coordination must be undertaken if these gaps are to be addressed and more robust preparation for future health threats is to take place.

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