

One Health Approach to Zoonosis: Integrating Medicine, Veterinary Science and Environmental Science

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ABSTRACT

Zoonotic diseases that transmit from animals to humans pose a major global health threat, accounting for over 60% of infectious diseases. Tackling these complex “one health” challenges requires integrating human medicine, veterinary science, and environmental monitoring into a unified framework. This chapter of the book provides a comprehensive overview of the One Health approach for addressing zoonosis. Tracing foundational concepts from Hippocrates through seminal thinkers like Virchow and James Steele, it chronicles paradigm shifts recognizing interdependencies between human, animal, and environmental health. Detailed case examples illustrate effective applications of One Health principles, from curbing sleeping sickness in Uganda by linking human outbreaks with animal reservoirs and vector control, to mitigating Rift Valley Fever in Kenya through joint animal-human health response systems. Core One Health focus areas for zoonosis include strengthened surveillance coordinating human and animal data streams to detect outbreaks early, comparative research on disease transmission pathways across species, and collaborative policies supporting prevention and control programs. The chapter emphasizes that overcoming systemic barriers limiting cross-sectoral coordination is essential to managing these complex risks, requiring medical experts, veterinary professionals, and environmental scientists to align efforts within an interconnected framework. Key recommendations include fostering interdisciplinary cooperation, establishing regular communication platforms, addressing resource constraints limiting One Health infrastructure, and actively engaging local communities. Ultimately, this holistic approach creates a shared defence against endemic and emergent zoonosis by enhancing preparedness, resilience, and risk reduction at the human-animal-environment interface.

Keywords: Zoonosis, One Health, Public health, Veterinary Public Health, Interdisciplinary collaboration.

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CHAPTER HISTORY

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1. INTRODUCTION

1.1. EXPLANATION OF ONE HEALTH AND ITS RELEVANCE TO ZOONOSIS

As we enter the twenty-first century, the global community is dealing with a shift in the landscape of infectious diseases that impact humans and animals. Some of these diseases significantly risk our overall health and welfare. The One Health (OH) concept has emerged as a solution to this issue, emphasizing the importance of integrating human, animal and environmental health. The approach of One Health recognizes that the health of humans, animals, and the environment is interconnected (Zumla et al. 2016). The idea of One Health isn't novel, but it has gained renewed attention in recent years, primarily due to the increase in zoonotic infectious diseases. A zoonotic disease is a disease that can be very commonly transmitted between animals and humans. These diseases can be transmitted from animals to humans, either through direct contact or indirectly via vectors. There are around 1,500 pathogens and 75% of the newly emerging infectious diseases are known to be zoonotic in nature (Sabour et al. 2022). . The "One Health" approach refers to the special and complex relationship between humans, animals, and pathogens that coexist in the same environment. The effects of these diseases on the well-being of humans, livestock, and wildlife, and their economic implications, have prompted global health organizations and governments to recognize the need to collaborate in tackling these health issues (Gibbs and Gibbs 2013).

1.2. OVERVIEW OF ZOONOSIS AND ITS IMPACT ON HUMAN AND ANIMAL HEALTH

Recently, zoonotic diseases have become increasingly important in both public and animal health. Over the past few years, there have been numerous new diseases emerging unexpectedly, causing serious issues for both animals and humans (Brown 2004). Zoonotic pathogens are spreading more rapidly due to various factors. These include increased animal movement, expanding global trade, urbanization, environmental changes, and a rise in the number of immune-compromised patients. (Bender and Tsukayama 2004). There are various zoonotic viral diseases, such as Ebola, Middle East Respiratory Syndrome, West Nile, SARS-Corona, Nipah, Hendra, Avian influenza, and Swine influenza. These illnesses have been a major danger to both the wellbeing of the general public and the economies of the world. The *Japanese encephalitis virus* (JEV) is currently spreading throughout Asia and Australia, with reported cases even in non-endemic countries such as the United States due to travel (Weaver and Reisen 2010). The increased use of horses for various purposes such as trade, sports, and breeding has heightened the risk of equine diseases spreading to new areas. There are various viral diseases that can impact horses, including Eastern equine encephalitis (EEE), Western equine encephalitis (WEE), and Venezuelan-equine encephalitis (VEE). These diseases can be highly contagious and can spread through aerosol transmission (Roy et al. 2009), West Nile fever has recently spread to many new areas (Chancey et al. 2015). Other than viruses and bacteria there are several parasites infections that are of both veterinary and medical

importance. Particularly, zoonotic cestods are reported from different areas of Pakistan in rat, goat and cattle (Alvi et al. 2021; Alvi et al. 2020).

