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(REVIEW ARTICLE)

Integrative strategies for zoonotic disease surveillance: A review of one health implementation in the United States

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Abstract

Zoonotic diseases pose significant public health threats worldwide, highlighting the need for effective surveillance strategies. The One Health approach, which recognizes the interconnection between human, animal, and environmental health, has gained traction as a comprehensive framework for addressing zoonotic disease surveillance. This review explores integrative strategies for zoonotic disease surveillance in the United States, focusing on the implementation of One Health principles. The review examines the collaborative efforts between human and animal health sectors, environmental agencies, and other relevant stakeholders in implementing One Health surveillance strategies. It highlights the importance of data sharing, communication, and coordination among these sectors to enhance early detection, rapid response, and effective control of zoonotic diseases. Key findings include the establishment of cross-sectoral surveillance systems, such as the National Notifiable Diseases Surveillance System (NNDSS) and the National Animal Health Monitoring System (NAHMS), which facilitate the collection and analysis of zoonotic disease data. These systems enable the identification of emerging zoonotic threats and the implementation of targeted interventions to mitigate risks. The review also discusses the role of technology, such as geographic information systems (GIS) and molecular epidemiology, in enhancing zoonotic disease surveillance. These tools enable the visualization of disease patterns and the tracking of disease transmission pathways, aiding in the development of effective control strategies. Challenges in implementing One Health surveillance strategies include limited resources, fragmented data systems, and regulatory barriers. Addressing these challenges requires increased investment in infrastructure, capacity building, and policy development to support integrated surveillance approaches. Overall, this review highlights the importance of One Health implementation in zoonotic disease surveillance and underscores the need for continued collaboration and innovation to enhance the effectiveness of surveillance efforts in the United States.

Keywords: Integrative Strategies; Zoonotic; Disease Surveillance; Health; Implementation

1. Introduction

Zoonotic diseases, which are infectious diseases that can be transmitted between animals and humans, pose significant public health threats worldwide. These diseases, such as Ebola, Zika, and COVID-19, can have devastating impacts on both human and animal populations, as well as the environment (Addy, et. al., 2024, Qiu, et. al., 2023, Shaheen, 2022). Effective surveillance strategies are essential for early detection, rapid response, and control of zoonotic diseases to prevent outbreaks and protect public health.

The One Health approach recognizes the interconnectedness of human, animal, and environmental health and emphasizes the collaborative efforts of multiple disciplines to address complex health challenges (Addy, et. al., 2024, Akinrinola, et. al., 2024, Ogunseitan, 2022). This approach is particularly relevant to zoonotic disease surveillance, as

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many emerging infectious diseases originate in animals and can spread to humans through various pathways. By integrating surveillance efforts across human and animal health sectors, as well as environmental agencies and other relevant stakeholders, the One Health approach seeks to improve the detection and response to zoonotic diseases. This integration enables a more holistic understanding of disease dynamics and transmission pathways, leading to more effective control measures (Addy, et. al., 2024, Akinrinola, et. al., 2024, Ghai, et. al., 2022).

This review explores integrative strategies for zoonotic disease surveillance in the United States, focusing on the implementation of One Health principles. It examines the collaborative efforts between human and animal health sectors, environmental agencies, and other stakeholders in implementing One Health surveillance strategies. The review also discusses the role of technology, such as geographic information systems (GIS) and molecular epidemiology, in enhancing zoonotic disease surveillance.

Overall, this review highlights the importance of effective surveillance strategies in combating zoonotic diseases and underscores the relevance of the One Health approach in addressing these complex health challenges. By integrating surveillance efforts and promoting collaboration among stakeholders, the One Health approach can enhance our ability to detect, respond to, and control zoonotic diseases, ultimately protecting public health.

1.1. Theoretical Framework

The One Health approach is a collaborative, interdisciplinary approach that recognizes the interconnectedness of human, animal, and environmental health. It emphasizes the need for integrated efforts across these sectors to address complex health challenges, such as zoonotic diseases. The key principles of the One Health approach include: One Health recognizes that the health of humans, animals, and the environment are interconnected and should be considered together. One Health encourages collaboration among professionals from various disciplines, including human health, animal health, environmental science, and social science, to address health challenges (Adeoye, et. al., 2024, Addy, et. al., 2024, Prata, Ribeiro & Rocha-Santos, 2022).

One Health adopts a systems thinking approach, recognizing the complexity of health systems and the need to consider the interactions between different components. One Health emphasizes the importance of preventive measures and early detection to control disease outbreaks and reduce the impact of zoonotic diseases (Addy, et. al., 2024, Jackson, 2019, Okoye, et. al., 2024). The theoretical underpinnings of One Health in zoonotic disease surveillance are grounded in several theories and concepts from various disciplines. One such theory is the social-ecological model, which posits that health outcomes are influenced by the interactions between individuals and their social and physical environments. In the context of zoonotic diseases, this model highlights the importance of considering the interactions between humans, animals, and the environment in disease surveillance and control efforts. Another relevant theoretical framework is the concept of transdisciplinary research, which emphasizes the integration of knowledge and expertise from different disciplines to address complex problems. In the context of One Health, transdisciplinary research can help bridge the gap between human health, animal health, and environmental science to enhance zoonotic disease surveillance.

The application of One Health principles in integrated surveillance systems involves several key strategies. One strategy is the establishment of cross-sectoral surveillance systems that enable the sharing of data and information between human and animal health sectors. These systems facilitate early detection and response to zoonotic disease outbreaks by providing a comprehensive view of disease dynamics (Abrahams, et. al., 2024, Donkoh, 2011, Hernando-Amado, et. al., 2019).

Another strategy is the use of technology, such as geographic information systems (GIS) and molecular epidemiology, to enhance surveillance efforts. GIS can help map disease patterns and identify high-risk areas, while molecular epidemiology can help track disease transmission pathways and identify sources of infection.

Overall, the theoretical framework of One Health provides a comprehensive and interdisciplinary approach to zoonotic disease surveillance. By integrating knowledge and expertise from different disciplines, One Health can enhance our understanding of zoonotic diseases and improve our ability to detect, prevent, and control them.

1.2. Collaborative Efforts in Zoonotic Disease Surveillance

Zoonotic diseases, which are infectious diseases that can be transmitted between animals and humans, pose significant public health threats worldwide. Effective surveillance strategies are essential for early detection, rapid response, and control of zoonotic diseases to prevent outbreaks and protect public health (Abrahams, et. al., 2024, Libera, et. al., 2022, Ohalete, et. al., 2023). Collaborative efforts between the human and animal health sectors, as well as environmental

agencies and other stakeholders, play a crucial role in enhancing zoonotic disease surveillance. This article explores the collaborative efforts in zoonotic disease surveillance, focusing on the United States.

Cross-sectoral collaboration between the human and animal health sectors is essential for effective zoonotic disease surveillance. The One Health approach, which recognizes the interconnectedness of human, animal, and environmental health, emphasizes the need for collaboration between these sectors (Aderibigbe, et. al., 2023, Odonkor, et.al., 2024, Thomas, et. al., 2021). In the United States, agencies such as the Centers for Disease Control and Prevention (CDC), the U.S. Department of Agriculture (USDA), and the Food and Drug Administration (FDA) work together to monitor and respond to zoonotic disease threats. For example, the CDC's One Health Office collaborates with the USDA and other agencies to track and investigate zoonotic diseases, such as rabies and influenza, that can be transmitted between animals and humans.

In addition to the human and animal health sectors, environmental agencies and other stakeholders play a crucial role in zoonotic disease surveillance. Environmental agencies, such as the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA), provide valuable data and expertise on environmental factors that can influence disease transmission. Other stakeholders, such as wildlife conservation organizations, academic institutions, and non-governmental organizations (NGOs), also contribute to zoonotic disease surveillance efforts through research, monitoring, and advocacy. For example, the Wildlife Health Information Sharing Partnership (WHISPers) is a collaboration between federal, state, and tribal agencies, as well as NGOs, to share information on wildlife health and zoonotic disease surveillance.

Several examples of successful collaboration in zoonotic disease surveillance can be found in the United States. One such example is the National Notifiable Diseases Surveillance System (NNDSS), which is a collaboration between the CDC, state and local health departments, and other partners to track and monitor notifiable diseases, including zoonotic diseases. Another example is the National Animal Health Monitoring System (NAHMS), which is a collaboration between the USDA's Animal and Plant Health Inspection Service (APHIS) and other agencies to monitor and respond to animal health issues, including zoonotic diseases (Odonkor, et. al., 2024, Ohalete, et. al., 2023, Sharan, et. al., 2023).

Overall, collaborative efforts between the human and animal health sectors, environmental agencies, and other stakeholders are essential for effective zoonotic disease surveillance. By working together, these sectors can enhance their ability to detect, respond to, and control zoonotic disease threats, ultimately protecting public health.