2. UNDERSTANDING THE ONE HEALTH APPROACH

2.1. HISTORICAL DEVELOPMENT AND EVOLUTION OF ONE HEALTH

The notion of One Health cannot be traced back to a single origin in human thought. Instead, it is a foundational aspect of life on our planet that has been rediscovered and studied throughout history. Historically, the health and well-being of humans have been closely connected to animals and the planet they inhabit. The idea of One Health has its roots in the cultural and spiritual beliefs of many ancient civilizations and modern indigenous communities. This concept highlights the connection between humans, animals, and the environment. It can be seen in various forms throughout Western thought, as it pertains to social, medical and ecological aspects. The concept of One Health can be traced back to the works of the physician Hippocrates (460 BCE-367 BCE). He highlighted the connection between a healthy environment and public health in his work titled 'On Airs, Waters and Places'. The edict of "Primum Non Nocere," which means "above all, do no harm," is attributed to him. This principle is agreed upon by all health practitioners, who strive to follow it (Wear 2008).

Giovanni Maria Lancisi, an Italian physician, veterinarian, and pioneering epidemiologist, recognized the crucial role that the environment plays in the transmission of diseases to both humans and animals almost 2,000 years after they were first discovered. Many consider him to be a trailblazer in dealing with rinderpest in cattle by promoting animal depopulation and quarantine methods. There are those who propose that he may have been the first to suggest draining swamps and using protection against biting flies as a means of preventing and managing human malaria (Evans and Leighton 2014).

Rudolf Virchow, a renowned German physician and pathologist (1821 to 1902), is widely recognized for introducing the term "zoonosis." Moreover, he is well-known for advocating that there should be no distinction between animal and human medicines (Natterson-Horowitz and Bowers 2013). He understood that environmental factors played a crucial role in determining health outcomes. For instance, he suggested that the best way to stop a long-lasting typhus epidemic, was to offer the affected area with greater independence, better transportation, and quality educational institutions.(Ackerknecht and Schwalbe 1953; Virchow and Rather 1985).

James Steele (1913-2013) and Calvin Schwabe (1927-2006), both hailing from the United States, are now recognized for their innovative leadership in promoting the link between animal and human health as well as the environment. Steele established the veterinary public health unit in 1947, which eventually evolved into the Centers for Disease Control and Prevention in the USA. He also played a crucial role in establishing graduate education in public health as a new veterinary specialty. The WHO established a veterinary public health unit based on the warnings regarding the socio-economic consequences of zoonotic diseases (Dunlop and Williams 1996).

Today's One Health concepts are a new way of thinking about managing health that takes into account the rapid changes in the environment over the last century, which have coincided with the explosive growth of the world's population. Today, the Earth is home to a larger population than ever before, and our actions and impact on the environment are more significant and faster-paced than ever before (Cohen 1995; McNeill 2001). The global population of domestic animals has surged alongside the growth of the human population, leading to increased usage of natural resources. Unfortunately, this has also resulted in a rise in environmental changes that pose risks to the health of both people and animals. The pace of change has exceeded the natural rate of adaptation for both humans and animals. However, the One Health approach offers a glimmer of hope and flexibility in achieving

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optimal health in a disrupted environment. The objective is to promote mutualism and integration to attain optimal health for humans, animals, and the environment. This approach acknowledges that all three domains must work together to achieve health simultaneously, or not at all (Evans and Leighton 2014).

2.2. KEY STAKEHOLDERS AND THEIR ROLES IN IMPLEMENTING ONE HEALTH

The One Health concept recognizes that human, animal, and environmental health are interconnected and should be approached holistically. To successfully implement the One Health approach, it is essential for multiple stakeholders to work together in a collaborative and coordinated manner. (Hailat et al. 2023). The One Health framework involves several key stakeholders such as government agencies, public health authorities, veterinarians, environmental scientists, and community representatives (Johnson et al. 2018). The development of policies and regulations to promote interdisciplinary cooperation and allocate resources for One Health initiatives is a crucial task carried out by government agencies. Public health authorities play a crucial role in monitoring and responding to disease outbreaks in humans and animals. They also facilitate the exchange of information between different sectors. Veterinarians play a crucial role in providing medical care to animals, identifying zoonotic diseases, and evaluating the overall health of wildlife populations. They are essential stakeholders in these areas. Environmental scientists examine how environmental factors affect human health and develop plans to reduce potential risks. (Zinsstag et al. 2012). It is crucial to involve community representatives as they possess valuable local knowledge, encourage community engagement, and facilitate behavior changes that promote sustainable practices and improved health outcomes for everyone. The stakeholders involved in One Health work together to advance research projects, exchange information and monitor the emergence of diseases. They collaborate to enhance communication and knowledge sharing among different sectors, thereby improving early detection and response to potential health hazards (Sinclair 2019). Furthermore, these people or organizations support programs that aim to improve the abilities of those involved and encourage educational efforts that highlight the interdependence of human, animal, and environmental well-being (Allen-Scott et al. 2015). By working together, the important players in the One Health strategy can enhance the healthcare system's resilience and integration. As a result, we can expect better prevention, control, and management of infectious diseases, reduced antimicrobial resistance, and improved health outcomes for both people and ecosystems.

3. UNDERSTANDING ZOONOSIS

3.1. ZOONOSIS AND ITS VARIOUS TYPES

Zoonosis (plural: zoonoses) is a term created by Rudolph Virchow in the late 19th century. It comes from two Greek words - 'zoon' meaning animals, and 'noson' meaning disease. This term is used to refer to illnesses that humans can catch from animals. There are various categories of zoonotic illnesses, depending on the type of pathogens implicated. These may include viral, bacterial, parasitic, mycotic, or unconventional (prions) (Chomel 2009).

3.2. CAUSES AND TRANSMISSION PATHWAYS OF ZOONOTIC DISEASES

There are various causes and transmission pathways for zoonotic diseases (Loh et al. 2015), which include:

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3.2.1. DIRECT CONTACT

Contact with the body fluids, tissues, or feces of infected animals can lead to transmission. Examples include handling livestock, pets, or wildlife. Zoonotic diseases can be transmitted through bites or scratches from infected animals. Rabies is a well-known zoonotic disease transmitted through animal bites.

3.2.2. INDIRECT CONTACT

Pathogens shed by infected animals can contaminate the environment, leading to human exposure. For example, zoonotic infections like histoplasmosis can be contracted by inhaling spores from bird or bat droppings. Another way of indirect contact is consuming undercooked or contaminated meat, unpasteurized milk, or contaminated water can lead to zoonotic infections such as salmonellosis and brucellosis.

3.2.3. VECTOR-BORNE TRANSMISSION

Ticks, mosquitoes, fleas, and lice are types of vectors that can transmit zoonotic pathogens from animals to humans. For example, ticks can transmit Lyme disease and mosquitoes can spread diseases like *West Nile virus*.