1.3. Integrative Surveillance Systems

Zoonotic diseases, which are infectious diseases that can be transmitted between animals and humans, pose significant public health threats worldwide. Effective surveillance systems are essential for early detection, rapid response, and control of zoonotic diseases to prevent outbreaks and protect public health. In the United States, several surveillance systems play a crucial role in monitoring zoonotic diseases and facilitating integrated surveillance efforts (Adekanmbi, et. al., 2024, Odonkor, et. al., 2024, Zhang, et. al., 2022). This article explores the overview of existing surveillance systems in the United States, the role of the National Notifiable Diseases Surveillance System (NNDSS) in zoonotic disease surveillance, and the contribution of the National Animal Health Monitoring System (NAHMS) to integrated surveillance.

The United States has a comprehensive surveillance system for monitoring zoonotic diseases and other public health threats (Adekanmbi, et. al., 2024, Atadoga, et. al., 2024, Erkyihun & Alemayehu, 2022). The system includes several key components. The CDC plays a central role in zoonotic disease surveillance in the United States. It operates the NNDSS, which is a nationwide surveillance system that collects and analyzes data on notifiable diseases, including zoonotic diseases, from state and local health departments. The USDA is responsible for monitoring animal health and disease threats. It operates the NAHMS, which collects data on the health and management practices of U.S. livestock producers. NAHMS data are used to monitor trends in zoonotic diseases and inform disease control efforts.

State and local health departments play a crucial role in zoonotic disease surveillance by collecting and reporting data on notifiable diseases to the CDC. They also conduct investigations and implement control measures to prevent the spread of zoonotic diseases within their jurisdictions. Other federal agencies, such as the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA), also contribute to zoonotic disease surveillance by monitoring food and water safety and environmental health factors that can affect disease transmission (Keshavamurthy, Thumbi & Charles, 2021, Oguejiofor, et. al., 2023, Ohalete, et. al., 2023).

The NNDSS is a nationwide surveillance system that collects and analyzes data on notifiable diseases, including zoonotic diseases, from state and local health departments. The system is used to monitor trends in disease incidence, detect outbreaks, and inform public health policy and practice. The NNDSS plays a crucial role in zoonotic disease surveillance by providing timely and accurate data on the occurrence of zoonotic diseases across the United States (Coker, et. al., 2023, Halabi, 2020, Ikwue, et. al., 2023). The NAHMS collects data on the health and management practices of U.S. livestock producers, including information on zoonotic diseases. NAHMS data are used to monitor trends in zoonotic diseases in livestock populations and inform disease control efforts. The NAHMS also collaborates with other federal agencies, state and local health departments, and other stakeholders to integrate animal health and human health surveillance efforts.

In conclusion, integrative surveillance systems play a crucial role in monitoring zoonotic diseases and facilitating early detection and response efforts. By collecting and analyzing data from multiple sources, these systems provide a comprehensive view of zoonotic disease trends and inform public health policy and practice.

1.4. Technological Advancements in Surveillance

Zoonotic diseases, which are infectious diseases that can be transmitted between animals and humans, pose significant public health threats worldwide. Effective surveillance is crucial for detecting, monitoring, and controlling zoonotic diseases. Technological advancements have revolutionized surveillance methods, providing new tools and capabilities to track and respond to these diseases (Atadoga, et. al., 2024, Oguejiofor, et. al., 2023, Rees, et. al., 2021). This article explores the use of geographic information systems (GIS) in disease mapping and visualization, the application of molecular epidemiology in tracking disease transmission pathways, and other technological tools that have impacted zoonotic disease surveillance.

GIS technology has transformed the field of disease surveillance by providing powerful tools for mapping, analyzing, and visualizing disease data. GIS allows researchers and public health officials to create detailed maps that show the distribution of zoonotic diseases and identify high-risk areas. By overlaying disease data with environmental and demographic information, GIS can help identify potential disease hotspots and target surveillance and control efforts more effectively (Ehimuan, et. al., 2024, Nembe, et. al., 2024, Saran, et. al., 2020). One example of GIS application in zoonotic disease surveillance is the tracking of vector-borne diseases, such as Lyme disease and West Nile virus. GIS can be used to map the distribution of disease vectors, such as mosquitoes or ticks, and identify areas where human exposure is most likely to occur. This information can help public health officials implement targeted control measures, such as insecticide spraying or habitat modification, to reduce the risk of disease transmission (Mulachew, 2023, Nembe, et. al., 2024, Treash, 2022).