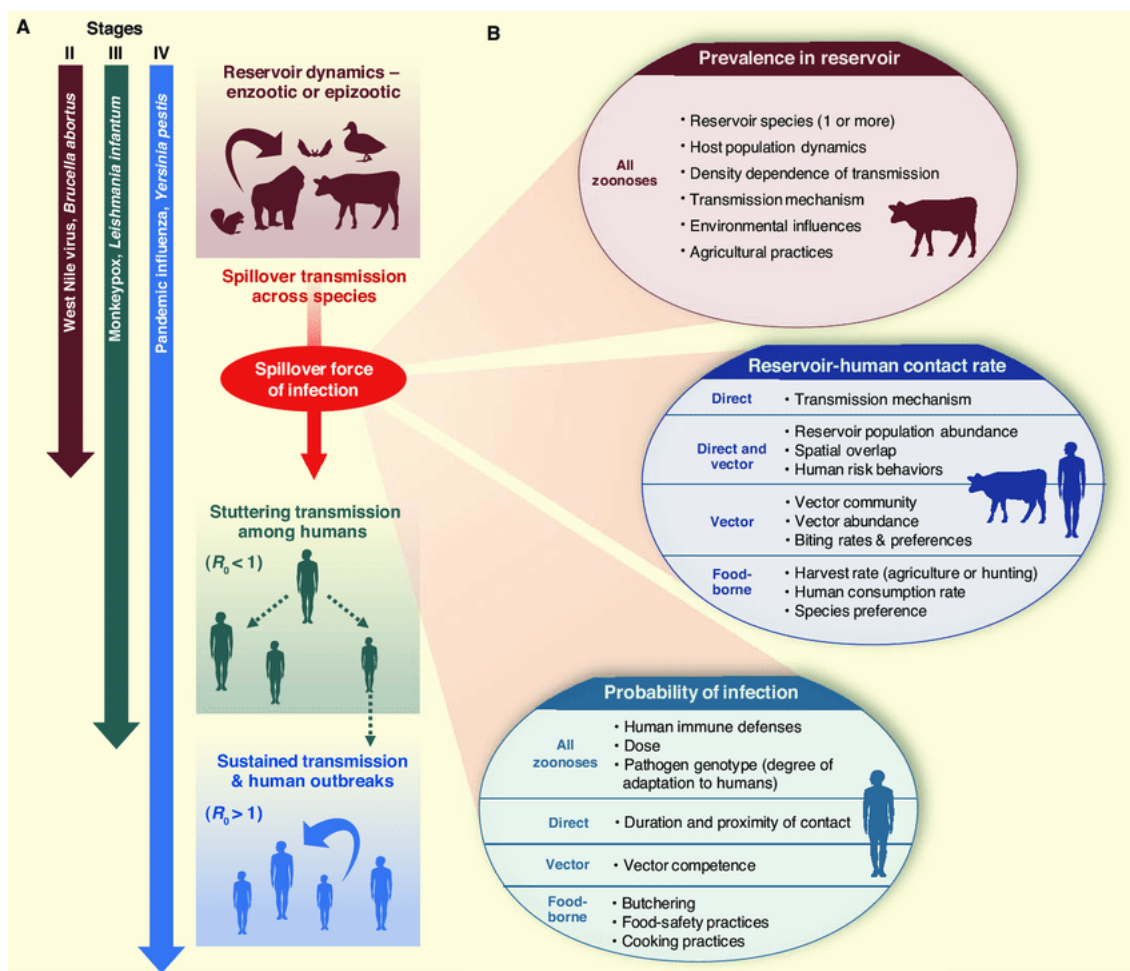


Fig. 1: Schematic diagram of zoonotic transmission pathways and dynamics. Modified from (Lloyd-Smith et al. 2009)

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3.2.4. Airborne Transmission

Some zoonotic diseases can spread through the air, where respiratory droplets containing pathogens are released by infected animals. Inhaling these droplets can lead to infections. An example is avian influenza (bird flu).

3.2.5. Nosocomial Transmission

In healthcare settings, zoonotic diseases can be transmitted from infected patients or animals to healthcare workers, visitors, or other patients if proper infection control measures are not followed.

3.2.6. Anthroozoonosis

It is possible for zoonotic diseases to spread from humans to animals, which is referred to as reverse zoonoses or anthroozoonoses. This can lead to a continuous cycle of transmission between humans and animals. For example, tuberculosis can be transmitted from humans to animals and vice versa.

It's crucial to understand that zoonotic diseases vary in their transmissibility and severity when transmitted to humans. Many zoonoses can be prevented or controlled through various measures, including proper hygiene practices, vaccination of animals, surveillance and monitoring of disease in animals, and public health awareness programs. Understanding the causes and transmission pathways of zoonotic diseases is crucial for preventing and managing outbreaks that could have significant impacts on both animal and human health.