Molecular epidemiology is another technological advancement that has revolutionized zoonotic disease surveillance. This approach uses genetic and molecular techniques to study the transmission dynamics of pathogens and trace their spread among different hosts. By analyzing the genetic fingerprints of pathogens, researchers can identify transmission pathways and understand how diseases are circulating in human and animal populations (Anyamene, 2020, Ehimuan, et. al., 2024, Gebreyes, et. al., 2020). One example of molecular epidemiology in zoonotic disease surveillance is the use of whole-genome sequencing to study the spread of foodborne pathogens, such as Salmonella and E. coli. By sequencing the genomes of bacteria isolated from human cases and animal reservoirs, researchers can trace the source of infection and identify factors contributing to disease transmission. This information can help inform control measures, such as improved food safety practices or targeted vaccination campaigns, to prevent future outbreaks (Akunne & Etele, 2021, Chigbu, et. al., 2021, Li, et. al., 2021).

In addition to GIS and molecular epidemiology, other technological tools have also impacted zoonotic disease surveillance. For example, remote sensing technology, such as satellite imagery, can be used to monitor environmental factors that influence disease transmission, such as vegetation cover or land use changes. This information can help predict disease outbreaks and guide public health interventions. Similarly, advances in data analytics and machine learning have enabled researchers to analyze large datasets and identify patterns that may not be apparent using traditional methods. These tools can help identify emerging zoonotic disease threats and guide surveillance and control efforts in real-time (Alsharif, et. al., 2020, Anyamene, Nwokolo & Etele, 2021, Azuji, et. al., 2020).

Overall, technological advancements have significantly enhanced zoonotic disease surveillance by providing new tools and capabilities for mapping, tracking, and responding to these diseases. By harnessing the power of technology, public health officials can better understand the dynamics of zoonotic diseases and implement more effective strategies to protect human and animal health (Valentina, et. al., 2021, Valentina, et. al., 2023, Zhang, et. al., 2023).

1.5. Challenges in One Health Implementation

One Health is a collaborative, interdisciplinary approach that recognizes the interconnectedness of human, animal, and environmental health. While the One Health approach has the potential to address complex health challenges, such as zoonotic diseases, its implementation faces several challenges (Akunne, et. al., 2023, Igbokwe, et. al., 2023, Jasani, S. (2019). This article explores the challenges in One Health implementation, including limited resources and funding, fragmented data systems, lack of interoperability, and regulatory barriers and policy challenges.

One of the major challenges in One Health implementation is the limited availability of resources and funding. Implementing a One Health approach requires collaboration among multiple sectors, including human health, animal health, and environmental health, which can be resource-intensive. However, funding for One Health initiatives is often limited, leading to challenges in coordinating efforts and implementing integrated surveillance and control measures (Collignon & McEwen, 2019, Igbokwe, et. al., 2023).

Limited resources can also impact the sustainability of One Health programs. Without adequate funding, it can be difficult to maintain long-term surveillance systems, train personnel, and invest in research and infrastructure needed to support One Health activities. Additionally, competing priorities and limited funding streams can further exacerbate resource constraints, making it challenging to prioritize One Health initiatives.

Another challenge in One Health implementation is the fragmented nature of data systems and the lack of interoperability between different sectors. Each sector, such as human health, animal health, and environmental health, often uses its own data systems and standards, making it difficult to share and integrate data. This fragmentation can hinder the ability to detect and respond to zoonotic disease threats effectively (Akunne, et. al., 2023, Desveaux, et. al., 2019).

The lack of interoperability between data systems can also lead to duplication of efforts and inefficiencies in data collection and analysis. Without standardized data sharing protocols and interoperable systems, it can be challenging to exchange information across sectors and integrate data from different sources. This fragmentation can limit the ability to conduct comprehensive surveillance and response efforts, undermining the effectiveness of One Health approaches (Kush, et. al., 2020, Valentina, et. al., 2023). Regulatory barriers and policy challenges can also pose significant challenges to One Health implementation. Differences in regulatory frameworks between sectors, such as human health, animal health, and environmental health, can create challenges in coordinating efforts and implementing integrated approaches. For example, regulatory barriers may hinder the sharing of data between sectors or the implementation of joint surveillance and control measures.

Policy challenges, such as conflicting priorities and interests among stakeholders, can also impede One Health implementation. Lack of coordination between government agencies, academic institutions, and other stakeholders can lead to fragmented approaches and limited progress in addressing complex health challenges. Additionally, competing interests and political pressures can influence policy decisions, making it challenging to implement integrated One Health strategies (Brack, et. al., 2022, Buregyeya, et. al., 2020).

In conclusion, while the One Health approach has the potential to address complex health challenges, its implementation faces several challenges. Limited resources and funding, fragmented data systems, lack of interoperability, and regulatory barriers and policy challenges can hinder the effectiveness of One Health initiatives. Addressing these challenges will require coordinated efforts among stakeholders and policymakers to overcome barriers and promote integrated approaches to health.

1.6. Strategies for Enhancing One Health Surveillance

One Health is a collaborative, interdisciplinary approach that recognizes the interconnectedness of human, animal, and environmental health. Effective One Health surveillance is essential for early detection, rapid response, and control of zoonotic diseases and other health threats that transcend species boundaries (Akunne & Etele, 2021, Chigbu, et. al., 2021, Zinsstag, et. al., 2021). This article explores strategies for enhancing One Health surveillance, including increased investment in infrastructure and capacity building, development of policies to support integrated surveillance approaches, and promotion of data sharing and collaboration among stakeholders.

One of the key strategies for enhancing One Health surveillance is increased investment in infrastructure and capacity building. This includes investing in the development of surveillance systems, laboratory facilities, and workforce training programs that can support integrated surveillance approaches. By strengthening the infrastructure and capacity of public health, veterinary, and environmental health systems, countries can improve their ability to detect,

monitor, and respond to zoonotic disease threats (Anyamene, et. al., 2021, Kandel, et. al., 2020). Investment in infrastructure should include the development of modern laboratory facilities equipped with the necessary tools and technologies for diagnosing zoonotic diseases. This can include molecular diagnostic tools, such as polymerase chain reaction (PCR) machines, as well as bioinformatics capabilities for analyzing and sharing data. In addition, training programs should be established to build the capacity of health professionals, veterinarians, and environmental scientists in integrated surveillance approaches.

Another key strategy for enhancing One Health surveillance is the development of policies that support integrated surveillance approaches. This includes developing regulatory frameworks that facilitate data sharing and collaboration between human health, animal health, and environmental health sectors. Policies should also encourage the use of standardized surveillance methods and data collection tools to ensure interoperability between different sectors (Azuji, et. al., 2020, Lal, et. al., 2021).

Policies should also address the legal and ethical considerations related to data sharing and collaboration. This includes ensuring data privacy and security, as well as protecting intellectual property rights. By establishing clear policies and guidelines, countries can create an enabling environment for One Health surveillance and facilitate cooperation between different sectors. Promoting data sharing and collaboration among stakeholders is another important strategy for enhancing One Health surveillance. This includes establishing mechanisms for sharing data between human health, animal health, and environmental health sectors, as well as between different countries and regions. Data sharing can facilitate early detection of zoonotic disease outbreaks and help identify emerging threats (Akunne & Nwadinobi, 2021, Bordier, et. al., 2020). Collaboration among stakeholders is also essential for effective One Health surveillance. This includes fostering partnerships between government agencies, academic institutions, non-governmental organizations (NGOs), and other stakeholders involved in health surveillance. By working together, stakeholders can pool resources, share expertise, and develop coordinated strategies for surveillance and response.

In conclusion, enhancing One Health surveillance requires a multi-faceted approach that includes increased investment in infrastructure and capacity building, development of policies to support integrated surveillance approaches, and promotion of data sharing and collaboration among stakeholders. By implementing these strategies, countries can strengthen their surveillance systems and improve their ability to detect, monitor, and respond to zoonotic disease threats.

2. Future Directions and Implications

Zoonotic diseases, which are infectious diseases that can be transmitted between animals and humans, pose significant public health threats worldwide. The One Health approach, which recognizes the interconnectedness of human, animal, and environmental health, has emerged as a promising strategy for addressing these complex health challenges. As One Health implementation continues to evolve, there are several potential advancements, implications for policy, practice, and research, and recommendations for promoting One Health implementation in zoonotic disease surveillance in the United States (Etele & Chinwe, 2021, Rahman, et. al., 2020, Nwakpadolu, et. al., 2024).