3.3. EXAMPLES OF ZOONOTIC DISEASES OF MEDICAL AND VETERINARY IMPORTANCE

Zoonotic diseases can affect the health of both humans and animals, including domestic animals, pets, and companion animals. The impacts of these diseases can be far-reaching. An example of a significant concern in both public health and veterinary medicine is bovine zoonoses. Out of all the zoonotic diseases, tuberculosis is considered the most crucial one. *Mycobacterium bovis* and *M. tuberculosis* cause this disease, which has caused significant economic loss in animal production (Torgerson and Torgerson 2010). Although developed countries have managed to largely eradicate bovine tuberculosis, other parts of the world are still grappling with significant zoonotic effects. Human tuberculosis is the second most prominent cause of death after AIDS, and *M. bovis* is responsible for 5-10% of all tuberculosis cases in humans, with children accounting for about 25% of those cases (Samad 2011). Anthrax is a serious illness caused by the *Bacillus anthracis* bacteria that poses a significant public health concern. The disease can spread to humans through close exposure to infected animals like cattle and goats, as well as their byproducts such as meat, skin, hides, and bones. Data shows that between 2,000 to 20,000 individuals worldwide are impacted by anthrax cases annually (Goel 2015). Countries that rely on agriculture for their economy, particularly developing nations, continue to face dangerous consequences caused by anthrax.

Brucellosis is a bacterial disease that is widespread among animals and can be transmitted to humans. It leads to more than 500,000 cases annually worldwide (Hull and Schumaker, 2018). Humans typically contract brucellosis by consuming unpasteurized milk or milk products. It is rare for the disease to spread from one human to another. It has also been reported that transmission can occur through inhaling aerosols and coming into contact with secretions (Corbel 2006). Brucellosis in animals can lead to abortion, lameness, abscess, a decrease in milk production, and a reduced chance of survival

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for newborns (Rahman et al. 2006). Individuals who work in dairy farms, care for animals, work in abattoirs, provide veterinary care, and reside in rural areas face a greater risk of contracting brucellosis infection.

In recent decades, there has been a rise in the number of pets and companion animals. However, these animals can also carry disease-producing agents, making them a potential source of illness. Surprisingly, a significant portion of pet owners, ranging from 14% to 62%, permit their beloved pets to enter their bedrooms. Unfortunately, this practice may potentially increase the risk of zoonotic diseases spreading (Chomel and Sun 2011). Pets and companion animals can carry various infectious diseases that can come from viruses, bacteria, parasites, and fungi (Halsby et al. 2014). Many people may be at risk of catching new zoonotic illnesses from their pets, companion animals, and exotic birds and animals.

Zoonoses can have various effects on the health of humans and animals. While it is difficult to measure the impact of zoonoses, we can evaluate it based on factors such as disease occurrence, frequency, sickness, death, and financial loss. Zoonoses can significantly impact human lives and wellness, which highlights the need for a joint approach from healthcare professionals, veterinary specialists, and environmental experts to control their effects and prevent future outbreaks.

4. ONE HEALTH APPROACH TO ZOONOSIS

Collaborating across various fields using the One Health method can result in better monitoring, prevention, and management of zoonotic disease outbreaks. Moreover, it can improve the safety and security of food products while decreasing the proliferation of antibiotic-resistant infections for the benefit of both humans and animals. This approach highlights the significance of enhancing surveillance systems, exchanging data, boosting laboratory diagnostic systems, and creating an early response network for zoonoses, which fosters efficient collaboration among concerned sections. This method enhances prevention and control of diseases that can be transmitted between animals and humans, and trains emergency response teams to work together efficiently. All of the tactics employed work towards reducing the spread of these types of diseases. The One Health approach prioritizes international health security by promoting effective collaboration, coordination, and communication among relevant industries. It specifically addresses the health risks that arise at the intersection of these sectors (Sinclair 2019). It provides a comprehensive and proactive strategy to tackle zoonotic diseases, mitigating risks, and promoting the well-being of both animals and humans while preserving the health of the environment.

Although there is significant interest in One Health, its implementation at the country, local, and project levels is limited. This is most likely because there aren't enough practical and proven methods for implementation and metrics for evaluation (Baum et al. 2017). Zoonoses present a unique challenge as they involve multiple sectors, including pharmaceuticals, crop and animal agriculture, food processing, water resources, and public health. The issue arises from and impacts all of these areas (Abbas et al. 2022). Each sector has its own incentive structures and is influenced by different disciplinary perspectives. Therefore, One Health collaborations and partnerships are essential for efficient surveillance and response to zoonotic diseases.

Numerous One Health initiatives have proven effective in managing zoonotic diseases and containing their transmission. The continent of Africa is a pertinent location for studying One Health policies, especially in the context of controlling endemic and "neglected" zoonotic diseases. In Uganda, there has been notable advancement in the management of Human African Trypanosomiasis (HAT), commonly referred to as sleeping sickness, and the corresponding disease in livestock known as Nagana, transmitted through the bite of infected tsetse flies. To achieve this, the country has employed a One Health approach, involving cooperation among health officials, veterinary services, and entomologists. They have carried out active

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monitoring of both human and animal cases, enforced measures to control tsetse flies, and encouraged community involvement in disease control efforts. Consequently, the number of reported HAT cases has considerably decreased in recent times (Welburn et al. 2006).

Kenya has had multiple outbreaks of Rift Valley Fever (RVF), which have caused significant economic losses in livestock and posed a public health threat to humans. RVF is a viral zoonotic disease that affects both animals and humans. To tackle this problem, the Kenyan government collaborated with international partners and researchers to adopt a One Health approach. This involved enhancing surveillance and monitoring of both animal and human cases, promoting safe livestock handling practices, and raising awareness among communities. In the 2006/07 outbreak of RVF, which had a wider geographic spread, prompt diagnosis and coordinated response led to improved disease control. This resulted in a decrease in human and animal morbidity and mortality, despite 700 suspected human cases and 90 deaths. These collaborative efforts successfully curbed the spread of RVF and lessened its effects on animals and humans (Munyua et al. 2010).

5. ONE HEALTH STRATEGIES TO ADDRESS ANTIMICROBIAL RESISTANCE IN ZOONOTIC DISEASES

Antimicrobial resistance (AMR) poses a significant health risk to humans and animals on a global scale. To effectively tackle this complex problem in zoonotic diseases, the implementation of One Health strategies is essential. With One Health, we can establish strong surveillance systems for both human and animal health, allowing for the monitoring of the spread of zoonotic diseases and the development of AMR. Collecting data on this topic can help detect and track resistant pathogens early, which in turn can aid in implementing timely interventions. One Health can also assist in developing and deploying quick and precise diagnostic tools to identify zoonotic infections and determine antimicrobial susceptibility patterns. This will lead to a more targeted and suitable use of antibiotics, ultimately reducing the risk of resistance development (Velazquez-Meza et al. 2022).

The One Health approach promotes judicious and careful usage of antimicrobials in human and veterinary medicine. This can be achieved through educating healthcare professionals, veterinarians, farmers, and the public about the significance of using antibiotics appropriately and the negative outcomes of misusing or overusing them. One Health strategies have the potential to create and enforce regulations on the production, sale, and application of antimicrobials in both human and animal healthcare sectors, which can help prevent misuse and overuse of these medications. This, in turn, can decrease the selection pressure for resistant pathogens (Aslam et al. 2021). Mitigating the risk of AMR in zoonotic diseases requires collaboration between the human health, animal health, and environmental sectors. This can be best achieved by adopting One Health strategies.

6. ENVIRONMENTAL FACTORS, ONE HEALTH AND ZOONOTIC DISEASES

Infectious zoonotic diseases are a significant concern in One Health. This is because the environment where humans come into contact with farm animals, pets, or wild animals plays a critical role in disease transmission. The ecosystem and how it is influenced by human activities such as agriculture are important factors in assessing the risk of zoonotic diseases spread (Landford and Nunn 2012). Climate change is a significant environmental factor that has a severe impact on both wild and domestic animal populations, food chains, and human health (Europea 2006). The climate's changes, such as fluctuations in temperature, can have a significant impact on the spread of diseases. They can affect how infectious pathogens, such as bacteria, viruses, parasites, and fungi, migrate and adapt. Climate change can create new environments where these pathogens can thrive, leading to the emergence of diseases in previously unaffected regions (Wu et al. 2016).