One potential advancement in One Health surveillance is the integration of new technologies, such as artificial intelligence (AI) and machine learning, into surveillance systems (Sanni et al., 2022, Ukoba et al., 2023, Sanni et al., 2024). These technologies have the potential to enhance the detection and monitoring of zoonotic diseases by analyzing large datasets and identifying patterns and trends that may not be apparent using traditional methods. Another potential advancement is the development of more comprehensive and interoperable data systems that can integrate data from multiple sources, including human health, animal health, and environmental health sectors. By improving data sharing and collaboration among stakeholders, these systems can provide a more holistic view of zoonotic disease transmission pathways and facilitate more effective surveillance and response efforts.

Additionally, advancements in molecular epidemiology and genomics are providing new insights into the transmission dynamics of zoonotic diseases. These advancements can help researchers track the spread of pathogens, identify sources of infection, and develop targeted control measures to prevent outbreaks. The continued implementation of One Health approaches in zoonotic disease surveillance has several implications for policy, practice, and research. From a policy perspective, there is a need for continued support and funding for One Health initiatives at the national, state, and local levels. Policies should also be developed to promote data sharing and collaboration among stakeholders and to address regulatory barriers that may hinder integrated surveillance efforts (Anyamene, 2020, Ribeiro, et. al. 2019).

In terms of practice, there is a need for continued capacity building and training programs to enhance the skills and expertise of public health professionals, veterinarians, and environmental scientists involved in One Health surveillance.

Practice guidelines should also be developed to promote standardized surveillance methods and data collection tools across different sectors.

From a research perspective, there is a need for continued research into the effectiveness of One Health approaches in preventing and controlling zoonotic diseases. This includes research into the impact of environmental factors, such as climate change and land use change, on disease transmission, as well as research into the development of new technologies and tools for surveillance and control (Akunne, et. al., 2022, Ellwanger, et. al., 2021, Mokwelu, Etele & Akunne, 2023). To promote One Health implementation in zoonotic disease surveillance, several recommendations can be made. First, there is a need for increased investment in infrastructure and capacity building to support integrated surveillance approaches. This includes investing in the development of surveillance systems, laboratory facilities, and workforce training programs.

Second, there is a need for the development of policies that support integrated surveillance approaches and facilitate data sharing and collaboration among stakeholders. Policies should also address regulatory barriers that may hinder integrated surveillance efforts. Third, there is a need for continued research into the effectiveness of One Health approaches and the development of new technologies and tools for surveillance and control. This includes research into the impact of environmental factors on disease transmission, as well as research into the development of new diagnostic tools and vaccines.

In conclusion, the future of One Health implementation in zoonotic disease surveillance holds great promise for improving public health outcomes. By embracing new technologies, enhancing collaboration among stakeholders, and investing in research and capacity building, we can continue to advance our understanding of zoonotic disease transmission and develop more effective strategies for prevention and control (Etele & Akunne, 2023, Munyua, et. al., 2019).

3. Conclusion

The implementation of integrative strategies for zoonotic disease surveillance, based on the One Health approach, holds immense promise for improving public health outcomes in the United States. This review has highlighted key findings regarding the potential advancements, implications for policy, practice, and research, and recommendations for promoting One Health implementation in zoonotic disease surveillance.

One key finding is the importance of increased investment in infrastructure and capacity building to support integrated surveillance approaches. This includes investing in the development of surveillance systems, laboratory facilities, and workforce training programs. Another key finding is the need for the development of policies that support integrated surveillance approaches and facilitate data sharing and collaboration among stakeholders. Additionally, advancements in technology, such as AI and machine learning, have the potential to enhance surveillance efforts by analyzing large datasets and identifying patterns and trends that may not be apparent using traditional methods.

In light of these findings, there is a clear call to action for implementing One Health surveillance in the United States. This includes increasing investment in infrastructure and capacity building, developing policies that support integrated surveillance approaches, and promoting data sharing and collaboration among stakeholders. By embracing these strategies, we can improve our ability to detect, monitor, and respond to zoonotic disease threats, ultimately protecting public health.

In conclusion, integrated strategies for zoonotic disease surveillance based on the One Health approach are essential for addressing the complex health challenges posed by zoonotic diseases. By recognizing the interconnectedness of human, animal, and environmental health, and by working together across sectors, we can enhance our ability to prevent and control zoonotic diseases. The future of zoonotic disease surveillance lies in our ability to embrace these integrated strategies and work collaboratively towards a healthier and safer future for all.

Compliance with ethical standards

Disclosure of conflict of interest

The authors report no conflicts of interest in this work.

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