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When assessing One Health initiatives, there is often a focus on veterinary and medical themes, while the environment is frequently overlooked (Humboldt-Dachroeden et al. 2020). The environment is present all around us and has a significant impact on human and animal health. Healthy soils and clean water play a crucial role in preventing the spread of diseases. Maintaining clean environments in slaughterhouses, preserving natural habitats of animals and biodiversity can also aid in reducing disease infections in both animals and humans. The environment and our health are closely interlinked (Keith et al. 2016). It is crucial to prioritize conservation and sustainable practices as part of the One Health approach. This approach aims to protect the health of both humans and animals, while also preserving the environment. By preserving natural habitats and safeguarding wildlife biodiversity, we can maintain a delicate balance in ecosystems, which reduces the risks of zoonotic diseases emerging and spreading. By using responsible land use and sustainable agricultural practices, we can reduce contact between humans and wildlife, which decreases the risk of diseases being transmitted. It's also crucial to mitigate climate change to protect habitats and biodiversity, ensuring ecosystems remain resilient and preventing diseases from emerging. When we prioritize conservation and sustainability within the One Health framework, we create a harmonious coexistence between humans, animals, and the environment, which promotes the well-being and health of all interconnected species.

7. CHALLENGES AND FUTURE DIRECTIONS

To effectively combat zoonotic diseases and their associated risks, it is crucial to address the barriers hindering the implementation of the One Health approach. One of the most significant challenges is the fragmentation of efforts among various sectors and disciplines, which hinders seamless collaboration and information sharing. Overcoming this obstacle requires fostering a culture of interdisciplinary cooperation and establishing platforms for regular communication between public health, veterinary, and environmental professionals. The implementation of comprehensive One Health programs and surveillance systems is hindered by inadequate funding and resource limitations. To overcome this, it is important for governments and international organizations to prioritize investing in One Health initiatives and infrastructure. Raising public awareness about the interconnectedness of human, animal, and environmental health is also crucial in garnering support and promoting behavior changes that can reduce zoonotic disease transmission. By actively engaging communities, healthcare providers, and policymakers in the One Health approach, we can break down barriers, strengthen global cooperation, and ultimately create a stronger defense against zoonotic diseases.

Efforts in research should prioritize advancing our understanding of how zoonotic diseases are transmitted, including examining the factors that contribute to spillover events and host-pathogen interactions. It is essential to integrate One Health principles into national and international frameworks as a policy priority. Governments must prioritize investing in zoonotic disease prevention and preparedness, with a focus on environmental conservation and sustainable practices. To prevent and control zoonotic outbreaks worldwide, it is crucial to strengthen cross-border cooperation and information exchange. Encouraging private sectors and industries to adopt One Health approaches can also support disease prevention efforts. Healthcare professionals, veterinarians, and other stakeholders should undergo capacity building and training programs to gain the necessary skills to respond effectively to zoonotic diseases. Embracing these future directions for research, policy, and practice can establish a comprehensive and proactive approach to disease prevention and control, safeguarding the health of individuals, communities, and the planet as a whole.

8. CONCLUSION

The One Health approach is a thorough framework that tackles the intricate challenges that arise from zoonoses and the interrelatedness of human, animal, and environmental health. The One Health approach emphasizes the importance of recognizing the interdependencies between human, animal, and environmental health. It encourages collaboration among professionals from different disciplines, breaking down traditional silos. This collaborative effort enables a deeper understanding of the complex dynamics of zoonotic diseases, leading to more effective prevention, early detection, and control strategies. Integrating medicine, veterinary science, and environmental science in the One Health approach is crucial for preventing and mitigating zoonotic disease outbreaks. It facilitates the implementation of comprehensive surveillance systems that monitor disease trends in both human and animal populations. Detecting zoonoses early and responding quickly is crucial to reduce the impact on both public health and animal welfare. In addition, the One Health strategy acknowledges the significant influence of environmental factors in the development and spreading of zoonotic diseases. Considering the ecological context, this approach promotes conservation practices and sustainable strategies that protect ecosystems and mitigate the risk of disease spillover. Looking to the future, it is essential to emphasize the continued adoption and promotion of the One Health approach. Integrated approaches are crucial in addressing the persistent threat of zoonotic diseases and emerging infectious diseases that pose significant risks to global health.

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